ECONOMIC ANALYSIS OF CATFISH PRODUCTION AND ITS CONTRIBUTION TO HOUSEHOLD FOOD SECURITY IN FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA

By

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER IN SCIENCE DEGREE IN AGRICULTURAL ECONOMICS.

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JANUARY, 2016

DECLARATION

I hereby declare that this dissertation titled "**Economic Analysis of Catfish Production and its Contribution to Household Food Security in Federal Capital Territory, Abuja, Nigeria**" is a record of research work undertaken by me. It has not been presented for any award in any institution of higher learning. All consulted literature as sources of information were duly acknowledged by means of references.

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CERTIFICATION

This thesis titled **"Economic Analysis of Catfish Production And its Contribution to Household Food Security in Federal Capital Territory, Abuja, Nigeria"** by Donald Ifeanyi MMEREOLE meets the regulations governing the award of Degree of Master in Science degree (M.Sc) in Agricultural Economics of the Ahmadu Bello University, Zaria is approved for its contribution to the scientific knowledge and literary presentation.

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I dedicate this dissertation to The Almighty God; my lovely wife, my dad and mum for all the encouragement.

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ABSTRACT

The study was carried out to evaluate the economics of catfish production and its contribution towards achieving household food security in Federal Capital Territory, Abuja, Nigeria. A multi-stage sampling technique was used to select 155 farmers for the study. Data were collected using structured questionnaire. Information was collected on socioeconomic characteristics, inputs and output quantities as well as their prices. Descriptive statistics were used to describe socioeconomic characteristics as well as the constraints to catfish production. The estimation of technical, allocative and economic efficiency and their determinants were achieved using stochastic frontier production and cost function. Food security line and Z-statistic were used to examine the contribution of catfish production on food security status of catfish farmers. The findings revealed that majority of the respondents were literate with mean age of 42 years; majority (56%) of the respondents had a mean household size of 9 people while about half (51%) of the respondents had a mean of 12 years experience in catfish farming. The results also show that an average total cost (TC) of ₦1,520,204.24 per production cycle was incurred while total revenue (TR) of ₦2,873,521.29 was realized with a gross margin (GM) of ₦1,718,616.84. The net farm income (NFI) of ₦1,353,317.05 was realised with a rate of return of 0.89 for every ₦1.00 invested. It was revealed that increase in number of fingerlings, fish feed and fuel will lead to increase in the output of catfish while age, education, experience and cooperative society were key determinants of technical, allocative and economic efficiency of the farmers. The mean technical, allocative and economic efficiencies of the farmers were 0.67, 0.65 and 0.44 respectively. The study highlights some problems facing the farmers such as: lack of access to financial capital, high cost of feed or other farm inputs, limited market sales and flooding during the rainy season and inadequate storage facility as the major constraints in catfish production. It was recommended that the Government should make policies that would encourage and make catfish farming attractive to younger generation as a means of livelihood. Existing farmers should also be encouraged to form cooperatives and access financial assistance from government institutions. The quantity and quality of feed input being fed to the fish should be improved if a reasonable level of productivity is to be achieved by the farmers toward achieving food security.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The increase in human population and reports of large numbers of people, undernourished or starving (especially in the developing countries) has made the need for food production a major worldwide issue of concern. There are three major groups of activities that contribute to food production namely, agriculture, aquaculture and fisheries. Recent knowledge shows that the world's natural stocks of fish and shell fish, though renewable, have finite production limits, which cannot be exceeded even under the best management regimes. For most of our lakes, rivers and oceans, the maximum sustainable fishing limit has been exceeded. Therefore, fish production will depend on aquaculture to bridge the gap of fish supply (Okechi, 2004).

Aquaculture refers to the cultivation of aquatic organisms under controlled or semi-controlled conditions for economic and social benefits. Aquaculture has been the world's fastest growing food production over the past decade (Fourier, 2006). The average growth rate has been 8.9% per year since 1970, compared to only 1.2% for capture fisheries and 2.8% for terrestrially meat production over the same period (Brink, 2001). Nigeria has become one of the largest importers of fish in the developing world, importing 600,000 metric tons annually (Olagunju *et al.,* 2007). Nigerians are large consumers of fish with demand estimate at 1.4 million metric tons. However, a demand supply gap of 0.7 million metric tons exists nationally with import making up the short fall at a cost of almost 0.5 billion US dollars per year (Kudi *et al.,* 2008). Catfish farming is a subset of aquaculture which involves the rearing of catfish under controlled conditions for economic and social benefits. According to Adewumi and Olaleye (2011), the favoured catfish for culture include *Clarias gariepinus*, *Heterobranchus bidorsalis*, *Clarias heterobranchus* hybrid (heteroclarias), with *C. gariepinus and H. bidorsalis* being the most cultured fish in Nigeria. *Clarias gariepinus* is regarded as an excellent aquaculture species because it grows fast and feeds on a variety of agricultural by-products, it is hardy and can tolerate extreme temperature, easy to produce in captivity with high annual production and good feed conversion rate.

Fish farming contributes significantly to the economy, creating employment opportunities in rural and urban areas, serving as a viable source of protein nutrients in Nigerian households and improving national food security. In 2009, fish accounted for 16.6 percent of the world population's intake of animal protein and 6.5 percent of all proteins consumed (FAO, 2012). Fish culture is an efficient means of animal protein production. It provides nutrition for over one billion people, including at least 50 percent of animal protein for about 400 million people from the poorest countries (The World Bank Group, 2011). Globally, fish provides about 3.0 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein (FAO, 2012). Increasing demand for fish products has resulted in the growth of fish farms to meet a substantial part of the world's food requirement (Olasunkanmi, 2012).

1.2 Problem Statement

Fish production in Nigeria is not only important as a source of rich protein, but it also can be used to bring about institutional changes. These changes can offer access to production assets and resources which can help to empower the poor and directly promote their livelihoods. The increase in fish consumption as a good source of protein and its cultural and religious acceptability are an indication that catfish culturists must live up to expectation of meeting the local demand (Tsue, Lawal, and Ayuba, 2012).

The current shortfall in fish supply compared to local demand is putting pressure on the price of fish and its products. This can make fish unaffordable for many households in Nigeria and further decreasing the per capita fish consumption rate (FAO, 2010). However, there is significant interest in the development of successful fish farming in Nigeria. The fish industry remains the most virgin investment in Nigeria compared with the importation of frozen fish in the domestic market (Ndu, 2006). A sure means of substantially solving the demand-supply gap is by embarking on widespread homestead/small scale fish production. Also, considerable efforts have been directed at examining productive efficiency of fish farmers in Nigeria that is exclusively focused on technical efficiency of fish farmers in general and profitability of fish farming (Kudi *et al.*, 2008). Consequent upon the increment in awareness of catfish farming and a substantial percentage of small scale catfish farmers in Nigeria, it has prompted the interest of researchers to study this firm, but most of the past studies in Nigeria focused on large scale fish farming (Obasi, 2002). There has been little information on economic analysis of catfish production and its contribution to food security status of catfish farmers in FCT Abuja. It is on these bases that the following research questions were addressed by this study:

i. What are the socio-economic characteristics of catfish producers in the study area;
ii. What are the costs and return of catfish production?
iii. What are the technical, allocative and economic efficiencies of catfish production?
iv. What are the determinants of technical, allocative and economic efficiencies of catfish production?
v. What is the contribution of catfish production on household food security status of farmers?
vi. What are the production constraints faced by catfish producers in the study area?

1.3 Objectives of the study

The broad objective of this study is to analyze the economics of catfish production towards achieving food security in FCT Abuja, while the specific objectives were to:

i. describe the socio-economic characteristics of catfish producers in the study area;
ii. estimate the costs and returns of catfish production;
iii. estimate the technical, allocative and economic efficiencies of catfish production;
iv. identify the determinants of technical, allocative and economic efficiencies of catfish production;
v. examine the contribution of catfish production on food security status of farmers;
vi. describe the production constraints faced by catfish producers in the study area.

1.4 Justification for the Study

Nigeria is one of the countries in sub-Saharan Africa with great potential to attain sustainable fish production via aquaculture considering extensive mangrove ecosystem available in the country (FAO, 2005). Nigeria is Africa's largest producer of catfish but the Netherlands, Hungary, Kenya, the Syrian Arab Republic, Brazil, Cameroon, Mali and South Africa also produce significant quantities (FAO, 2010). The Federal Government of Nigeria has disclosed that about 10million Nigerians are actively engaged in both the upstream and downstream areas of fisheries operations. According to figures revealed by the National Bureau of Statistics, the fisheries sector contributed 1.31% of total GDP in 2012 and this rose to 1.38% at the end of the third quarter of 2013. These figures represent 3.3% and 3.5% of agricultural GDP, respectively. Evaluation of catfish farming will expose the need for catfish farmers to adopt new technologies and achieve sustainable production. This study will also be important in determining the extent to which catfish farmers can raise productivity through improved efficiency with existing resource base and available technologies.

1.5 Statement of Hypotheses

The hypotheses are stated in the null form:

i. Catfish production is not profitable in the study area.
ii. There are no technical inefficiency effects in catfish production
iii. Catfish production has no effect on household food security status

CHAPTER TWO

LITERATURE REVIEW

2.1 An Overview of Fish Farming in Nigeria

Nigeria is reasonably endowed with large rivers, small water bodies and some natural springs. It also has an extensive coastline of approximately 900km and an Exclusive Economic Zone (EEZ) of about 217,313 km² (Sea Around Us, 2007). Nigeria has a high demand for fish (1.5 Million Metric Tons (MT)) and a per capital consumption of 7.5-8.5kg annually (FDF, 2005). Current national production stands at 511,000 MT/annum, thus resulting in a demand-supply gap of about a Million MT. Nigeria currently imports 700,000 MT of fish annually at a cost of some US$400 Million (Ovie and Raji 2006). The artisanal fishermen on the coastal waters supply about 260,000 MT, while those on inland waters contribute about 200,000 MT. The remainder of the 511,000 MT annual productions comes from industrial fisheries. Thus, fisheries are crucial to the Nigerian economy, contributing 5.4% of the Gross Domestic Product (FDF, 2005). Although contribution of the fisheries sector is essential to agricultural development in Nigeria, more than half of policies and programmes in agriculture development focus on forest matters while less emphasis is placed on food and animal production.

2.2 Fisheries Management Systems in Nigeria

There are three Fisheries Management systems practiced in Nigeria which are:

Type I. Traditional systems: These are classified as management systems operated by the administration of traditional authorities which enforce regulations to control fishing.

Practices such as ban on fishing at certain time of the year or during fish breeding period.

Type II. Mixed systems: The mixed systems involve the participation of both the traditional and the modern government administrations.

Type III. Modern systems: These include those operated by the administrations of the central government where fisheries regulations are enforced by officers of the fisheries departments.

Type II (mixed) is most common (56%), followed by the Type I (33%) and type III accounting for only 11%. However, the traditional management systems (Type 1), is the most effective at the local community level. The village heads that have responsibilities for enforcing the Type I management Systems are accepted and respected in their various domains. Although the Mixed System (Type II) is most prevalent, governments generally lack the logistic support (personnel, funds, field vehicles etc.) to enforce fisheries laws and regulations. In general, fisheries management systems in Nigeria can be described as variable and hindered by poor financial support for policy implementation. Three key issues confronting the management of the fisheries are:

- Environmental Change – climatic patterns and man's activities
- Exogenous Factors – human population, poverty and food demand
- Weak policies and policy implementations

2.3 Food and Agricultural Organization (FAO) Sustainable Fisheries Development

Sustainable fisheries development is defined by FAO as fisheries development that integrates bio-ecological, technological, economic and social dimensions to sustainably improve the well-being of all the people engaged in the fisheries sector as well as the natural productive system (Serge, 1998). In other words, such development must integrate (Environment, Social and Economic) the triple bottom line framework captured in the Samuel Mann Venn diagram of sustainability (Mann, 2011). The Code of Conduct for Responsible Fisheries (FAO, 1995) has developed the FAO definition of sustainable development into a much more detailed and specific set of General Principles (Article 6) and a large number of specific provisions aiming at facilitating the implementation of the FAO definition in the various facets of the fisheries-related activities: The current policy thrust of the Federal Government is aimed at ensuring sustainable development of Nigerian fisheries for national food security, optimum resource utilization and conservation. The policy focuses on employment generation, poverty alleviation and reduction in rural-urban migration, among others. This in line with the National Economic and Empowerment Development Strategy (NEEDS) of the Federal Government and the New Partnership for Africa's Development (NEPAD) initiatives. Specific objectives which are expected to be private-sector driven include the following: achievement of self-sufficiency in fish production; modernization of the means of production, processing, marketing and resources conservation; ensuring total compliance with the FAO's Code of Conduct for Responsible Fisheries (CCRF), amongst others.

2.4 Importance of Fish Farming in the Nigerian economy

Fisheries occupy a unique position in the agricultural sector of the Nigerian economy. In terms of Gross Domestic Product (GDP), the fishery sub-sector has recorded the fastest growth rate in agriculture to the GDP. The contribution of the fishery sub-sector to GDP at 2001current factor cost rose from ₦76.76 billion to ₦162.61 billion in 2005 (CBN Report, 2005). Fish is an important source of protein to large teaming population of Nigeria. Fish provides 40% of the dietary intake of animal protein of the average Nigerian (FDF, 1997). According to Adekoya (2004), fish and fish products constitute more than 60% of the total protein intake in adults especially in rural areas. Amiengheme (2005) enumerated the importance of fish in Human Nutrition as follows:

- Food fish has a nutrient profile superior to all terrestrial meats (beef, pork and chicken, etc) being an excellent source of high quality animal protein and highly digestible energy;
- Fish is a good source of sulphur and essential amino acids such as lysine, leucine, valine and arginine. It is therefore suitable for supplementing diets of high carbohydrates contents;
- Fish is also a good source of thiamine as well as an extremely rich source of Omega-3 polysaturated fatty acids, fat soluble vitamins (A, D and E) and water soluble vitamins (B complex) and minerals (Calcium, Phosphorus, Iron, Iodine and Selenium);
- It has a high content of Polyunsaturated (Omega III) fatty acids, which are important in lowering blood cholesterol level and high blood pressure. It is able to mitigate to alleviate platelet of (cholesterol) aggregation and various arteriosclerosis conditions in adult populations;
- It reduces the risk of sudden death from heart attacks and reduces rheumatoid arthritis;

- Omega-3 fatty acids also lower the risk of age related muscular degeneration and vision impairment; and
- It reduces the risk of bowel cancer and insulin resistance in skeletal muscles.

Nigerians are large consumers of fish with demand estimate at 1.4 million metric tones. However, a demand supply gap of at least 0.7 million metric tones exists nationally with import making up the short fall at a cost of almost 0.5 billion US dollars per year. Domestic fish production of about 500,000 metric tones is supplied by artisan fisher – folk (85%), despite over fishing in many water bodies across the country (Adekoya, 2004). Nigeria has a land area of 923,768Km^2 with a continental shelf area of 47,934Km^2 and a length of coast line of 853Km. It also has a vast network of inland waters like rivers, flood plains, natural and man-made lakes and reservoirs (Shimang, 2005). The inland water mass was estimated to be about 12.5 million hectares of inland waters capable of producing 512,000 metric tons of fish annually (Ita,1984; and Shimang, 2005).

2.5 Prospects and Potentials of Catfish Production in Nigeria

Economic considerations in the selection of an appropriate aquaculture production system by the private sector include its potential for economic returns, its economic efficiency and ultimately, the farmer's access to operating capital (Hebicha et. al., 1994). According to Olasunkanmi (2012), Ugwumba (2011), Emokaro *et al.* (2010), Oladejo (2010), Kareem and Williams (2008), catfish farming is a profitable business. However, increasing production costs demand that catfish farms should be run more efficiently, given the level of technology, in order to boost production.

It has been estimated that Nigeria has the potential to produce over 4 million metric tons annually (FGN, 2011). According to the Federal Government of Nigeria, current production stands at about 0.78 metric tons with an estimated domestic demand of about 2.66 metric tons leaving an estimated shortfall of about 1.8 metric tons. This shortfall is supplemented by imports of frozen fish from Europe, Latin America and Eastern countries. According to the Federal Government of Nigeria, the country spent over N100 billion on the importation of over 780,000 metric tons of frozen fish in 2010. The shortfall of fish supply in the country has led to a low annual per capita fish consumption rate of only 7.5 kilogrammes as against 15 kilogrammes per annum as recommended by the Food and Agriculture Organization (FGN, 2011).

It is therefore crucial to increase domestic production in order to meet the shortfall between demand and supply, and to diversify the country's resources. However, the current challenges of rising costs of production require a focus on technically efficient production systems. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (that is, to be technically efficient), use the right mix of inputs in the light of the relative price of each input (that is, to be input allocative efficient) and produce the right mix of outputs given the set of prices (that is, to be output allocative efficient) (Kumbhaker and Lovell, 2000).

Catfish farming also plays a crucial role in driving the aquaculture sector in Nigeria by creating employment directly and indirectly to millions of people, helping to diversify the nation's resources, earn foreign exchange through potential export and help the country achieve the millennium development goals (MDGs). It also has the potential of contributing more to the gross domestic product (GDP) of the country.

2.6 Constraints to Sustainable Fisheries Development in Nigeria

In Nigeria, there are a number of constraints that pose significant challenges to the sustainable development of fisheries, including the following:

- Inadequate knowledge of the resource and ecosystem: Insufficient and weak scientific data lead to incomplete information and knowledge, and policies based on such data will remain incomplete.
- Non-interaction between the government and the stakeholders: Another crucial gap in Nigeria's fisheries policy is the complete absence of stakeholders' input during the policy formulation process (Godfray *et al* 2010). Experience shows that top-bottom approach to fisheries management does not yield the best results.
- Unavailability of financial resources to meet specific needs: According to Ajibefun (2002), Nigerian governments do not have an adequate appreciation of the social and economic potential of sustainable fisheries development, and hence still invest minimum resources in fisheries development and management activities. Budgetary allocations to Fishery Departments and Research Institutes are too meager to meet vital requirements such as research to update the laws with national fishery statistics and other relevant information; or vessels for policing the coastal zone to enforce existing laws.
- Weak agricultural policy and implementation: Agricultural policies are not specific and most do not have strategy, targets, goals, or specific objectives and

most importantly, do not include programmes or projects geared towards accomplishment of the goals. Policy implementation also requires enforcement by laws which indicate lack of strong political commitment on the part of government (Adekoya 2004).

- Inconsistency in policies and programmes: Agricultural programmes have undergone changes that tend to reflect changes in government or administration.
- Inadequate technical advisory/extension services: Kareem and Williams (2008) suggested that technical advisory or extension services which are intended to provide, teach and convince farmers to adopt and diffuse innovation are lacking. The participants/beneficiaries are not adequately educated on the goals of these programmes, which leads to their failure.
- Lack of monitoring and evaluation of programme/project: The philosophy of monitoring and evaluation of projects in Nigeria is lacking.

2.7 Environmental Impact of Fish Farming

Negative environmental impacts associated with aquaculture are of increasing concern due to the rapid growth and often unregulated aquaculture industry (Evans *et al.*, 2007). The authors indicate that aquaculture has been associated with a range of issues including habitat degradation, contaminated water systems, increases in fish diseases, and the introduction of alien species. These adverse effects have to be addressed in order to develop sustainable, end-user level aquaculture systems.

This view is supported by (Piedrantha, 2003), who states that aquaculture effluents may contain a variety of constituents that could cause negative impacts when released into the environment. (Piedrantha, 2003) goes further to give suggestions on how this environmental degradation can be addressed by reducing potential environmental impacts by facilitating effluent treatments e.g. solids removal operations produce a stream with high concentration of solids (the sludge removed from the flow) that is also rich in nutrients and organic matter, while reducing the concentrations of these parameters in the culture water. The stream with a high concentration of solids could be treated prior to disposal using techniques appropriate for high strength waste and sludge.

In a research conducted in China by (Ellis & Turner, 2007), it was found that China's waterways are highly polluted thus rendering food security a major concern for Chinese aquaculture. Besides municipal and industrial waste water contamination, mercury emissions from China's coal-fired power plants are another potential source of aquaculture contamination. International concern has cost China dearly since China supplies 70% of the tilapia imported into the United States and is also its fourth largest supplier of shrimp (Ellis & Turner, 2007). Further, countries have continued to ban species they discovered to be contaminated. The authors cite two major cases of the 2005 eel ban in Japan and the 2003 shrimp ban in the European Union. Chinese consumers are also increasingly concerned about water pollution, dangerous farming practices and poor processing in the aquaculture industry that pose serious threats to human health.

(Ellis and Turner, 2007) have identified the following environmental impacts causing concern worldwide in aquaculture:

1. Eutrophication and algae blooms-runoff of uneaten food and effluent from fish farms.

2. Antibiotics, pesticides and fungicides which are fed to fish and often misused to clear the water of other creatures, reduce parasites, control disease and boost weight gain on severely overcrowded animals. Antibiotics are not biodegradable and persist in the surrounding environment threatening wild fish stocks.
3. Habitat destruction – More natural bodies of fresh water are converted into fish farms with the rising demand for fish and therefore, diseases and pollution from overcrowded fish farms, are often pumped out into natural waterways, endangering native species.
4. Depleting wild fish stocks for feed – wild ocean fish are normally caught and pellets made to feed fish that are being farmed, especially shrimps. This can be very damaging to ocean habitats. It is estimated that it takes 2.8 pounds of wild fish to produce one pound of industrially-produced shrimp.
5. Monoculture and invasive species – a major challenge for aquaculture is the need for fast-growing species that can withstand the conditions of farms. Monoculture of these fast-growing fish can lead to a reduction in genetic diversity and make farms susceptible to diseases.

2.8 Definition and Types of Efficiency

Fried, Lovel and Schmidt (2008) have defined efficiency as a comparison between observed and optimal value of output and input. Efficiency is improved if more outputs are generated without changing inputs, or if the same outputs are generated with fewer inputs. According to Bravo-Ureta and Rieger (1993), substantial resources can be saved through efficiency measurement. The importance of efficiency was highlighted by

Ajibefun (2002) and Freid *et al.* (2008): “Firstly, it is a success indicator and performance measure by which production units are evaluated. Secondly, the exploring of hypothesis relating to the sources of efficiency differential can only be possible by measuring efficiency and separating its effects from the effects of the production environment. Thirdly, identification of sources of inefficiency is important to the public and private policies designed to enhance performance” (Ajibefun, 2002). In general, efficiency indicates the inputs-output relationship of the production function which defines the possible combinations of inputs and the resulting outputs. Recent measurement of farmer efficiency has been based on the seminal paper by Farrell (1957), who decomposed economic efficiency into its technical and allocative components. Economic efficiency is the product of technical and allocative efficiencies (Coelli, 1996, Coelli *et al.*, 2005). Technical efficiency refers to the ability of a producing unit to obtain maximum output from a given amount of inputs. Allocative (or price) efficiency refers to the ability of the firm to choose its inputs in a cost-minimizing manner (Murillo-Zamorano 2004; Chavas and Aliber, 1993). For allocative efficiency to hold, farmers must equalize their marginal returns with true factor market prices. Allocative efficiency in input involves selecting that mix of inputs which produce a given quantity of output at minimum cost (given the input prices) (Coelli *et al.*, 2005).

2.8.1 Measuring farm efficiency

As an introduction, some items in the literature on approaches to measuring farm efficiency are briefly presented here. Farm efficiency can be measured using Data Envelopment Analyses (DEA) or Stochastic Frontier (SF) methods, which involve mathematical programming and econometric methods respectively (Coelli *et al.*, 2005). These techniques are broadly categorized into two approaches: parametric and non-parametric. The parametric SF approach and the non-parametric DEA approach (Sarafidis, 2002) are the most popular techniques used in efficiency analysis. The two methods have their advantages and disadvantages. The advantages of the SF approach are that it takes into account random errors and random variables and permits statistical tests of hypotheses pertaining to production structure and degree of inefficiency (Coelli, Prasada and Battese, 1998). The SF approach is also appropriate for agricultural application, especially in developing countries where the data are heavily influenced by measurement errors and the effects of weather (Bekele, 2003).

2.8.2 Stochastic frontier production function

In the Stochastic frontier analysis (SFA), the error term is assumed to have two components parts V and U. The V covers the random effects (random errors on the production and they are outside the control of the decision unit) while the U measures the technical inefficiency effects, which are behavioural factors that come under the control of the decision unit. They are controllable errors if efficient management is put in place. The stochastic frontier analysis is generally preferred for agricultural research for the following reasons: the inherent variability of agricultural production due to inter play of weather, soil, pests, diseases and environmental factors and many firms are small family owned enterprise where keeping of accurate records is not always a priority hence available data on production are subject to measurement errors. The application of the stochastic frontier model for efficiency analysis include: Aigner, *et al.*, (1977) in which the model was applied to U.S. agricultural data. Battese and Corra (1977) applied the technique to the pastoral zone of eastern Australia. More recently, empirical analysis has been reported by Bravo-Ureta and Pinheiro (1993).

The stochastic frontier production function model is specified as Y= f(X_i,β)+e, where Y is output in a specified unit, X denotes the actual input vector, β is the vector of production function parameters and e is the error term that is decomposed into two components, V and U. the V is a normal random variable that is independently and identically distributed with zero mean and constant variance σ^2. It is introduced to capture the white noise in the production, which are due to factors that are not within the influence of the producers. It is independent of U the U is a non negative one sided truncation at zero with the normal distribution (Tadesse and Krishnamoorthy, 1977), it measures the technical inefficiency relative to the frontier production function, which is attributed to controllable factors (technical inefficiency). It is half normal, identically and independently distributed with zero mean and constant variance. The variance of the random errors (σ_v^2) and that of the technical inefficiency effects (σ_u^2) and overall model variance (σ^2) are related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$, and the ratio $\gamma = \sigma_u^2/\sigma_v^2$ is called Gama. Gama measures the total variation of output from the frontier, which can be attributed to technical inefficiency.

The technical efficiency of an individual firm is defined in terms of the observed output Yi to the corresponding frontier output Y_i^*. The Y_i^* is maximum output achievable given the existing technology and assuming 100% efficiency. It is denoted as: Y_i^* = f(Xij,β) +V that is TE= Yi / Y_i^*. Also the TE can be estimated by using the expectation of Ui conditioned on the random variable (V-U) as shown by Battese and Coelli 1988. That is TE = f(Xi,β) + V-U / f(Xi,β) +V and that $0 \leq TE \leq 1$.

2.8.3 Review of Empirical Studies on Efficiency Measurement Approaches and Efficiency Levels

Farm efficiency can be measured using Data Envelopment Analysis (DEA) (non-parametric) or Stochastic Frontier (SF) (parametric) methods, which involve mathematical programming and econometric methods, respectively (Sarafidis, 2002; Coelli *et al.*, 2005; Alene *et al.*, 2006).

Wadud and White (2000) studied the farm household efficiency of rice farmers in Bangladesh. They compared the SF and DEA methods. The results from the DEA revealed that the mean technical efficiencies estimated for the Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) assumptions are 0.79 and 0.86, which indicate that there was some inefficiency among rice farmers in the study area. The scale efficiency index of the sampled farmers ranged from 0.62 to 1.00. The mean scale efficiency was 0.92. Most of the farms exhibited mildly decreasing returns to scale under the SF, but increasing and dominantly decreasing returns to scale under the DEA. A comparison of the efficiency scores between the SF and DEA models showed that the VRS DEA is greater than that obtained from the SF and that estimated from CRS DEA approach. Greater variability exists in the CRS DEA and VRS DEA efficiency scores than the SF model. The researchers concluded that there was considerable inefficiency among the farmers and that agricultural output could be enhanced through the improvement of technical efficiency without resorting to technical improvements.

The technical and scale efficiency of rice farms in West Java was investigated by Brázdik (2006) who identified determinants affecting farms' efficiency. The researcher used a DEA model to estimate the technical efficiency scores; the results showed that the TE ranged from 0.60 to 0.77 (under the assumption of the time varying production possibility frontier). The average scale efficiency was 0.90. Farmers could reduce their inputs from 23% to 42% while maintaining the same output. Decreasing returns to scale existed among 77% of the farms. Size-efficiency relation showed an inverse relationship between farm size and productivity. Technical inefficiency was caused by the employment of technically inefficient production mixes and not because of size of farming operations.

According to Singha *et al.* (2012); Wang *et al*. (2011); Rousan (2007); Chirwa (2005), farmers with higher levels of education can easily learn n and understand the importance of technology from different sources. They are more receptive to other things and accept changes to the new innovation. Similarly, Shang *et al.* (1998); Onumah and Acquah (2011) stated that the improvement of formal education and intense sufficient services/training to fix the management capabilities of farmers will increase productivity and ensure the sustainability of farming activities. According to Ellis (1993), training for farmers is relatively low-cost method to achieve improved production efficiency.

Leila, A. S., Sahri, M., Nuhfil, H. and Luthfi, F. (2013), in the two-stage least square analysis of their study revealed that stock size and fertilizer method were the most significant among the variable inputs in the study area. The three variables were found to be significant at 5% and 10% levels of significance. It could be deduced that the use of inorganic fertilizers seemed to result in higher productivity of catfish output than that of organic fertilizers. In addition, the higher the stocking capacity the highest the productivity of the farm; the increase in stock size on the farm would result in increase in utilization of resources, especially the space. Therefore, stocking optimization should be the aim of every farmer in the study area.

According to Olasunkanmi (2012); Ugwumba (2011); Emokaro *et al*. (2010); Oladejo (2010); Kareem and Williams (2008), catfish farming is a profitable business. However, increasing production costs demand that catfish farms should be run more efficiently, given the level of technology, in order to boost production.

2.9 Concepts of Food Security

Food security is a flexible concept as reflected in the many attempts at definition in research and policy usage. Whenever the concept is introduced in the title of a study or its objectives, it is necessary to look closely to establish the explicit or implied definition (Maxwell, 2009). The continuing evolution of food security as an operational concept in public policy has reflected the wider recognition of the complexities of the technical and policy issues involved. The most recent careful redefinition of food security is that negotiated in the process of international consultation leading to the World Food Summit

(WFS) in November 1996. The contrasting definitions of food security adopted in 1974 and 1996, along with those in official FAO and World Bank documents of the mid-1980s are set out below with each substantive change in definition underlined. A comparison of these definitions highlights the considerable reconstruction of official thinking on food security that has occurred over 25 years. These statements also provide signposts to the policy analyses, which have re-shaped our understanding of food security as a problem of international and national responsibility. Food security as a concept originated only in the mid-1970s, in the discussions of international food problems at a time of global food crisis. The initial focus of attention was primarily on food supply problems - of assuring the availability and to some degree the price stability of basic foodstuffs at the international and national level. That supply-side, international and institutional set of concerns reflected the changing organization of the global food economy that had precipitated the crisis. A process of international negotiation followed, leading to the World Food Conference of 1974, and a new set of institutional arrangements covering information, resources for promoting food security and forums for dialogue on policy issues (ODI, 1997).

Food security is a condition related to the ongoing availability of food. Concerns over food security have existed throughout history. There is evidence of granaries being in use over 10,000 years ago, with central authorities in civilizations including Ancient China and Ancient Egypt being known to release food from storage in times of famine. Yet it was only at the 1974 World Food Conference that the term 'food security' was established as a formal concept. Originally, food security was understood to apply at the national level, with a state being food secure when there was sufficient food to "sustain a steady expansion of food consumption and to offset fluctuations in production and prices". A new definition emerged at 1996 World Food Summit; this time with the emphasis being on individuals enjoying food security, rather than the nation. According to the Food and Agriculture Organization (FAO), food security "exists when all people, at all times, have physical and k economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"(Raj Patel, 2013 and FAO, 1996).

Household food security exists when all members, at all times, have access to enough food for an active, healthy life. Individuals who are food secure do not live in hunger or fear of starvation (FAO, 2006). Food insecurity, on the other hand, is a situation of "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways", according to the United States Department of Agriculture (USDA) (Gary *et al.*, 2000). Food security incorporates a measure of resilience to future disruption or unavailability of critical food supply due to various risk factors including droughts, shipping disruptions, fuel shortages, economic instability, and wars. In the years 2011-2013, an estimated 842 million people were suffering from chronic hunger (FAO, WFP, IFAD, 2013). The FAO identified the four pillars of food security as availability, access, utilization, and stability (FAO, 2009). The United Nations (UN) recognized the Right to food in the Declaration of Human Rights in 1948, and has since noted that it is vital for the enjoyment of all other rights (United Nations, 1999).

The 1996 World Summit on Food Security noted that "food should not be used as an instrument for political and economic pressure". According to the International Centre for Trade and Sustainable Development, failed agriculture market regulation and the lack of anti-dumping mechanisms engenders much of the world's food scarcity and malnutrition. As of late 2007, export restrictions and panic buying, US Dollar Depreciation, increased farming for use in biofuels, world oil prices at more than $100 a barrel, global population growth, climate change, loss of agricultural land to residential and industrial development, and growing consumer demand in China and India are claimed to have pushed up the price of grain (BBC News, 2008). However, the role of some of these factors is under debate. Some argue the role of biofuel has been overplayed as grain prices have come down to the levels of 2006. Nonetheless, food riots have recently taken place in many countries across the world (Julian, 2008). Food security is a complex topic, standing at the intersection of many disciplines.

2.9.1 Measurement of Food Security

Food security indicators and measures are derived from country level household income and expenditure surveys to estimate per capita caloric availability (Webb *et al*. 2006). In general the objective of food security indicators and measures is to capture some or all of the main components of food security in terms of food availability, access and utilization or adequacy. While availability (production and supply) and utilization/adequacy (nutritional status/anthropometric measures) seemed much easier to estimate, thus more popular, access (ability to acquire sufficient quantity and quality) remain largely elusive (Perez *et al*. 2008). The factors influencing household food access are often context specific. Thus the financial and technical demands of collecting and analyzing data on all aspects of household’s experience of food access and the development of valid and clear measures remain a huge challenge (Swindale and Bilinsky, 2006). Nevertheless several measures have been developed that aim to capture the access component of food security, with some notable examples developed by the USAID-funded Food and Nutrition Technical Assistance (FANTA) project, collaborating with Cornell and Tufts University and Africare and World Vision (Ballard *et al.*, 2011). These include:

- *Household Food Insecurity Access Scale* (HFIAS) - continuous measure of the degree of food insecurity (access) in the household in the previous month
- *Household Dietary Diversity Scale* (HDDS) - measures the number of different food groups consumed over a specific reference period (24hrs/48hrs/7days).
- *Household Hunger Scale* (HHS)- measures the experience of household food deprivation based on a set of predictable reactions, captured through a survey and summarized in a scale.
- *Coping Strategies Index* (CSI) - assesses household behaviours and rates them based on a set of varied established behaviours on how households cope with food shortages. The methodology for this is base on collecting data on a single question "What do you do when you do not have enough food, and do not have enough money to buy food (Maxwell *et al*., 2008)?

2.10 Rates of Food Insecurity

With its prevalence of undernourishment (PoU) indicator, the FAO reported that almost 870 million people were chronically undernourished in the years 2010-2012. This represents 12.5% of the global population, or 1 in 8 people. Higher rates occur in developing countries, where 852 million people (about 15% of the population) are chronically undernourished. The report noted that Asia and Latin America have achieved reductions in rates of undernourishment that put these regions on track for achieving the Millennium Development Goal of halving the prevalence of undernourishment by 2015. The UN noted that about 2 billion people do not consume a sufficient amount of vitamins and minerals. In India, the second-most populous country in the world, 30 million people have been added to the ranks of the hungry since the mid-1990s and 46% of children are underweight (WHO, 2013).

2.11 World Summit on Food Security

The World Summit on Food Security held in Rome in 1996, aimed to renew a global commitment to the fight against hunger. The Food and Agriculture Organization of the United Nations (FAO) called the summit in response to widespread under-nutrition and growing concern about the capacity of agriculture to meet future food needs. The conference produced two key documents, the Rome Declaration on World Food Security and the World Food Summit Plan of Action (FAO, 1996). The Rome Declaration calls for the members of the United Nations to work to halve the number of chronically undernourished people on the Earth by the year 2015. The Plan of Action sets a number of targets for government and non-governmental organizations for achieving food security, at the individual, national, regional and global levels (Godfray *et al*., 2010).

2.11.1 Pillars of food security

The WHO states that there are three pillars that determine food security: food availability, food access, and food use. The FAO adds a fourth pillar: the stability of the first three dimensions of food security over time. In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization, and stability" (Gregory *et al.*, 2005).

2.11.2 Availability

Food availability relates to the supply of food through production, distribution, and exchange. Food production is determined by a variety of factors including land ownership and use; soil management; crop selection, breeding, and management; livestock breeding and management; and harvesting. Crop production can be impacted by changes in rainfall and temperatures. The use of land, water, and energy to grow food often competes with other uses, which can affect food production (Godfray *et al*., 2010). Land used for agriculture can be used for urbanization or lost to desertification, salinization, and soil erosion due to unsustainable agricultural practices. Crop production is not required for a country to achieve food security. Nations don't have to have the natural resources required to produce crops in order to achieve food security, as seen in the examples of Japan and Singapore (Tweeten, 1999).

Because food consumers outnumber producers in every country, food must be distributed to different regions or nations. Food distribution involves the storage, processing, transport, packaging, and marketing of food. Food-chain infrastructure and storage technologies on farms can also impact the amount of food wasted in the distribution process. According to Godfray *et al*. (2010), poor transport infrastructure can increase the price of supplying water and fertilizer as well as the price of moving food to national and global markets. Around the world, few individuals or households are continuously self-reliant for food. This creates the need for a bartering, exchange, or cash economy to acquire food. The exchange of food requires efficient trading systems and market institutions, which can have an impact on food security. Per capita world food supplies are more than adequate to provide food security to all, and thus food accessibility is a greater barrier to achieving food security (Tweeten, 1999).

2.11.3 Access

Food access refers to the affordability and allocation of food, as well as the preferences of individuals and households (Gregory *et. al.*, 2005). The UN Committee on Economic, Social, and Cultural Rights noted that the causes of hunger and malnutrition are often not a scarcity of food but an inability to access available food, usually due to poverty. Poverty can limit access to food, and can also increase how vulnerable an individual or household is to food price spikes. Access depends on whether the household has enough income to purchase food at prevailing prices or has sufficient land and other resources to grow its own food. Households with enough resources can overcome unstable harvests and local food shortages and maintain their access to food (Ecker and Breisinger, 2012).

There are two distinct types of access to food: direct access, in which a household produces food using human and material resources, and economic access, in which a household purchases food produced elsewhere. Location can affect access to food and which type of access a family will rely on. The assets of a household, including income, land, products of labor, inheritances, and gifts can determine a household's access to food. However, the ability to access to sufficient food may not lead to the purchase of food over other materials and services (Garrett and Ruel, 1999). Demographics and education levels of members of the household as well as the gender of the household head determine the preferences of the household, which influences the type of food that are purchased. A household's access to enough and nutritious food may not assure adequate food intake of all household members, as intra-household food allocation may not sufficiently meet the requirements of each member of the household. The USDA adds that access to food must be available in socially acceptable ways, without resorting to emergency food supplies, scavenging, stealing, or other coping strategies (USDA, 2008).

2.11.4 Utilization

The final pillar of food security is food utilization, which refers to the metabolism of food by individuals. Once food is obtained by a household, a variety of factors impact the quantity and quality of food that reaches members of the household. In order to achieve food security, the food ingested must be safe and must be enough to meet the physiological requirements of each individual. Food safety impacts food utilization, and can be impacted by the preparation, processing, and cooking of food in the community and household. Nutritional values of the household determine food choice. Access to healthcare is another determinant of food utilization, since the health of individuals controls how the food is metabolized. For example, intestinal parasites can take nutrients from the body and decrease food utilization. Sanitation can also decrease the occurrence and spread of diseases that can affect food utilization. Education about nutrition and food preparation can impact food utilization and improve this pillar of food security (Ecker and Breisinger, 2012).

2.11.5 Stability

Food stability refers to the ability to obtain food over time. Food security can be transitory, seasonal, or chronic. In transitory food insecurity, food may be unavailable during certain periods of time. At the food production level, natural disasters and drought result in crop failure and decreased food availability. Civil conflicts can also decrease access to food (Ecker and Breisinger, 2012). Instability in markets resulting in food-price spikes can cause transitory food insecurity. Other factors that can temporarily cause food insecurity are loss of employment or productivity, which can be caused by illness. Seasonal food insecurity can result from the regular pattern of growing seasons in food production (FAO, 1997).

According to Ecker and Breisinger (2012), chronic (or permanent) food insecurity is defined as the long-term, persistent lack of adequate food. In this case, households are constantly at risk of being unable to acquire food to meet the needs of all members. Chronic and transitory food insecurity is linked, since the reoccurrence of transitory food security can make households more vulnerable to chronic food insecurity.

2.12 Effects of Food Insecurity and Measurement

Famine and hunger are both rooted in food insecurity. Chronic food insecurity translates into a high degree of vulnerability to famine and hunger; ensuring food security presupposes elimination of that vulnerability (Ayalew, 2009). Food insecurity is measured in the United States by questions in the Census Bureau's Current Population Survey. The questions asked are about anxiety that the household budget is inadequate to buy enough food, inadequacy in the quantity or quality of food eaten by adults and children in the household, and instances of reduced food intake or consequences of reduced food intake for adults and for children. A National Academy of Sciences study commissioned by the USDA criticized this measurement and the relationship of "food security" to hunger, adding "it is not clear whether hunger is appropriately identified as the extreme end of the food security scale" (IFAD, 2012).

The FAO, World Food Programme (WFP), and International Fund for Agricultural Development (IFAD) collaborate to produce The State of Food Insecurity in the World. The 2012 edition described improvements made by the FAO to the prevalence of undernourishment (PoU) indicator that is used to measure rates of food insecurity. New features include revised minimum dietary energy requirements for individual countries, updates to the world population data, and estimates of food losses in retail distribution for each country. Measurements that factor into the indicator include dietary energy supply, food production, food prices, food expenditures, and volatility of the food system. The stages of food insecurity range from food secure situations to full-scale famine (Ayalew, 2013).

2.13 Challenges to Achieving Food Security

2.13.1 Global water crisis

Water deficits, which are already spurring heavy grain imports in numerous smaller countries, may soon do the same in larger countries, such as China or India (Garrett and Ruel, 1999). The water tables are falling in scores of countries (including northern China, the US, and India) due to widespread over pumping using powerful diesel and electric pumps. Other countries affected include Pakistan, Afghanistan, and Iran. This will eventually lead to water scarcity and cutbacks in grain harvest. Even with the over pumping of its aquifers, China is developing a grain deficit. When this happens, it will almost certainly drive grain prices upward. Most of the 3 billion people projected to be born worldwide by mid-century will be born in countries already experiencing water shortages. After China and India, there is a second tier of smaller countries with large water deficits – Afghanistan, Algeria, Egypt, Iran, Mexico, and

Pakistan. Four of these already import a large share of their grain. Only Pakistan remains self-sufficient. But with a population expanding by 4 million a year, it will likely soon turn to the world market for grain (Molden, 2007).

Regionally, Sub-Saharan Africa has the largest number of water-stressed countries of any other place on the globe and as of an estimated 800 million people who live in Africa, 300 million live in a water stressed environment (Molden, 2007). It is estimated that by 2030, 75 million to 250 million people in Africa will be living in areas of high water stress, which will likely displace anywhere between 24 million and 700 million people as conditions become increasingly unlivable. Because the majority of Africa remains dependent on an agricultural lifestyle and 80% to 90% of all families in rural Africa rely upon producing their own food, water scarcity translates to a loss of food security.

Multimillion dollar investments beginning in the 1990s by the World Bank have reclaimed desert and turned the Ica Valley in Peru, one of the driest places on earth, into the largest supplier of asparagus in the world. However, the constant irrigation has caused a rapid drop in the water table, in some places as much as eight meters per year, one of the fastest rates of aquifer depletion in the world. The wells of small farmers and local people are beginning to run dry and the water supply for the main city in the valley is under threat. As a cash crop, asparagus has provided jobs for local people, but most of the money goes to the buyers, mainly the British. A 2010 report concluded that the industry is not sustainable and accuses investors, including the World Bank, of failing to take proper responsibility for the impact of their decisions on the water resources of poorer countries (Felicity, 2010). Diverting water from the headwaters of the Ica River to asparagus fields has also led to a water shortage in the mountain region of Huancavelica, where indigenous communities make a marginal living herding (Felicity, 2010).

2.13.2 Land degradation

Intensive farming often leads to a vicious cycle of exhaustion of soil fertility and decline of agricultural yields. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa (Ian, 2007).

2.13.3 Climate change

Extreme events, such as droughts and floods, are forecast to increase as climate change takes hold. Ranging from overnight floods to gradually worsening droughts, these will have a range of impacts on the agricultural sector. By 2040, almost the entire Nile region, which once included large areas of irrigated agricultural land, is expected to become hot desert where cultivation is impossible due to water limitation (Singh, 2004). According to the Climate & Development Knowledge Network report *Managing Climate Extremes and Disasters in the Agriculture Sectors: Lessons from the IPCC SREX Report*, the impacts will include changing productivity and livelihood patterns, economic losses, and impacts on infrastructure, markets and food security. Food security in future will be linked to our ability to adapt agricultural systems to extreme events. For example, the Garifuna women in Honduras are helping to ensure food security locally by reviving and improving production of traditional root crops, building up traditional methods of soil conservation, carrying out training in organic composting and pesticide use and creating the first Garifuna farmers' market. Sixteen towns have worked together to establish tool and seed banks. Efforts to plant wild fruit trees along the coast are helping to prevent soil erosion. The aim is to reduce the communities' vulnerability to the hazards of shifting weather patterns (Fraser, 2007).

Approximately 2.4 billion people live in the drainage basin of the Himalayan Rivers. India, China, Pakistan, Afghanistan, Bangladesh, Nepal and Myanmar could experience floods followed by severe droughts in coming decades. In India alone, the Ganges provides water for drinking and farming for more than 500 million people. The west coast of North America, which gets much of its water from glaciers in mountain ranges such as the Rocky Mountains and Sierra Nevada, also would be affected (Robin and Rice 2007). Glaciers aren't the only worry that the developing nations have; sea level is reported to rise as climate change progresses, reducing the amount of land available for agriculture. In other parts of the world, a big effect will be low yields of grain according to the World Food Trade Model, specifically in the low latitude regions where much of the developing world is located. From this the price of grain will rise, along with the developing nations trying to grow the grain. Due to this, every 2–2.5% price hike will increase the number of hungry people by 1%. Low crop yields are just one of the problem facing farmers in the low latitudes and tropical regions. The timing and length of the growing seasons, when farmers plant their crops, are going to be changing dramatically, per the USDA, due to unknown changes in soil temperature and moisture conditions (Fraser, 2007).

2.14 Review of Empirical Studies on Food Security Measurement Approaches and Food Security Statuses

According to Agbola (2005), the use of the term "food security" at the national (and global) level has been often focused on issues on supply side of the food equation and particularly a country's ability to provide enough food to meet the needs or demands to the population either through domestic production or food imports.

Agbola (2005), in his study on the Analysis of Food Insecurity and Coping Strategies among Farming Households in Osun State reported that based on the recommended daily calorie intake of 2260 kcal, 82% of the households were food secure and 18% were food insecure for households that combined crop with livestock production. Land size owned by household heads was found to have significant and positive relationship with food security status of households suggesting the larger the land size, the better food secure state of the household. The possible explanation is that the major source of food in the study area comes from own production and there was limited access to other means of income generating activities. So the household who have large size of cultivated land has better production which gives a better chance for the household to be food secured (Agbola, 2005).

Ahmed (2015), in his study found improved seed to have significant positive effect with the food security status of households. Households using improved seed are more likely to be food secure than those who did not apply. Improved seed and other technological inputs help farmers to augment productivity and to boost production. Farmers can enhance their production by using high yielding varieties and other complementary farm. He also found non-farm income to have significant and positive relation with the food security status of the household indicating farmers engaged in non-farm activities have better chance to be food secure. This might be due to the fact that households engaged in non-farm activities are better endowed with additional income and more likely to escape food insecurity.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study was carried out in the Federal Capital Territory (FCT), Abuja which lies between latitudes 8°25` and 9°25` N and longitudes 6°45` and 7°45` E (NPC, 2006). It has boundaries with Nasarawa State to the east and southeast, Niger State to the west and northwest, Kaduna State to the northeast and Kogi State to the southwest. Its capital, Abuja, is also the capital of Nigeria. The FCT was originally part of Niger, Nasarawa and Kogi states. It was established in 1976 by the Federal Capital Territory Act of the military government of General Murtala Muhammed. Abuja comprises of six (6) area councils namely; Abaji, Bwari, Gwagwalada, Kuje, Kwali and Abuja Municipal.

The Federal Capital Territory covers an area of 7,753.9 square kilometers (National population commission, 2006) the vegetation combines the best features of the southern tropical rain forest and guinea savanna of the north. It has a population of 1,406,239 (2006 census figures) with a 2014 projected population of 1,804,264 using a growth rate of 3.6% as allowed by National Population Commission (2006). Rainfall is moderate with a mean annual rainfall of 131,75cm. It has two distinctive seasons, dry and raining seasons. The average rainfall is 1300mm. Over 80% of the entire population is engaged in agriculture especially in the area of crop production, fisheries and livestock production. Catfish farmers make a significant contribution to the fish consumption of households and economy of the state through the presence of about 1209 registered catfish farmers in the Federal Capital Territory. (FMARD, 2005).

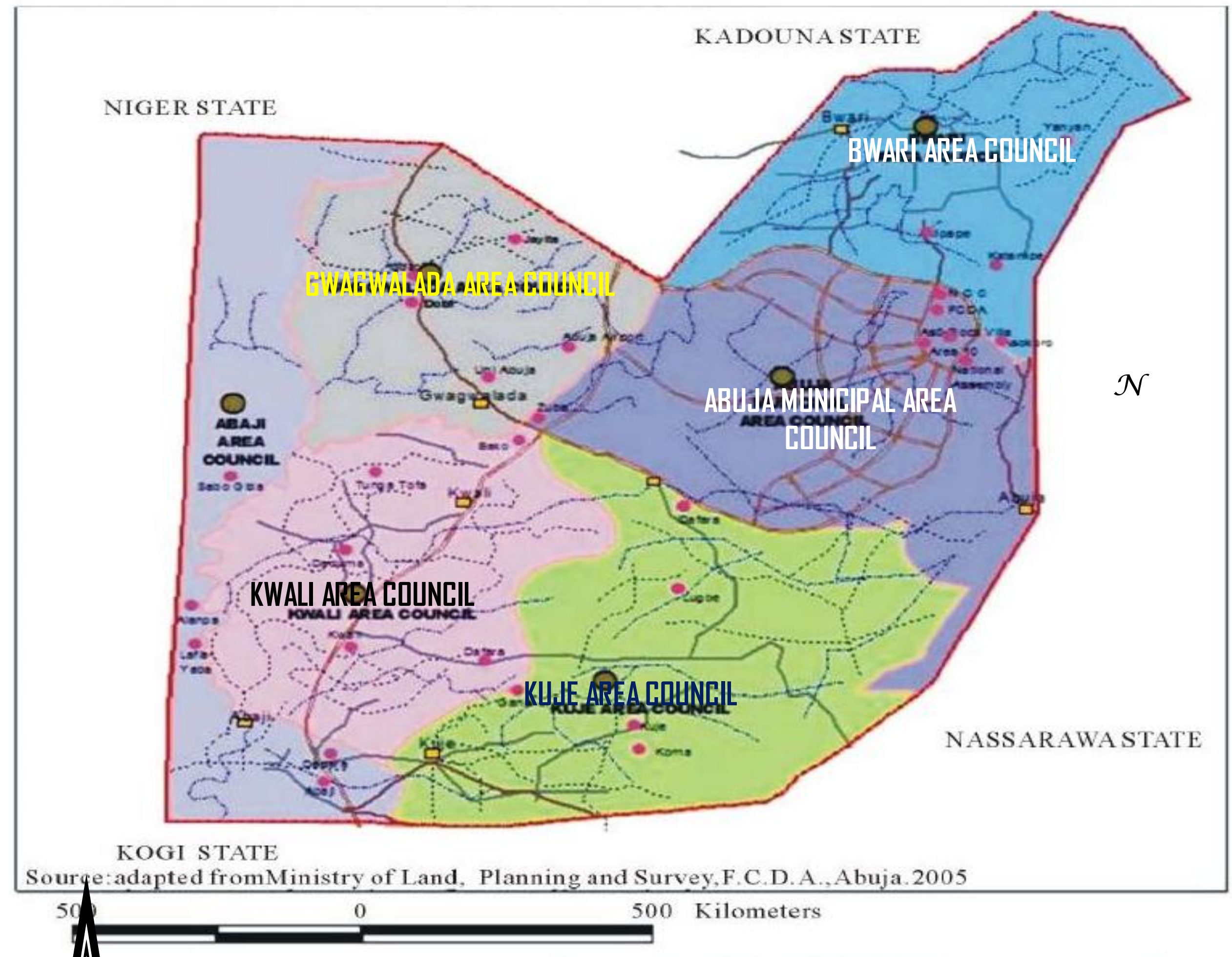

Figure [illegible]. Map of FCT, Abuja showing the study area

3.2 Sampling Procedure and Sample Size

The study was conducted in the Federal Capital Territory, Abuja. A multistage sampling technique was adopted in selecting the respondents for this study. In the first stage, two area councils were purposively selected (Gwagwalada and Kuje area councils). This is because they are notable for high production of catfish in the Federal Capital Teritory

(FCT), Abuja. Gwagwalada area council consists of ten wards namely: Central quarters, Ibuwa, Paiko, Gwako, Dobi, Ikwa, Zuba, Kutunku and Tunga Mage. Kuje area council consists of fifteen wards namely: Kwaku, Kuje, Rubochi, Gwargwada, Kujekwa, Gaube, Tukpeki, Yenche, Dibe, Agwai, Barayi, Kebi, Huni, Ukuya, and Gudunkarya. In the second stage, two wards from Gwagwalada area council and three wards from Kuje area council each were purposively selected due to presence of large number of catfish farms. These wards include: Gwako, Zuba from Gwagwalada area council and Kuje, Rubochi, Gwargwada from Kuje area council respectively. Finally, 20% of catfish farmers were randomly selected from each of the compiled list of catfish farmers from the wards giving a total of 155 catfish farmers for the study. The services of Local Government agriculture and fisheries officers and extension agents facilitated the selection.

Table 3.1**:** Distribution of respondents in the Study Area

Area Councils	Wards	Sample Frame	Sample Size (20%)
Gwagwalada	Gwako	127	25
	Zuba	181	36
Kuje	Kuje	205	41
	Rubochi,	154	31
	Gwargwada	107	21
Total	**5**	**774**	**155**

Source: Reconnaissance survey (2014).

3.3 Data Collection Techniques

Data were collected from primary sources. Primary data were collected using structured questionnaire which was administered on the respondents. The data collected during field survey were on the socioeconomic characteristics such as age, gender, household size, farm size, farming experience, income, and level of education. Data on catfish production, cost and returns, constraints to catfish production, income and expenditure of the household were also collected.

3.4 Analytical Techniques

The analytical tools employed to achieve the objectives and hypotheses of the study include descriptive statistics, net farm income, stochastic frontier production function analysis (SPF), food insecurity line and Z-statistic.

3.4.1 Descriptive statistics

The descriptive statistics such as frequency distribution, mean, percentage, minimum and maximum were used to achieve objectives i, and vi of the study.

3.4.2 Budgeting technique

Budgeting technique was used to achieve objective ii of this study. The indicators used include Net farm Income (NFI) and profitability index. NFI is expressed as:

$NFI = \sum P_{Yi} Y_i - \sum P_{Xj} X_j - \sum Fk$---(1)

Where:

NFI = Net farm Income (₦)/production cycle;

P_{Yi} = unit price of the output of catfish (₦)

Y_i = Total output of catfish (kg);

P_{Xj} = Unit price of variable inputs (₦)

X_j = Quantity of variable inputs (where j = 1,2,3……n)

F_k = Cost of fixed inputs (₦) (where k = 1,2,3…….n)

Σ = summation sign.

3.4.3 Stochastic production frontier analysis

The stochastic frontier function used by Onu *et al.* (2000) and Parikh and Shah (1995) as derived from the error model of Aigner, Lovell and Schmidt (1977) was employed to achieve objectives iii and iv of this study. The Cobb-Douglas production function was fitted to the frontier model of catfish production. The result was estimated using the maximum likelihood method. The stochastic frontier production function is written as:

$Y_i = f(X: \beta) + e_i$--2

$e_i = V_i – U_i$ --3

Where:

Y_i = Output of the i^{th} farm

X_i = Vector of inputs used by the i^{th} farm

B = A vector of the parameters estimated

e_i = Composite error term

V_i = Random error outside farmer's control

U_i = Technical inefficiency effects

The empirical stochastic frontier model that was employed is specified as follows:

$In\ Y1 = \beta_0 + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \beta_3 InX_{3i} + \beta_4 InX_{4i} + \beta_5 InX_{5i} + \beta_6 InX_{6i} + V_i - U_i$-------------4

Where;

Subscripts ij refer to the jth observation of ith farmer,

In =Logarithm to base e,

Y = Output of catfish (kg)

β_0 = Constant

$\beta_1 - \beta_6$ = Parameters estimated

X_1 = Fingerlings (Number)
X_2 = Fish feed (kg)
X_3 = Labour (Man-days)
X_4 = Drugs (₦)
X_5 = Fuel (Litres)
X_6 = Pond size (m^2)
V_i = Random noise (white noise)
U_i = Inefficiency effect which are non negative with half normal distribution.

It is assumed that inefficiency effects are independently distributed and Uij arises by truncation (at zero) of the normal distribution with mean Uij and variance δU^2 where Uij is specified as;

$U_i = \delta_0 + \delta_1 InZ_{1i} + \delta_2 InZ_{2i} + \delta_3 InZ_{3i} + \delta_4 In\ Z_{4i} + \delta_5 In\ Z_{5i} + \delta_6 In\ Z_{6i}$---------------------------5

Where;

Ui = Inefficiency effect of catfish production

δ_0 = Constant

$\delta_1 - \delta 6$ = Parameters to be estimated

Z_1 = Farmer's age (years)

Z_2 = Household size of farmer (number)

Z_3 = Years of formal education of the farmer (years)

Z_4 = Years of farming experience of the farmer in catfish production (years)

Z_5 = Number of years in cooperative society (years)

Z_6 = Number of contacts with extension agents (measured as number of contacts in a year)

Allocative Efficiency (AE)

The allocative efficiency also known as cost efficiency was determined using the cost frontier dual to the production frontier expressed as follows;

$\ln C_i = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + V_i + U_i$-----------------6

Where:

C_i = Total cost of production (₦)

b_0 = Intercept

X_1 = Cost of fingerlings (₦)

X_2 = Cost of fish feed (₦)

X_3 = Cost of labour (₦)

X_4 = Cost of Drugs (₦)

X_5 = Cost of Fuel (₦)

X_6 = Cost of Transportation (₦)

X_7 = Output of catfish (Kg)

$b_1 – b_6$ = Vector cost parameters to be estimated

V_i = Random variability in the cost of production that cannot be influenced by the farmer

U_i = Cost inefficiency effects of catfish production.

Economic Efficiency (EE): Economic efficiency is the product of technical (TE) and allocative efficiency (AE) (Coelli, 1996, Coelli *et al.*, 2005). Based on the technical and allocative efficiency the economic efficiency was estimated using the following equation:

$\mathbf{EE_i} = TE_i * AE_i$--7

Where:

EE_i = Economic efficiency,

TE_i = Technical efficiency, and

AE_i = Allocative efficiency

3.4.4 Food security line

Food security line was used to achieve part of objective v. It was used to classify farmers into either food secure or insecure depending on which side of the line they fall. The food security line was the recommended daily per capita calorie intake of 2,260 kilo calories (Babatunde, 2007). In this study, a one month (30 days) recall method was used. The food security line of daily 2260 kcal by FAO (1996) was adopted in this study. The household's calorie intake was obtained through the household's consumption and expenditure data. From the data, the quantity of every food item consumed by the households in the 30 days was estimated and converted to gram and the calorie content estimated using the nutrient composition table of commonly eaten foods in Nigeria (Oguntona and Akinyele, 1995). Per capita calorie intake was calculated by dividing total household calorie intake by the family size after adjusting for adult equivalent using the consumption factors for age-sex categories. To get daily per capita calorie intake, the household's per capita calorie intake was divided by 30. A household whose daily per capita calorie intake is up to 2260 kcal was regarded as food secure and those below 2260 kcal were regarded as food insecure households. The food insecurity line is given as:

$$Z = {Y_i}/{R} \quad \text{------------------------------} 8$$

Where:

Zi = food security status of ith farmers.

Yi = daily per capita calorie intake of ith farmers

R = recommended per capita daily calorie intake (2260Kilo calorie)

3.4.5 Z – Test statistic

Z-test was used to achieve objective iv and to test hypothesis (iii). It is used for large sample greater than thirty (30). Z-test model was used in the study to compare the differences in food security status of the farmers before and after going into catfish production in the study area. The average calorie intake was used as proxy for food security status. The Z-statistic is expressed as follows:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \text{ -------------------- } 9$$

$\bar{X}_1$ = Mean calorie intake of farmers with catfish production

$\bar{X}_1$ = Mean calorie intake of farmers without catfish production

S_1 = Standard deviation of farmers with catfish production

S_2 = Standard deviation of farmers without catfish production

n_1 = Sample size of farmers with catfish production

n_2 = Sample size of farmers without catfish production

CHAPTER FOUR

RESULTS AND DISCUSSION OF THE STUDY

4.1 Socio-Economic Characteristics of the Farmers

A total of 155 farmers were involved in the study, socioeconomic characteristics of catfish farmers were considered because of their perceived effects on the agricultural activities of farmers. Table 4.1 summarizes socio-economic characteristics.

4.1.1 Age distribution of catfish farmers

Findings from the study (Table 4.1) reveal that majority (43.8%) of the respondents were within the age bracket of 33–45 years. 7% of the respondents were 58 years and above with a mean age of 42 years. This has the potential to provide labor on the farms since most of the farm operations by small scale farmers in Nigeria are still carried out manually using low technology. This is in line with the findings of Olowosegun *et al.* (2004), that an economically active age portends better future for catfish production.

4.1.2 Education of household head

Findings from the study (Table 4.1) revealed that 14% had no formal education while 30%, 25% and 31% of the respondents had primary, secondary and tertiary education respectively. This means that fish farming is dominated by the educated class and mostly by those armed with high level of education. This is so because fish farming requires a lot of technical and scientific knowledge to be successfully undertaken. Their educational status as it is however, enough to provide them with the ability to read and write, handle and interpret messages relating to their farm operation in the instruction manuals on input and machinery uses, and also enable them to appreciate extension services. Sullumbe, (2004) opined that education is a major determinant of the nation's economy.

Table 4.1: Distribution of respondents according to socio-economic characteristics

Characteristics	Frequency	Percentage
Age of the farmer (Years)		
20-32	46	29.68
33-45	68	43.87
46-58	30	19.35
>58	11	7.10
Mean = 42 years		
Education of household head		
No formal education	22	14.19
Primary	46	29.68
Secondary	39	25.16
Tertiary	48	30.97
Household size		
1-7	24	15.48
8-14	86	55.48
>14	45	29.03
Farming Experience (Years)		
1-9	63	40.65
10-18	79	50.97
>18	13	8.39
Cooperative society (years)		
<1	94	60.65
1-5	31	20.00
6-11	13	8.39
>11	17	10.97
Mean = 6		
Extension Contact		
1-3	87	56.13
4-7	45	29.03
>7	23	14.84
Total	**155**	**100.00**

Source: Computed from field survey data, 2014.

4.1.3 Household size

The distribution of household sizes of the respondents in Table 4.1 reveals that majority 55.5% of the respondents had household sizes between 8 and 14. Although large family size can sometimes be an asset to the farmers in terms of available work force/labor, often time a farmer is faced with the challenges of providing social and welfare facilities such as feeding, education, sheltering, health care and other living expenses for such a large number of dependants.

4.1.4 Farming experience of the respondents

The distribution in Table 4.1 shows that majority (51%) fell within the range of 10 – 18 years experience in catfish farming and this shows that the managerial ability of the farmers can be inferred to be reasonably good. In line with the findings of Mbanasor and Kalu (2008) as well as Obare *et al.* (2010), years of farming experience has a positive and significant relationship with a farmer's economic efficiency. This implies that the higher the level of experience of the farmer, the higher his cost efficiency level will be.

4.1.5 Cooperative society membership

The study as shown in Table 4.1 reveals that less than half (39%) of the respondents were members of cooperative societies and had spent various years with a mean of 6 years spent in cooperative organization. Naturally, being members of associations afforded catfish farmers to benefit from financial institutions and/or lending agencies since such requirement is the determinant factor. Farmers who belong to cooperatives are better informed on resource use and farm planning which enables them to utilize resources more efficiently. Membership of cooperative organizations is expected to have a positive influence on allocative efficiency (Obare *et al.*, 2010).

4.1.6 Extension contact

Extension contact in a year, according to the study in Table 4.1, reveals that majority (56%) of the respondents had extension visits. Through extension visits, farmers become better informed about farm management planning and new technologies, hence improving their efficiency in production. Mbanasor and Kalu (2008) in their study found that the number of extension visits had a significant positive relationship with economic efficiency of commercial vegetable farmers in Akwa Ibom State, Nigeria.

4.2 Profitability Analysis of Catfish Farming

Estimates of costs and returns were made from fish farming using average cost (fixed and variable) and yield data generated from each of the sampled fish farmers per cropping season. The cost and return analysis in Table 4.2, reveals that the variable cost accounted for the largest proportion (75.97%) of the total cost of fish farming in the study area. This shows that large amount of money spent by fish farmers' in the study area was majorly for purchase of fish feeds and fingerlings. The fixed cost of production consists of cost of land (depreciation on rent), water pump, concrete tanks, earthen pond, deep well, generator, building/shed, drag net, wheel barrow etc which accounted for 24.03% of the total cost. Also, the result shows that an average total cost (TC) of ₦1,520,204.24 was incurred while total revenue (TR) of ₦2,873,521.29 was realized with a gross margin (GM) of ₦1,718,616.84 and a net farm income (NFI) of ₦1,353,317.05 with a rate of return of 1.89 which implies that for every ₦1.00 invested, ₦1.89kobo was gained by the respondents. This result is consistent with the finding of Ashaolu *et al*. (2006) who observed that fish farming is profitable**.**

Table 4.2: Costs and returns of catfish farming in the study area

Items	**Amount (₦)**	**%Total Cost**
Variable Cost		
Fish Feed	958,456.11	63.05
Fish seed	101,801.51	6.70
Lime/Fertilizer	3,473.18	0.23
Labour	40,296.28	2.65
Fuel	19,314.29	1.27
Transportation	17,351.08	1.14
Others	14,212.00	0.93
Total Variable Cost	**1,154,904.45**	**75.97**
Fixed Cost		
Land purchase/rent	20,221.23	1.33
Water pump	8,378.69	0.55
Concrete tanks	54,154.59	3.56
Deep well	21,570.00	1.42
Earthen pond	26,514.11	1.74
Plumbing materials	3,010.45	0.20
Building/Shed	169,856.00	11.17
Generator	45,761.00	3.01
Drag net/Weighing Scale/Cutlass	10,694.62	0.70
Wheel barrow/ Shovel/Bowls	5,139.10	0.34
Total Fixed Cost	**365,299.79**	**24.03**
Total Cost	**1,520,204.24**	**100.00**
Total Revenue	**2,873,521.29**	
Gross Margin	**1,718,616.84**	
Net Farm Income	**1,353,317.05**	
Rate of Return	**1.89**	

Source: Computed from field survey data, 2014.

4.3 Stochastic Frontier Analysis

4.3.1 Stochastic frontier production function analysis of catfish production

The estimates of the parameters of the stochastic production frontier of the elasticity of output with respect to the various inputs in catfish production (Table 4.3) reveal that the coefficient estimates of fingerlings, fish feed and fuel were positive and statistically significant ranging from 1% to 5% levels of probability. This implies that increase in these variables (fingerlings, fish feed and fuel) with positive coefficients will lead to increase in the output of catfish production. The coefficient estimate of pond size was negative and was statistically significant at 5% level of probability which implies that an increase in this variable will lead to a decrease in total output. This may be caused by low stocking density of the ponds. The σ^2 (0.68) and $\boldsymbol{\gamma}$ **(**0.42**)** were significantly different from zero at 1% levels of probability. The sigma squared (0.68) was significantly different from zero at 1%. This indicates a good fit and correctness of the distribution form assumed for the composite error term. The gamma estimate, which was 0.42, shows the amount of variation in output resulting from the technical inefficiencies of the farmers. This means that 42% of the variation in the output of catfish farmers was due to technical inefficiency.

Table 4.3: Maximum likelihood estimates of stochastic frontier production function of catfish farming in the study area

Variables	Coefficients	Standard Error	T-ratio
Constant	11.5763***	3.9502	2.9306
Fingerlings (Number)	4.1301***	1.6818	2.4558
Fish Feed (kg)	0.2054**	0.0972	2.1132
Labour (Man-days)	0.0963	0.0691	1.3936
Drugs (₦)	0.0417	0.0223	1.4700
Fuel (Litres)	3.0747***	0.9864	3.1171
Pond size (m^2)	-0.2106**	0.0975	-2.1600
Variance parameters			
Sigma-squared ($\boldsymbol{\sigma^2}$)	0.6804***	0.1082	6.2884
Gamma (γ)	0.4231**	0.2108	2.0071
log likelihood	104.6646		
Number of observations (n) = 155			

Source: Computed from field survey data, 2014.
***P<0.01 ** P<0.05 *P<0.10

4.3.2 Stochastic frontier cost function analysis of catfish production

The estimated parameters for the stochastic cost frontier for catfish production presented in Table 4.4 reveal that σ^2 (0.86) and **γ** **(**0.32**)** were significantly different from zero at 1% level of probability. The sigma squared (0.86) was significantly different from zero at 1% which indicates a good fit and correctness of the distribution form assumed for the composite error term. The gamma estimate, which was 0.32, shows the amount of variation in the total cost of production resulting from the allocative efficiencies of the farmers. This means that 32% of the variation in the total cost of production of catfish farmers was due to allocative efficiency. The coefficient estimates of the costs of fingerlings, feed, transportation and output of catfish were positive and were statistically significant ranging from 1% to 10% levels of probability respectively. This implies that the costs of these inputs significantly influenced the cost of catfish production in the area.

Table 4.4: Stochastic frontier cost Function of catfish farmers

Variables	**Coefficients**	**Standard Error**	**T-ratio**
Constant	0.5763***	0.0862	6.6856
Cost of Fingerlings (₦)	1.2844*	0.7187	1.7871
Cost of Fish feed (₦)	0.7214***	0.0653	11.0475
Cost of Labour (₦)	0.4163	0.3581	1.1625
Cost of Drugs (₦)	0.2847	0.1689	1.6856
Cost of Fuel (₦)	0.0747	0.0810	0.9222
Cost of Transportation(₦)	0.2106*	0.1059	1.9887
Output of Catfish (kg)	1.0647***	0.2241	4.7510
Variance parameters			
Sigma-squared ($\boldsymbol{\sigma}^2$)	0.8604***	0.1983	4.3389
Gamma (γ)	0.3242***	0.0438	7.4018
Log likelihood	-19.2069		
Number of observations (n) = 155			

Source: Computed from field survey data, 2014.
***P<0.01 ** P<0.05 *P<0.10

4.3.3 Frequency distribution of technical, allocative and economic efficiency estimates

4.3.3.1 Frequency distribution of technical efficiency scores of catfish farmers

It was observed from the study that 15% of the farmers possess efficiency levels between the range of 0.10 – 0.20, about 11% of the farmers possess efficiency which ranged from 0.21 – 0.30, 18% of the farmers possess efficiency range of 0.31 – 0.50, while about 56% of the farmers were able to achieve efficiency level above 0.50. The best farmer demonstrated a technical efficiency of 0.93 while the worst farmer had a technical efficiency of 0.11 with a mean efficiency score for the catfish farms as 0.67 as shown in Table 4.5. Hence, on the average, catfish farmers in the study area incurred output loss of about 33% due to technical inefficiency. In other words, there exist 33% potential for increasing output by the catfish farms. There is therefore room for improvement in catfish production in the study area given the available resources and available technology. In similar efficiency studies, Alawode and Jinad (2014), study of catfish farmers in Oyo State revealed a technical efficiency of 52.9%.

Table 4.5: Technical, allocative and economic efficiency distribution of catfish farms

	Technical Efficiency		**Allocative efficiency**		**Economic Efficiency**	
Efficiency Level	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
0.10-0.20	24	15.48	20	12.90	17	10.97
0.21-0.30	17	10.97	22	14.19	21	13.55
0.31-0.40	15	9.68	9	5.81	12	7.74
0.41-0.50	13	8.39	11	7.10	15	9.68
0.51-0.60	38	24.52	40	25.81	36	23.23
0.61-0.70	19	12.26	21	13.55	24	15.48
0.71-0.80	16	10.32	25	16.13	15	9.68
0.81-0.90	10	6.45	7	4.52	13	8.39
0.91-1.00	3	1.94	0	0.00	2	1.29
Total	**155**	**100.00**	**155**	**100.00**	**155**	**100.00**
Minimum	**0.11**		**0.20**		**0.14**	
Maximum	**0.93**		**0.88**		**0.95**	
Mean	**0.67**		**0.65**		**0.57**	

Source: Computed from field survey data, 2014.

4.3.3.2 Frequency distribution of allocative efficiency scores of catfish farmers

It was observed from the study that about 40% of the farmers had allocative efficiency scores between the range of 0.10 – 0.50, while 60% of the farmers were able to achieve allocative efficiency scores of above 0.50. The best farmer demonstrated an allocative efficiency of 0.88 while the worst farmer had an allocative efficiency of 0.20. The mean allocative efficiency of the respondents was 0.65 as shown in Table 4.5. Hence, on average, cost efficiency of catfish farms can be improved by about 35% with existing resources. This result compares with Kaliba and Engle (2004) who reported mean cost efficiency scores of 33%. The persistent rise in the price of inputs may be forcing catfish farmers to opt for less efficient choices in their decision making. This is because catfish farmers who cannot afford the costly imported feeds supplement their feed with local materials such as rice grains, brewery wastes, chicken offals, and so on, and this lowers overall cost efficiency of production.

4.3.3.3 Frequency distribution of economic efficiency scores of catfish farmers

Economic efficiency is the product of technical and allocative efficiency indices. The combined effects of technical and allocative factors showed that the average economic efficiency level for this sample was 0.57. The best farmer demonstrated a technical efficiency of 0.95 while the worst farmer had an economic efficiency of 0.14 as shown in Table 4.5. Hence, on average, economic efficiency of catfish farms can be improved by about 43% with existing resources.

4.3.4 Determinants of technical, allocative and economic efficiency

4.3.4.1 Determinants of technical efficiency

The existence of technical inefficiency paves way to find out the sources of efficiencies among catfish farmers in the study area. Socio-economic variables were considered and estimated in the model and the results are presented in Table 4.6. The hypothesis that there are no technical efficiency effects among catfish farmers was rejected at the 1% level of significance. Positive or negative signs on the coefficients indicate that increase in the variable increases or decreases efficiency respectively. The estimated coefficient for age (Z_1) was negative and statistically significant at 1% level of probability. This implies that farmers who are older tend to be more efficient in catfish production. This is in line with Amos (2007) who found that age increases technical efficiency. It is believed that experience increases with age and resource endowment, hence giving an increase in efficiency. The coefficient estimate for years in cooperative society (Z_5) was negative and statistically significant at 5% level which implies that farmers who are members of cooperative society tend to be more efficient in catfish production and as a result reduces technical inefficiency.

Table 4.6: Determinants of technical efficiency

Variable	**Coefficient**	**Standard Error**	**T-ratio**
Constant	0.2650	0.1941	1.3653
Age (Z_1)	-0.0109***	0.0041	-2.6585
Household Size (Z_2)	-0.0167	0.0123	-1.3577
Education (Z_3)	-0.0134	0.0141	-0.9504
Farming experience (Z_4)	-0.0573	0.0428	-1.3388
Years in cooperative society (Z_5)	-0.2166**	0.1024	-2.1152
Extension contact (Z_6)	0.1623	0.1581	1.0266

Source: Computed from field survey data, 2014.
***P<0.01 ** P<0.05 *P<0.10

4.3.4.2 Determinants of allocative efficiency

The hypothesis that there are no inefficiencies was rejected at the 1% level of significance. Positive or negative signs on the coefficients indicate that increase in the variable increases or decreases allocative inefficiency respectively. The results (Table 4.7) show that coefficient estimate of age was positive and statistically significant at 1% level of probability. This implies that older farmers tend to be allocatively inefficient. This compares to Ajibefun and Abdulkari (2004) and Otitoju and Arene (2010) who in their studies stated that age of household heads have an inverse relationship with farmers' productivity. They argued that this was understandable since it was expected that as a farming household head becomes older, the farmer's productivity would decline.

Level of education, household size, farming experience, years in cooperative society and extension contact had negative signs but only household size and years in cooperative society were statistically significant at 10% and 5% level of probability. This implies that larger household sizes and longer years in cooperative society would decrease the total cost of production thereby reduce allocative inefficiency. This is so because large household sizes are a source of cheap labour on the farm. This agrees with the report of Ugwumba (2005) which found a negative relationship between household size and catfish farm inefficiency. The coefficient estimate of years in cooperative society was in consonance with *a priori* expectation; years in cooperative organizations are expected to have a positive influence on allocative efficiency (Obare *et al.*, 2010). Farmers who belong to cooperatives are better informed on resource use and farm planning which enables them to utilize resources more efficiently.

Table 4.7: Determinants of allocative (cost) efficiency

Variable	**Coefficient**	**Standard Error**	**T-ratio**
Constant	1.1259^{***}	0.3746	3.0056
Age (Z_1)	0.0287^{**}	0.0121	2.3719
Household Size (Z_2)	-0.0102^{*}	0.0057	-1.7895
Education (Z_3)	-0.0044	0.0062	-0.7097
Farming experience (Z_4)	-0.0282	0.0467	-0.6039
Years in cooperative society (Z_5)	-0.0236^{**}	0.0112	-2.1071
Extension contact (Z_6)	-0.1623	0.1581	-1.0266

Source: Computed from field survey data, 2014.
$^{***}P<0.01$ $^{**}P<0.05$ $^{*}P<0.10$

4.3.4.3 Determinants of economic efficiency

The results on determinants of economic efficiency (Table 4.8) reveal that the coefficient of age was statistically significant at 1% level of probability. This implies that the older the farmer the more efficient he or she becomes. This goes contrary with the findings of Idiong (2005) who reported that the older a farmer becomes, the more he or she is unable to combine the available technology. The coefficient estimates for education, farming experience and years in cooperative society were positive and statistically significant ranging from 1%, to 10% level of probability.

This implies that education, farm experience and years in cooperative society have negative influence on economic efficiency among the catfish farmers sampled. Level of education was positive and was statistically significant at 1% level of probability which implies that increase in educational level of catfish farmers will reduce economic efficiency. The coefficient estimate of farming experience was negative and was statistically significant at 5% level of probability. This implies that the more experienced catfish farmers produced more output from the given inputs. This finding is similar to that reported by Kaliba and Engle (2004) that experienced catfish farmers were more efficient than new farmers. On the same note, the coefficient estimate of years in cooperative society from the result was positive and statistically significant at 10% level of probability. This implies that increased number of years in cooperative society will increase economic efficiency of catfish farmers. This is because farmers who belong to cooperatives are better informed on resources use and farm planning which enables them to utilize resources more efficiently (Obare *et al.*, 2010).

Table 4.8: Determinants of economic efficiency

Variable	Coefficient	Standard Error	T-ratio
Constant	0.2359**	0.1127	2.0932
Age (Z_1)	-0.0387***	0.0121	-3.1983
Household Size (Z_2)	-0.2102	0.1473	-1.4270
Education (Z_3)	0.0162***	0.0062	2.6129
Farming experience (Z_4)	0.1082**	0.0467	2.3169
Years in cooperative society (Z_5)	0.0281*	0.0161	1.7453
Extension contact (Z_6)	-0.1623	0.1581	-1.0266
Adjusted R^2	0.6870		
F-Statistics	12.0412***		

Source: Computed from field survey data, 2014.
***P<0.01 **P<0.05 *P<0.10

4.4 Contribution of Catfish Production to Food Security Status of Farmers

The result of the food security status of the respondents is presented in Table 4.9. Based on the recommended daily calorie intake (R) of 2260 kcal, the headcount ratio shows that 32% of the participants with an average daily per capita household calorie consumption of 3190.64 kcal were food secure and 68% were food insecure without catfish production with an average daily per capita calorie consumption of 1492.71 kcal. With catfish production, the headcount ratio indicates that 73% of the households were food secure with an average daily per capita calorie consumption of 3412.40 kcal and 27% were food insecure with an average daily per capita calorie consumption of 1543.62 kcal. This is similar to results obtained by Agbola (2005) in his study on the Analysis of Food Insecurity and Coping Strategies among Farming Households in Osun State. He reported that based on the recommended daily calorie intake of 2260 kcal, 82% of the households were food secure and 18% were food insecure for households that combined crop production with livestock production. Based on the headcount ratio, it is expedient to infer that the respondents were more food secure ($P<0.05$) as a result of catfish farming. From the food security profile of the respondents, it can be deduced that the respondents had a lower food insecurity level with than without catfish production and this implies that catfish production has contributed in enhancing food security among households. Therefore, catfish production can be a panacea for food insecurity among farming households and hence, the fight against the menace of food insecurity among rural farming households who are into catfish production can be fostered by encouraging farmers to venture into catfish production. This result is consistent with other related studies on the impact of agricultural technologies on food security (Mendola, 2007; Mignouna *et al*., 2011; Omilola, 2009).

Table 4.9: Distribution of the respondents by their food security status

	Without		With	
	Food secure	Food insecure	Food secure	Food insecure
Frequency	67	88	114	41
Average daily calorie intake (kcal)	3160.64	1492.71	3412.40	1543.62
Maximum daily calorie intake (kcal)	6253.41	2245.44	2932.89	2238.58
Minimum daily calorie intake (kcal)	2113.34	812.61	2367.61	971.14
Head count ratio (H)	0.32	0.68	0.73	0.27
Standard deviation	120.14	379.53	1140.37	397.06

Source: Computed from field survey data, 2014.

4.4.1 Hypothesis 111

Table 4.10 shows the result of the hypothesis test comparing the means of the food security status of the households with and without catfish production. The average calorie intake was used as proxies for food security status. The result showed a significant difference between the food security statuses of catfish producers. Since the average calorie intake of the farmers with catfish production is greater than the average calorie intake without catfish production with a z-value of 7.5707 which was higher than the tabulated Z-value and significant at 5% level of significance, the null hypothesis which states that catfish production has no impact on household food security status is therefore rejected. This implies that there is a significant impact of catfish production on household food security level of catfish farmers. Therefore, catfish production has contributed in enhancing food security status of farming households in the study area.

Table 4.10: Contribution of catfish production on household food security

	Without	**With**
Mean	2198.993	2918.8187
Variance	20442.02	79635.17
Observations	155	155
Hypothesized Mean Difference	0	
Z-Calculated	7.570791	
P(Z<=Z) One-Tail	1.85E-14	
Z Critical One-Tail	1.644854	
P(Z<=Z) Two-Tail	3.71E-14	
Z Critical Two-Tail	1.959964	

Source: Computed from field survey data, 2014.

4.5 Constraints to Catfish Production

The major constraints to catfish production identified by the farmers in Table 4.11 include lack of access to financial capital, high cost of feed or other farm inputs, limited market sales, flooding during the raining season and inadequate storage facility.

In general, the most important factor inhibiting farmers' productivity in the study area include lack of access to financial capital (30.08%), high cost of feed or other farm input (26.27%), market price fluctuation (19.49%), flooding during the raining season (13.98%) and inadequate storage facility (10.17%). Majority of the farmers do not have access to financial capital. High cost of feed is a second ranked challenge facing catfish farmers in the study area. This might be due to high cost of most fish feed ingredients such as soya meal, fishmeal, premix, and its competitive use by livestock farmers. It might also be due to availability of few commercial fish feed producers in the study area.

A lot of farmers depend on imported quality fish feeds, which are expensive and not affordable. This increases their cost of production and reduces their profit margin. Marketing problem as a result of market price fluctuation which ranked third is another major problem facing the catfish farming in the study area. Many farmers sell their fish in fresh form to middle-men at very low prices. Lack of processing or storage facility to process or store their fish during glut also constitutes a major constraint for the catfish production in the study area. The most common reason for processing or storage is to take advantage of price rises later in the season. This practice is very difficult in the area due to high cost of storage facility, which catfish farmers cannot afford. Other major problems identified in the study area are flooding during the rainy season as a result of excess rainfall, inadequate water due to lack of rainfall, poaching or theft as a result of lack or inadequate security, predators, high mortality rate as a result of poor management and disease and pest infestation which are adversely affecting catfish production in the study area.

Table 4.11: Distribution of constraints faced by catfish farmers

Constraints	**Frequency**	**Percentage**	**Rank**
lack of access to financial capital	71	30.08	1st
High cost of feed	62	26.27	2nd
Market price fluctuation	46	19.49	3rd
Flood problems	33	13.98	4th
Inadequate storage facility	24	10.17	5th
Total	**236**	**100**	

Number (n) > 155 implies multiple responses

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The empirical study was carried out to evaluate the economics of catfish production and its contribution to household food security in FCT, Abuja, Nigeria. The findings revealed that the respondents were literate with mean age of 42 years; majority (56%) of the respondents had household sizes between 8 and 14 people. More than half (51%) of the respondents had more than 10 years experience in catfish farming. The result also shows that an average total cost (ATC) of ₦1,520,204.24 was incurred while total revenue (TR) of ₦2,873,521.29 was realized with a gross margin (GM) of ₦1,718,616.84. A net farm income (NFI) of ₦1,353,317.05 with a rate of return of 1.89 which implies that for every ₦1.00 invested, ₦1.89 is gained by the respondents.

The coefficient estimates of the inputs (fingerlings, fish feed and fuel) were positive and statistically significant ranging from 1% to 5% levels of probability implying that an increase in these variables will lead to an increase in the output of catfish. The gamma estimate, which was 0.42, shows that 42% variation in output was resulting from the technical efficiencies of the farmers. The determinants of technical efficiency in the production of catfish showed that age and years in cooperative society significantly increased the farmers' technical efficiency.

The variables significantly influencing allocative efficiency of catfish production in the area were costs of fingerlings, feed, transportation and output of catfish which were positive and statistically significant ranging from 1% to 10% levels of probability. Among the determinants of allocative efficiency in catfish production, only household size and years in cooperative society were statistically significant at 10% and 5% levels of probability. The mean technical, allocative and economic efficiencies of the farmers were 0.67, 0.65 and 0.44, respectively. The determinants of economic efficiency showed that education, farming experience and years in cooperative society were positive and statistically significant ranging from 1% to 10% level of probability. This implies that education, farming experience and cooperative society membership have a positive influence on economic efficiency among the catfish farmers.

Based on the recommended daily calorie intake (R) of 2260 kcal, the headcount ratio shows that 32% of the farmers with an average daily per capita household calorie consumption of 3190.64 kcal were food secure and 68% were food insecure without catfish production with an average daily per capita calorie consumption of 1492.71 kcal. With catfish production, headcount ratio of 73% indicates that the households were food secure with an average daily per capita calorie consumption of 3412.40 kcal while 27% were food insecure with an average daily per capita calorie consumption of 1543.62 kcal. The farmers reported lack of access to financial capital, high cost of feed or other farm input, limited market sales, flooding during the raining season and inadequate storage facility as the major constraints in catfish production.

5.2 Conclusion

It can be concluded from the study of the catfish farming in FCT, Abuja that the industry is relatively young and there is hope for a increase in level of involvement among the people in the study area. The majority of those who were involved in catfish production were able bodied men in their active age bracket, hence the potential to sustain catfish farming for many more years. A positive net farm income with increased return per naira invested indicated that catfish farming in the study area was profitable. Quantity of fingerlings, fish feed and fuel were positively influencing the output of catfish which implies that increasing the usage of fingerlings, fish feed and fuel (water quality) would improve the output of fish. Also, costs of fingerlings, feed and transportation were significantly influencing the total cost of catfish production in the area. Education, farm experience and years in cooperative society were positively influencing the economic efficiency of the farmers. Catfish production also had a significant contribution on the food security status of farming households in the study area. The catfish farmers in the study area were facing some challenges in their production. The major identified constraints were lack of access to financial capital, high cost of feed or other farm inputs, limited market sales, flooding during the rainy season, inadequate storage facility, high mortality rate and disease and pest infestation in ranking order.

5.3 Recommendation

Based on the findings of this study, the following recommendations were made:

i. There is need for catfish farmers to improve on the technical know-how of catfish production through seminars and workshops especially on the efficient use of resources in production of catfish.

ii. The government should encourage financial institutions to give loans to active and registered catfish farmers at considerable interest rates but with proper monitoring. This will help to increase farmers' production levels and profitability.

iii. Catfish production has great potentials in the study area; Government should formulate policies that will create an enabling environment and attract more youths to invest in catfish production. This will create room for new ideas and increased level of productivity by the farmers towards achieving food security.

5.4 Contribution of the Study to Knowledge

i. The study revealed that catfish production in the study area was profitable. The result shows that an average total cost (TC) of ₦1,520,204.24 was incurred while total revenue (TR) of ₦2,873,521.29 was realized with a gross margin (GM) of ₦1,718,616.84 and a net farm income (NFI) of ₦1,353,317.05 with a rate of return of ₦1.89 for every ₦1.00 invested.

ii. The efficiency distribution of the respondents from the study revealed that the mean technical, allocative and economic efficiencies were 0.67, 0.65 and 0.57 respectively.

iii. A headcount ratio indicated that 73% of farmer’s households who engage in catfish production were food secure with an average daily per capita calorie consumption of 3412.40 kcal while 27% were food insecure with an average daily per capita calorie consumption of 1543.62 kcal. This implies that catfish farming can improve food security status of farmers’ household.

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APPENDIX

Questionnaire on the Economic Analysis of Catfish Production and its Contribution to Household Food Security in FCT- Abuja, Nigeria.

Dear Respondent,

Please kindly answer the following questions. All information provided shall be in strict confidence. Tick correctly in the brackets and fill in the gaps provided as may be applicable to each question.

Thank you.

The questionnaire comprises of four sections A to D

SECTION A. Socio-Economic Variables

1 Sex: (a) male (b) female

2 Age: ---years

3 Highest level of education attained---

4 Marital status ( ) Married ( ) single ( ) Widowed ( ) Divorced

5 Size of household at time of interview (excluding visitors)----------------------------

6 Main occupation: ( ) Farming ( ) Trading ( ) Formal employment ( ) Casual work ( ) Others (specify)---

7 How long have you been involved in farming? 0-5 years ( ) 6-10 years ( ) 10+ years ( )

8 Do you engage in catfish farming? Yes ( ) No ( )

9. Is your catfish farming for; commercial purposes ( ) domestic purposes ( ) both commercial and domestic purposes ( )

10. Do you have contact with extension agent? Yes ( ) No ( )

11. If yes, how many times does the extension agent visit you in a year?-----------------

12. How many times have you visited the extension agent in a year----------------------

13. Are you a member of any cooperative association? Yes ( ) No ( )

14. If yes, for how long have you been a member?---------------------------------(years)

15. Is credit readily available to you? Yes ( ) No ( )

16. If yes, from where do you source your credit? (a) Banks ( ) (b) Money Lenders ( ) (c) Cooperatives ( ) (d) Friends and relatives ( ) (e) Others specify-------------------

17. Do you have enough technical information to successfully take care of your catfish farm? Yes ( ) No ( )

SECTION B: Production Information on catfish

18. Which method of catfish farming do you use? Cage ( ) Ponds ( ) Tanks ( )

19. How do you acquire your land? (a) Inheritance (b) Purchase (c) Rent (d) Borrow

20. Do you have access to inputs from government agencies Yes ( ) No ( )

21. What is the main source of labour? (a) Family labour (b) Hired labour

22. Costs and Returns in catfish production of:

Please fill in the table below

Variable Inputs	Price/unit or day (₦)	Total (₦)
Fingerlings		
Feeds		
Medication		
Pond preparation		
Water		
Labour		
Water pump		
Output of catfish (kg)		

23. How do you acquire knowledge and learn new things about catfish farming?

	Not at all important	A little important	Some importance	Important	Extremely important
Attend training courses					
Read relevant literature					
Information from NGO's					
Information from family					
Information from wider social network					
Information from local authorities					
Radio/TV					

24. How do you dispose of waste from your ponds? Through the municipal waste system ( ) Drain it into a nearby river/lake ( ) Recycling solids and used as fertilizer on land ( )
25. How would you rate the inputs to catfish farming in relation to your profit (land, water, fertilizer, wages) Very high ( ) High ( ) Moderate ( ) Low ( ) Very low ( )
26. Do you feel well informed about the future of catfish farming Yes ( ) No ( )
27. If not, state your reason No resources to read from ( ) Not literate ( ) Not computer literate ( ) Resources not readily available in area ( ) Lack of support from government ( )
28. Would you say, your life has improved since you started your catfish farm? Please state reasons: I have been able to take care of my family's finances ( ) I can employ people on my catfish farm ( ) Our health has improved ( ) We are no longer worried about food insecurity ( ) Nothing has changed ( ) I have not benefitted from catfish farming ( )
29. How do you consider the future of catfish farming? Will decline( ) Is sustainable ( ) Will grow( )

SECTION C: Constraints

30. What are the extents of some of the challenges you face as a catfish farmer? (Please tick)

Issue	Not a problem	Minor problem	Some problem	Major problem
Lack of finance				
Acquiring land on which to farm				
Farming inputs (water, fingerlings, equipment and machinery)				
Technical support from government/local authorities				
Pollution				
Environmental/Climate change				

Thank you for your cooperation.