ANALYSIS OF PROFITABILITY AND DETERMINANTS OF ADOPTION AND DISADOPTION OF CAGE TILAPIA (*Oreochromis niloticus*) FARMING IN SOUTHERN GHANA

BY

VIDA MANTEY

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

NOVEMBER, 2019

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

Vida Mantey

Reg. No. A56/9492/2017

Signature……………………………… Date………………………………………

This thesis has been submitted with our approval as University supervisors.

Prof. John Mburu

Department of Agricultural Economics, University of Nairobi

Signature……………………………… Date………………………………………

Dr. Chepchumba Chumo

Department of Agricultural Economics, University of Nairobi

Signature…………………………….. Date………………………………………

DEDICATION

This work is dedicated to my lovely husband, Charles Narteh Boateng and daughters; Victory and Gracelyn.

ACKNOWLEDGEMENT

I am thankful to the Almighty God for His favour, guidance and gift of strength throughout my academic life, especially while working on this thesis.

I am extremely grateful to my able supervisors; Prof. John Mburu and Dr. Chepchumba Chumo for their inspiration, thought provoking suggestions, corrections and constructive criticism that played a major role in shaping this thesis. I found academic parents in you. I also appreciate all lecturers in the Department of Agricultural Economics, University of Nairobi for their support.

I also thank my family for their support throughout my education and my colleagues who offered me support in diverse ways. I am thankful to all respondents and researchers at the Aquaculture Research and Development Centre (ARDEC), Akosombo, Ghana for providing the relevant data for this study.

Finally, I am highly grateful to African Economic Research Consortium (AERC) for offering me the scholarship and funding of this research.

May God bless you.

ABSTRACT

Ghana's national annual fish deficit was 550,000 tons in 2018 leading to persistent increase in fish importation due to decline in capture fisheries. Adoption of aquaculture technologies has the potential to improve fish productivity, but the decision to adopt new technologies by fish farmers is rather complex and influenced by many factors including demographic, socioeconomic and institutional factors. Cage fish farming was introduced along the Lake Volta as a means of improving fish productivity. However, low adoption and disadoption of the technology raises reservation about its appropriateness, especially among small scale producers. Further, profitability of cage tilapia farming has not been comprehensively documented. This study therefore analyzed profitability and determinants of adoption and disadoption of cage tilapia aquaculture. The study was conducted in Eastern and Greater Accra regions of Ghana. Three districts and 11 communities along the Lake Volta known for cage fish farming were selected. Multistage sampling was used to select 206 respondents. Data were obtained through face to face interview with a semi-structured questionnaire. Gross Margin and Net Fish Income were used to estimate the profitability of cage tilapia aquaculture. The Heckprobit model was employed to identify determinants of adoption and disadoption of cage tilapia aquaculture. On profitability, Gross Margin of Gh₵2,550 (USD 520) and Net Fish Income of Gh₵829 (USD 169) were realized. This is an indication that cage tilapia aquaculture in the study area is profitable. The selection equation of the Heckprobit results revealed that access to credit, policy information and extension services increased the likelihood of adopting cage tilapia aquaculture. On the other hand, the outcome equation results showed that age of the respondent and distance from the Lake Volta positively correlated with disadoption of cage tilapia farming. Further, market price of tilapia, membership of farmer groups and cost of fingerlings reduced the likelihood of disadopting cage tilapia farming. Stakeholders in the industry should promote cage tilapia farming to attract potential financiers and investors, especially the youth to venture into cage tilapia aquaculture. The study also recommends supporting policies leading to input reduction and training of fish farmers. Enhancement of access to aquaculture policy and regulations is required to improve adoption of cage tilapia aquaculture. Improvement in the extension services is required to enhance the capacity of extension programs to efficiently support fish farmers. Fish farmers should be encouraged to form farmer associations to facilitate access to information and credit facilities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

ARDEC	Aquaculture Research and Development Centre
FAO	Food and Agricultural Organization
FASDEP	Food and Agriculture Sector Development Policy
GBN	Ghana Business News
GDP	Gross Domestic Product
GM	Gross margin
GMR	Gross margin ratio
GNADP	Ghana National Aquaculture Development Plan
GOG	Government of Ghana
GSS	Ghana Statistical Service
KII	Key Informant Interview
MoFAD	Ministry of Fisheries and Aquaculture Development
MoFEP	Ministry of Finance and Economic Planning
NAFAG	National Aquaculture and Fisheries Association, Ghana
NFI	Net fish income
NGO	Non-Governmental Organization
RUM	Random Utility Model
SDG	Sustainable Development Goal
TFC	Total fixed cost
TR	Total revenue
TVC	Total variable cost
VRA	Volta River Authority

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Fish is the primary source of animal protein for about one billion people in the world (FAO, 2005). Aquaculture and fisheries continue to provide income, food and nutrition for millions of people around the globe (FAO, 2016). Fish farming in Sub-Saharan Africa (SSA) has the prospect to reduce poverty and alleviate hunger (Kaliba *et al.*, 2007). The fisheries sector in Ghana comprises of two main categories: capture fisheries (marine and inland fisheries) and culture fisheries or aquaculture (ponds, pens and cages). About 10 percent of Ghana's population including fishers, traders, processors and boat builders derive their livelihoods from the fisheries industry (Kassam, 2014). The contribution of fisheries to Ghana's Gross Domestic Product (GDP) is 3-5 % with a growth rate of 5 percent (GSS, 2015).

Ghana is considered one of the highest fish consuming countries in sub-Saharan Africa with a per capita fish consumption of 26 kg (Asiedu *et al.*, 2017), which is more than World average of 20.3 kg and 10 kg for Africa. Fish constitutes 60% of animal protein intake of Ghanaians compared to 20% for low-income countries and 15% at the global level (FAO, 2014). A report on Ghana Living Standards Survey conducted in 2008 shows that the budget share for food in rural areas of fish and seafood was 27% far higher than that of cereals and bread (15%) and meat (7%) (GSS, 2008). Sea food and fish constitute 16% of the overall expenditure on food by households (GSS, 2008).

Domestic production of fish is about 451,000 tonnes while annual domestic demand for fish is above one million tonnes (MoFAD, 2016), leading to persistent importation of fish to cater for the deficit. In 2015, for example, the value of imported fish was USD 154,019,585 (MoFAD, 2016). Capture fisheries has been declining over the years in most parts of the globe (FAO, 2018), Ghana inclusive due to increasing population and over fishing. It is reported that capture fisheries being the major source of fish supply in Ghana have reached low-level with little prospects leading to impeding socio-economic progress intensely (GBN, 2015). This has led to the promotion of aquaculture by both governmental and non-governmental agencies (Ansah, 2014), due to its numerous benefits.

Aquaculture is globally considered to be the fastest growing food-producing sector which has the potential for sustainable food security and decreased malnutrition in developing countries like Ghana (UNCTAD, 2013). The country has experienced tremendous growth in the sector over the years with production rising from 5,000 tonnes to 62,700 tonnes between 2009 and 2018 (Figure 1.1). The aquaculture sub sector has the potential of maximizing the fisheries sector's contribution to food security and nutrition of Ghanaians. Yet, the sector is faced with numerous challenges including information asymmetry regarding the economic profitability of fish production, which poses a challenge for investment in the sector, high cost and difficulty in accessing credit for gainful operations, high cost and lack of good-quality fish feed (Cobbina, 2010; Nunoo *et al.*, 2014; Antwi *et al.*, 2017). Also, fish production in the country is low and characterized by small scale fish producers. Increase in aquaculture productivity will cause a rise in food security and nourishment through fish availability and affordability for the increasing population that rely on fish and its products (FAO, 2012).

The natural features of Ghana offer an array of opportunities such as rivers, reservoirs, lakes, estuaries and irrigation sites that could be exploited for aquaculture practices. The coastline stretches more than 500 km, providing opportunities for Mariculture (NAFAG, 2014). Mariculture is a special branch of aquaculture that deals with the cultivation of marine organisms for food in the open ocean, an enclosed part of the ocean, or in ponds, tanks or raceways which are filled with seawater (NAFAG, 2014). The Lake Volta, one of the largest man-made reservoirs globally (Failler *et al*., 2014), offers the most favourable location for aquaculture advancement in the country. In order for the aquaculture sector to be fully developed, one of the requirements would be to improve adoption of aquaculture technologies such as cage fish farming.

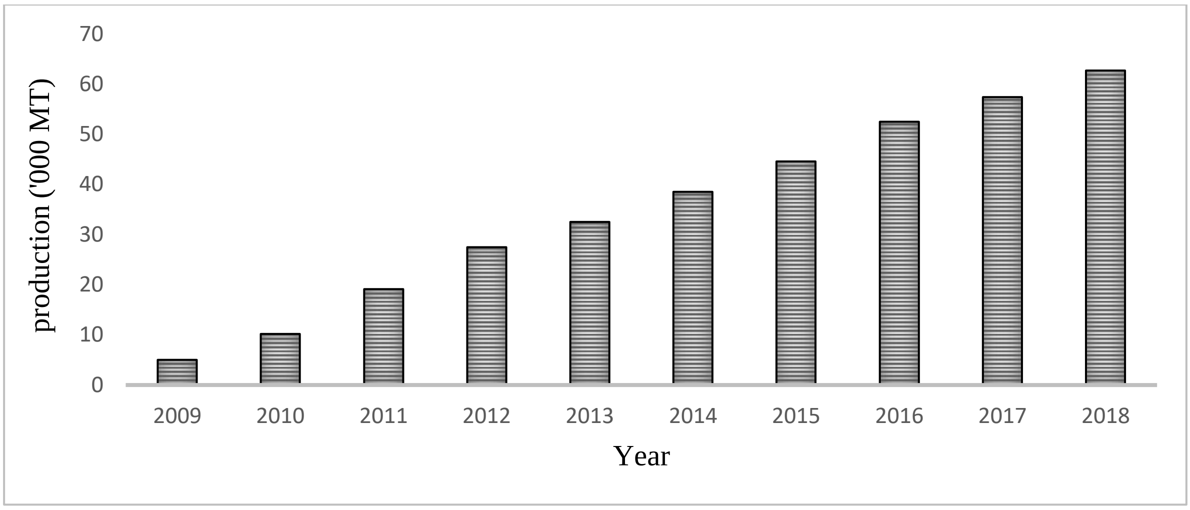

Figure 1.1: Ghana's total aquaculture production, 2009-2018
Source: (MOFAD, 2019)

The introduction of cage fish farming on the Lake Volta is one of the strategies employed by the Government of Ghana to promote fish production. Adoption of cage fish farming has contributed immensely to fish production in the country. Nevertheless, Anane-Taabea (2012) reported that a number of cages have been abandoned on the Lake Volta. Similarly, Rurangwa *et al*. (2015), reported that about 1,200 cages have been abandoned on the Lake Volta by local producers. Aquaculture Technology adoption has the potential to increase fish productivity. However, adoption decision among farmers is complex and it is determined by several critical factors. Drivers of technology adoption become critical for appropriate policy formulation.

Tilapia (*Oreochromis niloticus*) production in Ghana is done mainly along the Lake Volta and has developed rapidly as a commercial activity, with 73% growth rate annually and contributes up to 90% of the overall aquaculture production (Rurangwa *et al*., 2015). Other cultured fish species in the country include *Heterotis niloticus*, *Clarias gariepinus* (African catfish) and the *Heterobranchus species* (Frimpong & Anane-taabeah, 2017). These other species of fish are common with pond culture (Frimpong *et al*., 2014), while tilapia dominates cage culture in the country. Tilapia is the most preferred and highly demanded fish in Ghana and there exists ready market locally for all sizes of tilapia (MoFAD, 2014). Tilapia is mostly preferred for culture due to its relative advantages such as resistance to diseases, easy to confine and tastiness. The Ghanaian Government's decision to ban the importation of frozen tilapia was an entry to the National Aquaculture Development Plan (GNADP) with a determined goal of 100,000 tonnes of farmed fish at the end of 2016 (Failler *et al.*, 2014). Development of Tilapia and fish farming in general will enable the country to attain its target of zero hunger (SDG, 2) and poverty reduction (SDG, 1). There is therefore the need for effective and efficient networks to provide incentives to boost productivity of farmed tilapia and increase farmers share of benefits. This will increase the availability and affordability and thus reduce malnutrition and poverty.

1.2 Problem Statement

Ghana remains one of the highest fish consuming countries in sub-Saharan Africa with per capita fish consumption of 26 kg (Asiedu *et al*., 2017). Nonetheless, the country has an annual fish deficit of about 55 % (Asiedu *et al.*, 2017), leading to persistent importation of fish to supplement domestic supply. In 2015, the value of imported fish (180,801 tonnes) in Ghana was USD 154,019,585 (MoFAD, 2016). However, capture fisheries have been declining in most parts of the world, including Ghana.

Aquaculture has the possibility of reducing poverty and alleviating hunger in developing regions (Kaliba *et al*., 2007). The aquaculture sub-sector in Ghana has established improvement in attractiveness, producing tilapia strains that performs better in a responsive environment and gainful system of farming (Anane-Taabea *et al.*, 2015). Yet, the sector is still bedevilled with numerous critical challenges such as weak governance and government institutions, high cost of commercially compounded feed, poor infrastructure and high cost and difficulty to access to credit (Hiheglo, 2008; Ansah, 2014; Nunoo *et al*., 2014).

The introduction of cage fish farming in the country is a means of improving fish productivity. Nevertheless, aquaculture production in the country is still low considering the potentials and resources that exist such as readily available market, legalization of Lake Volta for cage culture, lagoons and estuaries (Asmah *et al.*, 2016). Furthermore, about 1,200 cages have been abandoned on the Lake Volta by local producers (Rurangwa *et al*., 2015). Thus, low adoption (2% of total fish farms) and disadoption of cage fish farming in the country raise reservation about the appropriateness of the technology, especially among small scale producers.

Adoption of aquaculture technologies has the potential to enhance fish productivity (Kumar *et al.*, 2015). However, the decision to adopt a new technology by farmers is quite multifaceted and influenced by several critical factors and especially profitability. However, the profitability of cage fish farming in Ghana has not been comprehensively documented. A lot of attention has been given to factors affecting other agricultural technologies but less emphasis has been placed on aquaculture technologies such as cage fish farming. There is inadequate information concerning drivers of adoption and disadoption of cage tilapia farming on the Lake Volta. Understanding these drivers in cage tilapia farming is of paramount importance and particularly for the provision of appropriate policy direction. Thus, this study is geared towards filling this knowledge gap.

1.3 Objectives of the Study:

The general objective of this study was to evaluate profitability and determine factors affecting adoption and disadoption of cage tilapia farming among small scale fish farmers in Southern Ghana.

Specific Objectives:

1. To evaluate the profitability of cage tilapia farming among small scale tilapia producers.
2. To assess socioeconomic and institutional factors influencing adoption of cage tilapia farming among small scale fish producers.
3. To assess socioeconomic and institutional determinants of disadoption of cage tilapia farming among small scale tilapia producers.

1.4 Hypotheses

1. Cage tilapia farming is not profitable to small scale tilapia producers.
2. Socioeconomic and institutional factors do not influence adoption of cage tilapia farming.
3. Socioeconomic and institutional determinants do not influence disadoption of cage tilapia farming.

1.5 Justification of the Study

The Sustainable Development Goal number 2 is geared towards zero hunger through food security. Adoption of cage fish farming is one of the aquaculture development strategies to increase fish productivity. Therefore, profitability of cage tilapia farming provides relevant information to investors on its economic viability to enhance investment. This will contribute towards the country’s effort of achieving zero hunger and poverty eradication. Furthermore, the Ghana Fisheries and Aquaculture policy aims at promoting aquaculture development that will lead to socio-economic development through food and nutritional security and poverty eradication in a sustainable and economically efficient way. Empirical evidence of factors influencing adoption and disadoption of cage tilapia aquaculture provides relevant information to policy makers to formulate and design appropriate policies and programs that will help tilapia farmers increase fish productivity and improve upon their livelihoods. Technology adoption promotes productivity but adoption behaviour among farmers is complex. It is influenced by several critical factors. Therefore, drivers of cage tilapia farming provide a very useful information for its adoption and enhance fish productivity. The empirical evidence of economic viability and drivers of cage fish farming also form a useful material to researchers and other readers in general.

1.6 Organization of the Study

This thesis is structured into five chapters. After this introduction, Chapter two deals with review of important literature and theoretical framework of the study. Chapter three describes the study area, research design, sampling procedure and data types. Chapter 4 presents results and discussion while Chapter 5 deals with summary, conclusion and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Brief History of Aquaculture in Ghana

Fish farming started in the Northern part of Ghana in 1953. Already, there exist traditional forms of aquaculture such as '*atidja*' (brush parks in lagoons and reservoirs), '*hatsi*' (fish holes), and '*whedo*' (mini dams in coastal lagoons). The culture of bivalves (Egeria radiata) in the lower Volta which involved the transplanting of clams from areas along the Volta estuary where farmers bred, to family "owned" sites up the river for on-growing during the dry season also existed (Asmah, 2008). The initiative to introduce aquaculture was taken by the colonial administration when fishponds were built for hatcheries as sustenance for the fishery development programme (FAO, 2014). The programme was established to supplement the nation's fish demand and to improve living conditions especially in rural areas. Fishing skills were taught in communities to enhance the practice. However, this approach was not successful due to lack of proper management (Hiheglo, 2008).

The government of Ghana (GOG) adopted a strategy to develop fishponds in all irrigation schemes across the nation after independence in 1957. The policy was aimed at converting 5 percent of state-owned irrigation schemes into fish farms to increase fish production (FAO, 2014). The government, in the 1980s, embarked on a nationwide campaign to encourage pond fish culture. The campaign was effective considering the number of ponds built in different parts of the country (Cobbina, 2010). This strategy by the government was to take advantage of the potential that exist in the country such as the Lake Volta, estuaries, rivers, dams and streams which has been underutilized. Although there was a huge entry into aquaculture production (Cobbina, 2010), the programme was not workable due to lack of government support.

Despite past failures, efforts are made to develop aquaculture in Ghana. A study by (Frimpong & Anane-taabeah, 2017) show that aquaculture has experienced a tremendous improvement in the country with an estimated annual growth rate of 73%. The authors attributed this growth to the existence of few large-scale cage tilapia farms in the country.

2.2 Overview of Tilapia Production in Ghana

Tilapia production in Ghana has experienced rapid growth since 2000. Estimates show that tilapia production improved from 2000 tonnes to 30,000 tonnes between 2006 and 2013 (Frimpong & Anane-taabeah, 2017). Tilapia is the dominant aquaculture species in the country contributing about 90 percent of total aquaculture production (Frimpong & Anane-taabeah, 2017). Apart from tilapia, other cultured fish species include *Heterotis niloticus*, *Clarias gariepinus* (African catfish) and the *Heterobranchus species* (Frimpong & Anane-taabeah, 2017). These other species of fish are common with pond culture (Frimpong *et al*., 2014), while tilapia dominates cage culture in the country. The increasing contribution of tilapia to the total fish production in Ghana indicates less development by the other fish species, however, inconsistent reporting of pond production makes it difficult to make a solid conclusion.

Aquaculture production in general constitute a little but increasing proportion of the overall fish production in the country. It is estimated that tilapia's share in the total fish production in the country increased from 0.5 to 9.4 percent between 2006 and 2013 (Asmah *et al*., 2016). Capture fisheries, mainly artisanal is believed to contribute to tilapia production in the country. Cage based tilapia production improved from 5,000 tonnes to 47, 000 tonnes between 2009 and 2016 (Figure 2.1). Tilapia and *Sarotherodon species* are common with inland capture fisheries production. The Volta river makes the most significant contribution to tilapia production as compared to other major water bodies in the country. The major source of tilapia production in the Ashanti region of Ghana is the Lake Bosomtwi (Antwi-Asare and Abbey, 2011).

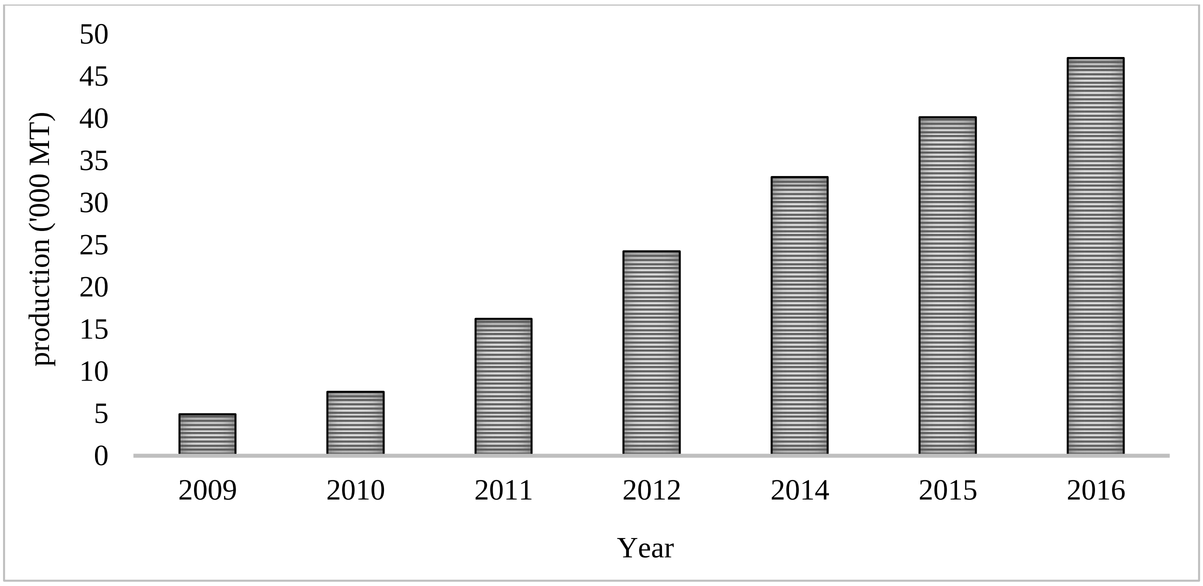

Figure 2.1: Cage based tilapia production in Ghana, 2009-2016

Source: Ragasa *et al*. (2018). Note 2013 figures are not available due to logistical challenges

Cage system of fish farming contributes about 90% of total tilapia production in Ghana with only about 900-2500 tonnes coming from pond culture in 2012 (Frimpong *et al*., 2014). The introduction of cage tilapia production has increased the contribution of tilapia in Ghana. In 2004, tilapia aquaculture production in Ghana was only 760 tonnes. A survey conducted by Anane-Taabeah (2012) specified that the country has about 100 cage farms. However, almost half of the total tilapia aquaculture production in the country come from few large-scale cage tilapia producers. The huge contribution of about three to four large scale cage tilapia producers shows less development in small scale tilapia production.

2.3 Marketing of Tilapia

Tilapia or fish trading in general is a significant occupation in Ghana especially for women. About 10% of Ghana's population engage in fish trading either part time or full-time job, in both urban and rural areas (Asiedu *et al.,* 2017). Farmed tilapia in the country is not exported but sold to domestic consumers, restaurants and 'chop bar' operators at local markets (Cobbina, 2010; Asiedu *et al*., 2017) due to low production. Harvested tilapia is mostly sold fresh. Most Commercial fish producers sell to wholesalers who also sell to retailers and fish processors. Majority of the non-commercial producers retail harvested fish by themselves or their spouses but few of the non-commercial producers sell to wholesalers (Asmah, 2008; Cobbina, 2010). However, some commercial farms also distribute fresh tilapia to retailers, restaurants and chop bar operators as well. Unsold fresh tilapia is either processed by salting or fermentation, smoking or frozen (Cobbina, 2010). Tilapia sizes of 200g and above are preferred by consumers and fish farmers producing such sizes of tilapia have no problems of selling their product (Asmah, 2008).

Tilapia marketing is generally concentrated in the southern part of Ghana, where consumption of fish is high. The southern zone of the country has the highest per capita fish consumption of 30kg followed by the middle and the northern zones with 20kg and 10kg respectively (Hiheglo, 2008). To ensure good tilapia prices for farmers, there is a ban on the import of frozen tilapia in the country. Majority of tilapia farmers in the country sold their fish fresh (live) at the farm gate (Ansah *et al*., 2014).

2.4 Profitability of Fish Farming

Improving profitability is one of the major goals of business managers who look for several different ways to change the business to achieve this purpose (Nunoo *et al*., 2014). A well conducted profitability analysis gives evidence about a business's earnings potential and management effectiveness (Engle and Neira, 2005). The profitability of a business activity can be analysed in several different ways depending on selected time frame, data availability and scope of the selected activity (Engle and Neira, 2005). Enterprise budget, cash flow budgets, balance sheet and income statement constitute the four types of financial records (Engle, 2010). Enterprise budget gives the overall picture of the cost and returns of an enterprise for a given period of time while cash flow budget shows the capacity of the enterprise to make payments when due. Balance sheet summarises solvency and capital position of the enterprise while income statement shows profit or loss of the enterprise in a given time frame.

Asmah (2008) examined the development potential and financial profitability of aquaculture in Ghana using enterprise budget and found that commercial fish farming in the country was profitable as opposed to subsistence fish farming which was unprofitable. The study revealed that high cost of feed and fingerlings, poor management practices and lack of technical know-how hampered aquaculture production in the country. Similarly, Nunoo *et al*. (2014) employed enterprise budget to analyse profitability of pond and pen culture in southern Ghana. The study realised an average net return of US$ 0.55 and US$ 0.42 m^{-2} for pond and pen culture respectively to indicate that both systems were profitable. The study further revealed that lack of capital, poaching and predators were the major constraint of fish production.

Ansah (2014) analysed profitability of pond aquaculture in southern Ghana using both traditional and stochastic enterprise budget. The study revealed that fish farmers who used commercial floating feed had a gross revenue of US$ 21,400 per annum while fish farmers who applied sinking feed grossed close to five times less. The study also revealed that feed cost constituted between 74% and 77% of total cost of production and financing 50% of total cost at a mean interest rate of 8.5% decreased profitability.

The current study evaluated profitability of cage tilapia farming using enterprise budget with gross margin and net fish income as performance indicators. Enterprise budget provides a summary of costs and revenue associated with a business for a specified time frame for a definite production unit (Engle, 2012) which forms a useful way of finding the profitability of a technology or an enterprise. Time periods employed to develop enterprise budget can be based on one production cycle (Engle and Neira, 2005). This study therefore used one production cycle (six months) to analyse the profitability of cage tilapia aquaculture. Profitability is one important factor that farmers consider during adoption decision making; that is whether to adopt or not (Karanja, 2010).

2.5 Review of Empirical Studies on Determinants of Adoption and Disadoption of Agricultural Technologies

Adoption as defined by Feder *et al*. (1985) is the incorporation of a new technology into the usual farming activities in future given the potential benefits and adequate information about the technology. Adoption decision depends on human, institutional and social factors. Adoption in this study means practicing of cage tilapia farming. On the other hand, disadoption is the abandonment of a technology after initial adoption. Wendlands and Sills (2008) defined technology abandoning as having implemented the technology initially but later abandoned such technology. Disadoption in the current study means abandoning cage tilapia farming after initial uptake.

While a wide range of literature exist on factors influencing adoption of improved technologies, only few studies focused on determinants of disadoption of technologies.

Dasgupta, (1989) postulated that, an individual may discontinue the utilization of an innovation due to several factors which include the availability of alternative technology which provides relatively greater utility to the farmer.

A study by Neill and Lee (2001) documented factors influencing farmers' decision to disadopt maize-macuna systems in Honduras. The study considered three categories of contributing factors: external factors, agronomic and biophysical factors internal to maize-macuna system and management related issues. The study concluded that age of household head, limited access to market and weed *Rottboellia* encouraged disadoption. Also, farmers who had available household labour, larger farm size, cultivated high-value crops and used best management practices including annual reseeding and more farm experience in maize-macuna system were less likely to disadopt. Moser and Barrett (2006) also documented increased labour requirement, educational attainment and farm size as influencing factors of disadoption of the Systems of Rice Intensification (SRI) in Madagascar.

Hassen (2015) modelled drivers of disadoption of green revolution technologies using multivariate probit. The study considered whether the disadoption is linked to adoption or non-adoption of other sustainable land management practices. The study concluded that shorter distance to homestead, extension centers and access to credit affect farmers decision on continued use of green revolution technologies. The study also established that disadoption of green revolution technologies was related to non-adoption of other sustainable land management practices. Moreover, Wendland and Sills (2008) also found that resource endowment, household preference, risk and uncertainty influence households' decisions on continued adoption of soybeans in Benin and Togo.

Pedzisa (2016) examined determinants of abandonment of conservation agriculture (CA) in Zimbabwe using standard probit regression model. Age of the farmer, NGO support, farm experience, household size, female headed households and value of assets were found to be important factors that influence disadoption of CA. Further, Grabowski *et al*. (2016) document that age of household head, limited household labour and high cost of farming equipment affect cotton farmers decisions on continued use of minimum tillage in Zambia.

Habanyati *et al*. (2018) modelled factors contributing to disadoption of conservation agriculture (CA) in Petauke, Zambia using logistic regression model. The study found that attendance to CA training sessions, perception on labour requirement, access to incentives such as hybrid maize seed and fertilizer affect small scale farmers decision to disadoption conservation agriculture. Marenya and Barrett (2007) also found that the decision to use integrated natural resource management practices among small scale farmers in Western Kenya was affected by off-farm income, level of education, female household head, farm size and household labour supply.

The reviewed literature in this study showed that different models were employed to analyse determinants of adoption and disadoption of technologies. For instance, the use of multinomial logistic regression to model determinants of adoption and disadoption raises concern about the appropriateness of its application. This is because, in modelling adoption and disadoption of technologies, all the three decisions, that is adoption, non-adoption and disadoption are not available for the decision maker at the same time. The decision to disadopt is a later decision made after the initial uptake of the technology. Furthermore, the use of binary dependent model such as logit and probit to examine determinants of adoption and disadoption does not take into consideration the first stage of the decision-making process, that is either to adopt or not. This may generate sample selection bias which can be resolved using Heckman's sample selection models (Heckman, 1976). Thus, this study employed the Heckprobit model to examine determinants of adoption and disadoption of cage tilapia farming.

2.6 Review of Empirical Methods on Determinants of Adoption and Disadoption of Agricultural Technologies

A wide range of approaches exist for modelling determinants of adoption of agricultural technologies. On the other hand, only few studies focused on determinants of adoption and disadoption of these technologies. Among the few studies that exist, approaches employed include Multinomial Logit (MNL), Multivariate Probit (MVP), Bivariate Probit, Logit and Probit models. The Multinomial Logit model is applied when the dependent variable has more than two choices which are not ordered in any specific manner (Gujarati, 2004). The model assumes independence of irrelevant alternatives (IIA) among the various choices. This implies that the removal or addition of any of the choices from the model does not affect the relative probability of the selected options. Furthermore, it is assumed that all the choices are available to the decision makers at the same time to enable them make the choice that maximizes utility (Gujarati, 2004). With regards to determinants of adoption and disadoption of technologies, all the three choices (adoption, non-adoption and disadoption) are not available to the decision maker at the same time. The decision to disadopt happens only after the farmer had adopted (Dasgupta, 1989). This makes the MNL not appropriate for modelling determinants of adoption and disadoption.

The logit and probit models have been applied as single equation model to analyse determinants of disadoption. The model is used in decisions that require choices with dichotomous outcomes. The difference between the logit and the probit models is that the latter assumes normally distributed independent error terms while the former assumes a standard logistic distribution in the error terms (Greene, 2000). Abandonment of a technology can be treated as a binary variable equalling one when the technology is disadopted or abandoned and zero otherwise (Pedzisa, 2016). However, modelling disadoption using a single equation approach is appropriate only under the condition that there is no correlation between the error terms in both stages of the decision-making process (Heckman, 1976). Thus, the current study assumes a correlation between the unobserved characteristics in both stages of the decision-making process making a single equation model non-suitable.

Studies such as Neill and Lee (2001), Sanou *et al*. (2017) and Simtowe and Mausch (2018) employed the Bivariate Probit model to analyse determinants of adoption and disadoption. The Bivariate Probit is a two-step model that use Probit regression in both the first and second stages. It assumes dichotomous dependent variable in the first and the second stages. Application of the model follows Heckman (1976), which assumes that the disturbance terms in the decision-making process are correlated and application of a single equation model yields bias and inconsistent estimation. The Multivariate Probit (MVP) model is also used to analyse determinants of adoption and disadoption. The MVP allows correlation among the unobserved disturbances in the adoption and abandonment decisions for interrelated agricultural technologies and practices (Hassen, 2015). The model is suitable in case of multiple agricultural technologies. Unlike previous studies, the current study considered only one aquaculture technology, making the MVP not suitable for the study.

The Heckprobit model was employed by Asrat and Simane (2018) and Muema *et al*. (2018) to analyse access and use of climate information services. The model assumes binary dependent variables in both stages of the decision-making process. The model corrects for selectivity bias that occurs as a result of correlation between the disturbances in the decision-making process. The current study adopted the Heckprobit model, which is a two-step Probit regression model to analyse determinants of adoption and disadoption of cage tilapia farming. The Heckprobit is appropriate for this study due to the fact that a single technology was considered. Furthermore, the current study assumed a correlation between the disturbances in the decision-making process.

2.7 Theoretical Framework

This study applied the random utility model (RUM) which assumes that the decision maker has perfect discrimination ability (Brooks *et al*., 2011). In selecting any of the adoption options, the farmer deliberates on the costs and benefits related to these adoption decisions and how they will derive maximum utility from it subject to external factors. If the costs that are related to continued adoption of cage tilapia farming are more than the benefits, the farmer will not be encouraged to continue using it, thus, choosing the next best alternative. To maximize their expected utility, a farmer can decide to continue or discontinue adoption of cage tilapia farming. Farmers are expected to discontinue adoption of cage tilapia farming if the satisfaction from disadoption is greater than continued adoption. The utility of the farmer depends on maximum profit attained through cost minimization and productivity optimization (Feder *et al*., 1985). It is assumed that the decision made by farmers is a function of technology, institutional and socio-economic characteristics. The utility of adopting or disadopting cage tilapia farming is a latent (unobserved) variable and can only be observed through the decision (adopt or disadopt) made by the farmer. Let U_j^n, U_j^a and U_j^d represent the utility in the state of non-adoption (n), adoption (a) and disadoption (d) of cage tilapia farming respectively. The farmer chooses to change from the position of non-adoption to that of adoption of cage tilapia farming if: $U_{ij}^* = U_{ij}^a - U_{ij}^d > 0$ and choose to disadopt if $U_{ij}^* = U_{ij}^d - U_{ij}^a > 0$, where U_{ij}^* is the unobserved net benefit of adopting or disadopting cage tilapia farming. Therefore, the decision made by the farmer to adopt or disadopt can be determined by:

$$U_{ij}^* = X_{ij}\beta + \varepsilon_{ij} \qquad \ldots\ldots(1)$$

where X_{ij} is a vector of observable farmer i characteristics for adopting or disadopting cage tilapia farming and β represents a vector of estimated parameters and ε_{ij} is the random error term which represents unobserved characteristics that influence the decision made by the farmer (Lancsar and Savage, 2004). In other words, it represents uncertainty, since it is assumed that the farmer does not have perfect information. For instance, in the current study, the farmer who is the decision maker, chooses to disadopt cage tilapia farming to achieve some level of utility, U_{ij}^*. The model assumes that the farmer will choose the option that gives maximum satisfaction. The deterministic part (X_{ij}) of the model is a linear combination of observable explanatory variables such as age, education and household size.

The decision of a farmer to disadopt cage tilapia farming is a two-step process suggesting that farmer *i* becomes self-selected in the population of farmers who initially adopted cage tilapia farming if he chooses to disadopt. Therefore, Heckman's sample selection model is required to address the sample selection bias (Heckman, 1976; Asrat and Simane, 2017).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual Framework

The conceptual framework showing linkages between factors influencing adoption and disadoption of cage tilapia aquaculture and profitability is presented in Figure 3.1. Adoption or disadoption of cage tilapia farming is dependent upon farmer's expected utility. The expected utility is influenced by several critical factors which can be categorized into economic factors, socio-demographic factors and institutional factors (Teklewold *et al.,* 2013), although not exhaustive.

Institutional factors such as extension contacts, membership of farmer groups, access to credit and policy information enhance adoption and continued use of technology. Adoption of technology is accompanied by cost; therefore, access to credit helps farmers especially smallholder farmers to adopt the technology and also participate in input markets which will improve productivity and profitability. Access to credit increased the likelihood of adopting fish farming technologies in Nigeria (Olaoye *et al*., 2016). Extension service is an important variable that distinct adoption status amongst fish farmers. Most of the agricultural technologies are facilitated through extension system. Participation in demonstrations, trainings and field day offer opportunities for acquisition of relevant information which promotes technology adoption. Fish farmers that were frequently visited by extension officers were reported to have more relevant information which enhanced their likelihood of adopting fish farming technologies (Asiedu *et al*., 2017).

Consistent aquaculture policies with proper enforcement mechanisms promote investment as well as technology adoption. Policy interventions like input subsidies, credit programs and affordable interest on loans provide incentives for technology adoption by farmers and attract potential investors (Feder *et al*., 1985). Thus, farmers who have access to aquaculture policy information were hypothesized to adopt and continue use of cage tilapia farming. Group membership influence adoption of technologies. Farmers who belong to farmer groups or cooperatives have higher bargaining power, social capital and better access to information as compared to individual farmers.

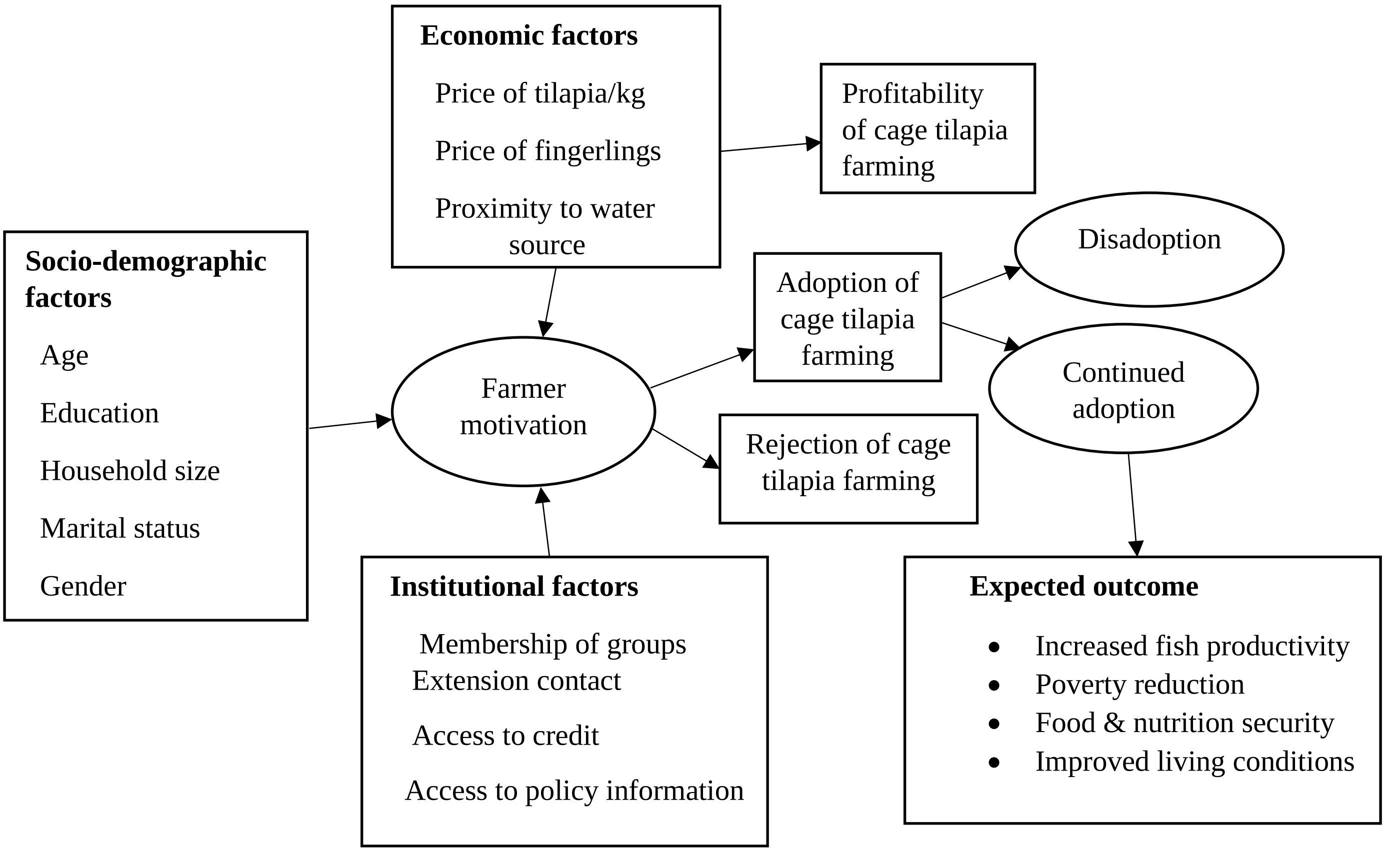

Figure 3.1: Conceptual framework showing the linkages between factors that influence adoption/disadoption and profitability of cage tilapia aquaculture

Source: Author's conceptualization

Socio-demographic factors such as age, education, household size, marital status and gender influence the adoption behaviour among farmers. Fish farming requires technical and scientific knowledge. Farmers with higher levels of education have more knowledge, skills and access to information than those farmers with low or no formal education. Therefore, farmers with higher level of education are more likely to adopt new technologies. A study conducted by Maddassir *et al*. (2016) on awareness and adoption of fish farming technologies in Hafizadab, Pakistan showed that level of education as well as age of the farmers had significant relationship with adoption of aquaculture technologies.

Household size was hypothesised to influence aquaculture technology adoption. The availability and existence of active labour force in rural households is likely to influence adoption of technologies. However, this depends on the characteristics of the given technology. For instance, labour demanding technologies are likely to be adopted by larger households. Gender is one of the important factors that influence aquaculture technology adoption. Women are less zealous in the adoption of agricultural technology (Adesina and Chianu, 2002). However, society placed varying tasks amongst female and male members of households, especially in rural settings of Ghana. The prevailing cultural norms and values in rural settings give men the freedom of movement, participate in various trainings and meetings. Consequently, these men who have more access to information on fish farming technologies are more likely to adopt cage fish farming than females who are constrained by social norms and traditions. Moreover, the role of women in fish farming is found in post-harvest sector as processors and marketers.

Economic factors such as price of fingerlings, market price of harvested tilapia and proximity to water source (Lake Volta) influence adoption as well as the profitability of cage tilapia aquaculture. Market prices of output and input influence the relative profitability and adoption behaviour of farmers with regards to technologies (Feder *et al*., 1985). Price of fish and fish products as well as perceived profitability of fish farming technologies were major economic factors that influenced aquaculture technology adoption decision (Kumar *et al.*, 2018). For instance, the proportion of land allocated to split-pond system improved under stable output price conditions on catfish farms (Kumar and Engle, 2017b). Fish farmers who are closer to the Lake Volta are more likely to adopt and continue use of cage tilapia farming.

Adoption and continued use of cage tilapia farming will benefit not only the producers but all actors in the tilapia value chain and the nation at large. Adoption and continued use of cage tilapia farming provides employment and improves household income leading to poverty reduction. Improvement in fish productivity as a result of adoption will promote food and nutrition security.

3.2 Study Area

This study covered Greater Accra and Eastern regions of Southern Ghana. It was done in three Districts.

3.2.1 Shai Osudoku District

The Shai Osudoku District, formerly known as Dangme West District of the Greater Accra Region occupies a land area of 968.361 km^2 (GSS, 2014) with Dodowa as the capital. The District has a maximum temperature of 40^o C, usually between November and March. It is characterized by low and erratic rainfall pattern with average yearly rainfall of 762.5 - 1220 cm. The District shares boundaries to the North East with North Tongu District, Manya and Yilo Krobo Municipals to the North West, to the West is Akwapim North District, to the South West is Tema Metropolitan, Dangme East District to the East and the Gulf of Guinea to the South (MoFEP, 2011). The District is endowed with a 37 km coastline and a 22 km stretch of the Volta River flowing along the Northern to Eastern borders of the country, where most tilapia farms are located. Agriculture is the major economic activity employing 58.6 percent of the population. The Asutuare area of the district serves as a major location for most large-scale cage tilapia farms providing employment for the people, especially the youth. The fisheries industry employs close to 4 percent of the population (GSS, 2014).

3.2.2 Lower Manya Krobo District

The Lower Manya Krobo District is located in the Eastern part of the Eastern Region along the South-Western corner of the Volta River. It lies between latitude 6.05^0S and 6.30^0N and longitude 0.08^0E and 0.20^0W. It is bordered to the North-East by Kwahu West Municipal, to the North-West by Fanteakwa, to the South-West by Dangme West, to the East and West by Asuogyaman and Yilo Krobo Districts respectively and to the South-East by North Tongu District. The District covers an area of 1,476 km^2, constituting about 8.1 percent of the total land area within the Region (18,310 km^2), with Odumase Krobo as its capital. The Lake Volta stretched along the District which makes it conducive for aquaculture production. Agriculture (crop, livestock and fisheries) constitute the major economic activity providing employment for the people. A section of the population earns their living through fishing and fish farming on the Lake Volta (GSS, 2014). The Agormanya market serves as the major fish market in the area (GSS, 2014).

3.2.3 Asuogyaman District

The Asuogyaman District of the Eastern Region is located between latitudes 6º 34º N and 6º 10º N and longitudes 0º 1º W and 0º14E with Atimpoku as its capital. The District is about 120m above Sea Level and occupies a land area of 1,507 km^2, which constitute about 5.7 percent of the total area of the Region. The District shares borders with Afram Plains South District to the North, Upper and Lower Manya Krobo Districts to the South and West respectively and with Kpando, North Dayi, Ho and the North Tongu Districts to the East. The District generally has an undulating topography, mountainous and interspersed with low lying plains to the East and the West. The Lake Volta cuts through such ridges of the District. The District has a bimodal rainfall pattern with the major season occurring from May to July and the minor season starting from September to November. Annual rainfall is between 67mm and 1130 mm and average temperature of 29ºC. Relative humidity ranges between 31% and 98% (GSS, 2014). The hydroelectric dam (Akosombo Dam) that generate power to the entire country is located in the District.

Agriculture is the major economic activity that generates employment and rural income to about 75% of the working population in the District. The Asuogyaman District forms the major location for cage fish farming. Fish farming and fishing in general in the Volta Lake forms an important part of the agriculture sector and is done in most communities along the 141 km shoreline (MoFEP, 2011).

3.3 Research Design

This study employed both qualitative and quantitative research designs to collect data on why farmers, especially smallholder farmers are disadopting cage tilapia farming despite its potential benefits. Both the quantitative and qualitative research approaches used in this study employed a cross-sectional survey design to collect data from the sample at a specific time. The quantitative data collected through questionnaire administered to households was used for the analysis.

3.4 Sampling Procedure and Data Collection

3.4.1 Sampling Procedure

A multi-stage sampling procedure was used to identify the respective respondents. In the first stage, Eastern and Greater Accra regions were purposively selected due to high concentration of tilapia farming. Lower Manya Krobo, Asuogyaman, and Shai Osudoku Districts were also selected purposively in the second stage from the two Regions. The choice of these Districts was based on similar characteristics and therefore can be regarded as one study area. In the third stage, 11 fish farming communities along the Lake Volta were randomly selected by the help of field officers from Akosombo and Asutuare fishing zones. Due to homogeneous characteristics of the selected communities, systematic random sampling procedure was used to select at least 18 households from each community to arrive at the desired sample of 206. Out of the 206 respondents, 55 were current cage tilapia farmers, 53 were cage tilapia farmers who had abandoned their cages and 98 were potential adopters (non-adopters) of cage tilapia farming who had never practiced cage fish farming.

Anderson, *et al*. (2011) posit that a sample size of an unknown population can be estimated as follows:

$$n = \frac{p(1-p)Z^2}{E^2} \qquad (2)$$

Where:

n = sample size

p = proportion of target population that is not known

Z = confidence interval

E = allowable margin of error.

Anderson *et al*. (2011) recommended 0.5 standard deviation for unknown population.

P = 0.5, Z = 1.96, E = 0.0682

$$n = \frac{0.5(1-0.5)1.96^2}{0.0682^2} = 206$$

3.4.2 Data Collection

Key informant interviews (KII) were carried out to obtain meaningful insight from various stakeholders such as tilapia farmers, farmer organizations, fish traders, community leaders and government officials regarding tilapia production and marketing. These interviews were helpful in identifying relevant variables of the study. The KII and pretesting of questionnaire helped to restructure the questionnaire based on the findings. Thus, merged similar questions, deleted irrelevant questions and rephrased questions appropriately.

Semi-structured questionnaires were used to collect data from household member who is a cage fish farmer, has abandoned cage fish farming or has never practiced cage fish farming (fish monger, fish trader, fisherman, etc). Data were collected on household characteristics, access to credit, sources of finance, group membership, tilapia production management practices and marketing information, extension contacts, access to aquaculture policy information and distance to the Lake Volta and the nearest hatchery. Five enumerators were employed and trained based on their qualification and data collection experience. Fluency in the local languages and familiarity with the study region were also taken into account in selecting the enumerators. Open Data Kit tool (ODK) was used for direct data entry.

3.5 Data Analysis

Data were analysed using both descriptive and econometric model. Statistical packages and programmes used were STATA 14 and Microsoft Excel.

3.5.1 Profitability Analysis of Cage Tilapia Farming

To determine the profitability of cage tilapia farming, gross margins (GM) and net fish income (NFI) were employed as performance indicators of interest. Gross margin was obtained by subtracting the total variable costs (TVC) from the total revenue (TR). It was calculated in terms of ratio as total sales revenue minus the total variable cost, divided by the total sales revenue. The gross margin ratio depicts the percent of total revenue that a farmer holds after incurring the costs related to the production and making tilapia available to consumers.

Gross margin was expressed as:

$$GM = TR - TVC \quad (3)$$

where GM, is gross margin, TR is total revenue and TVC is total variable cost.

Gross margin ratio was expressed as:

$$GMR = GM/TR \quad (4)$$

where GMR, is gross margin ratio, GM, is gross margin and TR is Total revenue.

Production costs were classified as fixed and variable costs (Engle and Neira, 2005). Variable costs are expenses that are paid and differ with quantity of tilapia produced while fixed costs are independent of production (Nunoo *et al*., 2014). Total variable cost in this study include cost of fingerlings, feed, labour, transportation and other cost. The other cost component of the variable cost includes harvest cost, occasional net mending and communication costs. Fixed cost incurred in cage fish farming includes cage, canoe, platform for sorting fish, building for feed storage and interest on loan where applicable. Miscellaneous cost constituted such cost as permit as well as other documentation requirements and oxygen meter. Fixed cost components were fully depreciated using the straight-line depreciation method. Cages and canoes were depreciated on the average, over five years. Total cost was the sum of total variable costs (TVC) and total fixed costs (TFC).

Total revenue (TR) was computed as the quantity of tilapia harvested per cage (Q), multiplied by the unit price (P) of tilapia (farm gate price), (price/kg). Tilapia eaten at home, given out as gift and paid out in kind were included in the total tilapia output (Q). This followed Asmah (2008), who included fish paid out in kind and eaten at home in total fish output. The net fish income (NFI) indicate profit and it was estimated both over total fixed cost (TFC) and total variable cost (TVC). Engle (2012) postulated that it is economically viable for an enterprise to remain in production as far as the net return above total variable cost is positive.

Net fish income was calculated as:

$$NFI = TR - TC \quad (5)$$

where NFI (Profit) is net fish income, TR is total revenue and TC is total cost.

3.5.2 Assessing Determinants of Adoption and Disadoption of Cage Tilapia Farming

In modelling determinants of adoption and disadoption, past studies employed multinomial logit (MNL) model and single equation models like the logit and probit models. For instance, Grabowski *et al*. (2016) employed multinomial regression model to analyse determinants of adoption and disadoption of conservation agriculture (CA) in Zambia. However, the decision to disadopt a technology only happens at a later stage after the farmer has adopted the technology. The MNL assumes that all the unordered choices are available to the decision maker at the same time. In the case of adoption and disadoption, the farmers can only decide to disadopt after initial adoption. This would suggest refuting the multinomial logit regression model, and to choose a Heckman's sample selection model to correct for selectivity bias.

Farmer's decision to adopt or disadopt cage tilapia farming follows a two-step process. The first stage involves the decision to adopt cage tilapia farming or not while the second stage deals with the decision to continue adoption or disadopt cage tilapia farming among those who had adopted. The second stage of disadopting cage tilapia farming is a sub-sample of the first (adoption of cage tilapia farming). It is therefore likely that the sub-sample used in the second stage is non-random and necessarily different from the first (which included farmers who did not adopt cage tilapia farming), which creates a sample selection bias (Deressa *et al*., 2011). Thus, two-step regression models such as Heckman's sample selection model is required (Heckman, 1976) to correct for selection bias made through the farmer's decision-making process.

In the current study, the Heckprobit model was employed to correct for sample selection bias (Van de Ven and Van Praag, 1981). The dependent variables in both the selection and outcome equations are binary. The determinants of adoption and disadoption of cage tilapia farming were analysed in the selection and outcome equations respectively. The Inverse Mills Ratios (IMR) were included in the outcome equation to correct for non-exposure bias (Heckman, 1979), since the sub-sample used in the outcome equation was non-random and necessarily distinct from the selection equation (which included farmers who did not adopt cage tilapia farming).

Past studies including Daressa *et al*. (2011), Muema *et al*. (2018) and Asrat and Simane (2018), employed Heckprobit to analyse farmer's perception and adaptation to climate change. To achieve accurate results, it is expected that the selection equation should include at least one variable (instrumental variable) that is not included in the outcome equation (Sartori, 2003).

Model specification

The Heckman sample selection model assumes the existence of an underlying relationship, also known as latent equation:

$$Y_j^* = X_j\,\beta + u_{1j} \tag{6}$$

such that only the binary outcome is observed, which is a mirror reflection of a probit model:

$$Y_j^{probit} = (Y_j^* > 0) \tag{7}$$

The dependent variable, however, is not always observed. Rather, the dependent variable for observation

$$Y_j^{select} = (z_j\gamma + u_{2j} > 0) \quad (8)$$

where

$u_1 \sim N(0, 1)$

$u_2 \sim N(0, 1)$

corr (u_1, u_2) = ρ

Where Y_j^{select} represents whether a farmer has ever adopted cage tilapia farming or not, z is a vector of explanatory variables expected to influence adoption; γ is the estimated parameter, u_{2j} represents the error term and u_1 and u_2 are the normally distributed error terms with zero mean and unit variance. Thus, the selection equation (Equation 8) is the first stage of the Heckprobit model which represent farmer's decision to adopt cage tilapia farming. Equation 6 represents the outcome equation of disadoption of cage tilapia farming conditional upon adoption of cage tilapia farming.

When ($\rho \neq 0$), the standard probit techniques applied to the first equation yield biased results (Asrat and Simane, 2018; Van de Ven and Van Praag, 1981). This study therefore considered that Prob (Y1 = 1) = Prob (u_{2i} > -αZ_i) = Prob (αZ_i) = Φ (αZ_i), where Φ represent the cumulative distribution at αZ_i. Hence:

$$E[Y2 | Y1] = \beta X_i + \rho\sigma\lambda_i(\alpha Z_i) \quad (9)$$

where λ_i = Φ (αZ_i) / Φ (αZ_i), Φ is the probability density function at αZ_i. λ_i represents the inverse mills ratio (IMR) which is the ratio of value of density function of standard normal distribution αZ_i and the probability of being in the sub sample with adoption which is similar to cumulative distribution value at αZ_i for the farmers who have adopted cage tilapia aquaculture and a complement of 1 for farmers who have not adopted. On the other hand, $\rho\sigma$

represents the regression coefficient on IMR, $\beta\lambda$. Therefore, IMR was included in the second stage equation (Equation 6) to correct for the selectivity bias. Thus, the Heckprobit offers consistent, asymptotically efficient estimates for all the parameters in such models. The Heckprobit requires that the selection equation should include at least one variable that is not in the outcome equation for a well identified model. Otherwise, only the functional form of the model is identified and the coefficients have no structural interpretation.

The dependent variable of the selection equation represents whether a farmer has adopted cage tilapia farming or not while the outcome equation is whether a farmer has disadopted cage tilapia farming or otherwise. The explanatory variables constitute socio-demographic, economic and institutional factors chosen based on past studies (Ansah, 2014; Kumar *et al.*, 2018) and observations made in the study area during the field survey.

3.6 Justification of Explanatory Variables included in the Heckprobit Model

The explanatory variables are presented in Table 3.1

Age of the respondent: This variable has shown conflicting results with regards to technology adoption behaviour of farmers. For instance, Kashem (2005) reported significant negative relationship between age and adoption of fish farming technology in Bangladesh. On the other hand, Okoronkwo and Ume (2013) found older farmers to be more likely to adopt new technology as compared to younger farmers. The authors associated this to the fact that older farmers have better access to credit, more extension contacts and higher capital accumulation. It is therefore hypothesized that age will have either negative or positive correlation with both adoption and disadoption of cage tilapia farming.

Education: The educational background of farmers was expected to have a positive and a negative influence on adoption and disadoption of cage tilapia farming respectively. Fish farmers with better education had more knowledge and skills leading to adoption of new technologies and efficient application of inputs in the fish production process in Cameroon (Wandji *et al.*, 2012). Similarly, Okoronkwo and Ume (2013) found fish farmers in Nigeria with better education to be more likely to adopt improved fish farming technologies as compared to their counterpart with little or no formal education.

Table 3.1: Variables included in the Heckprobit model and expected signs

Variable	Description	Expected sign for adoption of CTF	Expected sign for disadoption of CTF
Age	Age of respondent in years	+/-	+/-
Education	Years of schooling	+	-
Credit	Access to credit (Yes =1, 0 no access)	+	-
Polaware	Access to policy information (yes=1, 0 otherwise)	+	-
Price/kg	Price of harvested tilapia	+	-
Extserv	Access to extension service (yes=1,0 otherwise)	+	-
Distancewater	Distance from water source (km)	-	+
Memgrp	Membership of farmer groups (yes=1, 0 non-member)	+	-
Fingerlingcost	Cost of fingerling (GhȻ)	-	+
Distancefingerlings	Distance from the nearest hatchery (km)	-	+
Landsize	Size of land owned (acres)	-	*

Note: * shows that the variable land size (instrumental variable) was not included in the outcome equation and CTF represents cage tilapia farming

Source: Author's conceptualization

Access to credit: Access to credit is hypothesized to improve adoption of cage tilapia farming but discourage disadoption. Access to credit helps farmers especially smallholder farmers to adopt new technology and participate in input markets to improve productivity (Feder *et al*., 1985).

Proximity to water source and fingerling suppliers (hatcheries): These variables were found to facilitate technology adoption (Kumar, 2015). Fish farmers who are close to hatcheries and other input markets will incur less transportation cost leading to improved profitability. It is therefore expected that distance to the nearest hatchery and water source (Lake Volta) will reduce adoption of aquaculture technology and encourage disadoption.

Access to policy information: Government policy interventions like input subsidies, credit programs and affordable interest on loans provide incentives for technology adoption by farmers (Feder *et al.*, 1985). They further posit that policies that target small scale farmers are more likely to improve technology adoption. However, farmers can only take advantage of this intervention when they have enough information about their existence and how to access them. It is therefore expected that access to aquaculture policy information will improve the likelihood of adopting cage tilapia aquaculture but reduce disadoption.

Market price of tilapia and fingerlings: These variables are important factors that influence farmers perception on profitability. Perceived profitability was found by D'Emden *et al*. (2006) to be a very important factor in predicting adoption behaviour of farmers. Proportion of land allocated to split-pond system improved under stable output price conditions on catfish farms (Kumar and Engle, 2017b). It is hypothesized that falling prices of fingerlings and increase tilapia prices have higher likelihood of enhancing adoption of cage tilapia aquaculture. On the other hand, increased fingerling price and reduced tilapia price have a positive correlation with disadoption.

Extension contacts: Extension contacts play a very important role in technology adoption behaviour of farmers. It is expected that fish farmers who had access to extension services are more likely to adopt cage tilapia farming. Small-scale farmers in Zashuke, who had access to extension services were found to have better potential of adopting no-till conservation Agriculture (Ntshangase *et al*., 2018).

Membership of farmer groups: Farmers who belong to farmer groups have better access to information relevant to fish production and new technologies. Collective action of farmer associations also decreases the transaction cost associated with accessing technology and market information leading to improvement in fish farmers bargaining power regarding fish price determination. Fish farmers who belong to farmer groups were more likely to adopt aquaculture technologies (Asiedu *et al*., 2017). Wholesalers also prefer buying from farmers who are in groups due to ease of fish quality standard enforcement and economies of scale.

Land size: Ownership of farm land was expected to reduce the likelihood of adoption of cage tilapia farming. Cage fish farming is done on the Lake Volta in Ghana. Farmers who have larger farm land are more likely to invest in crop farming than aquaculture.

3.7 Diagnostic Tests of the Model

3.7.1 Heteroscedasticity

This is the situation in which the variance across the error terms are not constant. The presence of heteroscedasticity causes inefficient estimates. This study employed the Breusch-Pagan Test to detect the presence of unequal variance in the regression model (Greene, 2000).

3.7.2 Multicollinearity

This is the state where the explanatory variables are highly correlated to each other. Multicollinearity problem can lead to high standard errors, magnitude of the coefficients and variation in signs in the regression analysis. According to Gujarati (2004), the Variance Inflation Factor (VIF) can be used to test for the presence of multicollinearity among the explanatory variables. If the variance Inflation Factor of any of the explanatory variables exceeds ten, it must be dropped from the model since it reveals the existence of close correlation (Gujarati, 2004). To ascertain whether there is a strong linear relationship between the independent variables, Pearson correlation matrix test was performed.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic and Socioeconomic Profile of Respondents

The demographic and socioeconomic characteristics of the respondents are presented in Table 4.1. The mean age of respondents (pooled) was 40.53 years (range = 19-88) and a standard error of 11.64. The age of respondents was significantly different between adopters and disadopters (p=0.04) and also between non-adopters and disadopters (p=0.07). The farmers in the study area were amongst the active population of the country. Adoption decisions require maturity and adventure which is among the characteristics of persons who fall within this age category. On the other hand, the higher mean age (43.58) of disadopters shows that older farmers are more likely to abandon cage tilapia farming. This may be attributed to the tedious nature of cage fish farming. This result is in line with findings of Asmah (2008) and Anane-Taabea *et al*. (2015) who reported that fish farmers in Ghana are among the active and productive population. This finding also agrees with Chuchird *et al*. (2017) who found older farmers in Thailand to be less likely to adopt agricultural irrigation technologies.

The average years of schooling of respondents (pooled) was about 8 years and a standard deviation of 3.98. The years of schooling was significantly different between adopters and non-adopters (p=0.001). This implies that majority of the farmers had attained basic education, made compulsory by the Government of Ghana (GOG). The lower mean years of schooling (6.87) for non-adopters implies that education is likely to support adoption. Educational level of respondents is a bit low and this may have a negative effect on adoption of aquaculture best management practices and adoption of new tilapia aquaculture technologies. Education of fish farmers is very crucial for the development of the fisheries sector as the educational level of fish farmers is thought to affect skill development, knowledge level and adoption levels of improved aquaculture technologies (Asmah, 2008). This result is in line with Antwi *et al*. (2017) who reported that majority of tilapia farmers in Southern Ghana had attained middle school level of education.

Table 4.1: Demographic and socioeconomic profile of respondents

Variable	Adopters n = 55	Disadopters n = 53	Non-adopters n = 98	Pooled n = 206
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age of respondent	38.40[a**]	43.58	40.53[b*]	40.53
	(12.30)	(10.28)	(11.79)	(11.64)
Years of schooling	8.69	7.81	6.87[c***]	7.59
	(4.31)	(3.85)	(3.75)	(3.98)
Household size	5.13	4.92	4.85	4.94
	(2.86)	(2.11)	(2.12)	(2.33)
Distance to the nearest	9.24	9.55[b**]	4.66	7.14
hatchery(km)	(14.53)	(13.66)	(7.66)	(11.67)
Distance to Lake Volta(km)	0.19	0.82	0.24	0.38
	(0.33)	(4.09)	(0.28)	(2.88)
Gender (male =1)	0.94	0.98	0.42	0.70
Group membership (yes =1)	0.27	0.16	0.09	0.16
Married (yes =1)	0.74	0.90	0.80	0.81

Significant groups: [a]Adopters vs Abandoned; [b]Non-adopters vs Abandoned; [c]Adopters vs Non-adopters. Note: figures in bracket represent standard deviation (SD).

Source: Field survey, 2019

The result also reveals a mean household size of about 5 persons. This finding is in line with the nation's average household size of 4.5 (GSS, 2010). Similarly, Ansah *et al*. (2014) reported an average household size of 5 persons for pen fish farmers in the Volta region of Ghana. The average distance to the nearest hatchery was 7.14 kilometers and it was significantly different between non-adopters and disadopters ($p = 0.03$). This result shows that most hatcheries are not located very close to the Lake Volta. Average distance to the water source (Lake Volta) was 0.38 kilometers. This shows that most of the respondents reside close to the Lake. Proximity to source of water is an important factor that influence adoption of best management practices among fish farmers in Southern Ghana (Ansah *et al*., 2014).

Majority (71%) of the respondents were males. Males comprised of 95% adopters and 98% abandoned. This indicates that fish farming in Ghana is dominated by males. The possible reason for male dominance may be attributable to the tedious and energy-demanding nature of fish farming which only few women could cope with. Some activities associated with cage fish farming demand diving and canoeing which discourages many women from adopting cage fish farming. Additionally, discussion with the respondents revealed that most of the fishing communities in the area prohibit women from diving and going to the Lake during menstruation periods. This result agrees with Asmah (2008); Nunoo *et al*. (2014) and Antwi *et al*. (2017) who found fish farming in Ghana to be male dominated. Asmah (2008) attributed the low involvement of women in aquaculture to the fact that men in Ghana are deemed to be the head of household units and farms owned and run by the family are likely to be in the name of the family head. Also, women's role in the fisheries industry is found in the post-harvest sector (Weeratunge *et al*., 2010), as processors and marketers.

Additionally, only 16 percent of the respondents belonged to farmer groups. However, 28 percent of the adopters belonged to farmer groups. This shows that membership of farmer groups is likely to support adoption of cage tilapia aquaculture. Similarly, Chuchird *et al*. (2017) found a positive relationship between group membership and adoption of Agricultural irrigation technologies among rice farmers in Thailand.

The result further revealed that 82 percent of the respondents were married. Detailed analysis show that about 14 percent of the respondents were single and the rest were either divorced or widowed. This may be attributed to the fact that the married have additional responsibility and are likely to adopt improved technologies to increase their income generating capacities for better livelihood. Onumah and Acquah (2010) similarly found over 80 percent of fish farmers in Ghana to be married.

4.2 Access to Support Services

Table 4.2 shows that only 5 percent of the respondents had access to credit. Limited access to credit is likely to have effect on fish productivity as well as adoption levels. This finding concurs with that of Antwi *et al*. (2017) who found tilapia farmers in Greater Accra region of Ghana to have limited access to credit. Similarly, Kwikiriza *et al*. (2018) found cage fish farmers in South Western Uganda to have limited access to credit.

Table 4.2: Percent Access to Support Services

Variable	Adopters n = 55	Disadopters n = 53	Non-adopters n = 98	Pooled n = 206
Access to credit (yes)	7.27	7.55	3.15	5.34
Access to extension (yes)	67.27	35.85	46.94	49.51
Access to aquaculture policies and regulations (yes)	49.09	33.96	6.12	24.76

Source: Field survey, 2019

Furthermore, the results revealed that 50 percent of the respondents had access to extension services. The lower percentage (36%) of access to extension services among disadopters indicates that less extension contact is likely to increase disadoption of cage tilapia farming. This finding is in line with that of Asiedu *et al*. (2017) who found extension access to play a very important role in adoption of aquaculture technologies among fish farmers in the Sunyani fisheries zone in Southern Ghana.

The results also revealed that 25 percent of the respondents had access to Government policy information regarding aquaculture. The lower percentages of access to policy information among disadopters and non-adopters indicate the important role policy plays in adoption of cage tilapia aquaculture. This result corroborates with that of Olaoye and Oloruntuba (2010) who found that Government policy improved adoption of aquaculture technologies in Nigeria.

4.3 Reasons for Abandoning Cage Tilapia Aquaculture

The fish farmers who had abandoned cage fish farming were asked for the reason of abandonment. The result in Figure 4.1 indicates farmers' reasons for abandoning cage tilapia farming. Majority (43%) of the farmers indicated heavy tilapia mortality as the major cause of abandonment followed by lack of funds (32%). High cost of fish feed constituted 15%. Low output levels and theft also constituted 6% and 4% respectively. Low oxygen levels of the Lake Volta, poor water quality and diseases could be possible causes of tilapia mortality. *Streptococcus lake bacteria* was reported by Ragasa *et al*. (2018) as major cause of tilapia mortality in the Lake Volta. High cost of feed could be due to the fact that most commercial fish feed and materials for feed manufacturing in the country are imported. Lack of funding for fish farmers could be associated with the risky nature of cage fish farming. Asiedu *et al*.

(2017) similarly found high cost of feed and lack of funding for fish farmers as major causes of pond abandonment in the Sunyani fishing zone of Ghana. This finding is also consistent with the result of Chinabut (2002) who reported that fish farmers in Thailand had abandoned their cages due to tilapia mortalities.

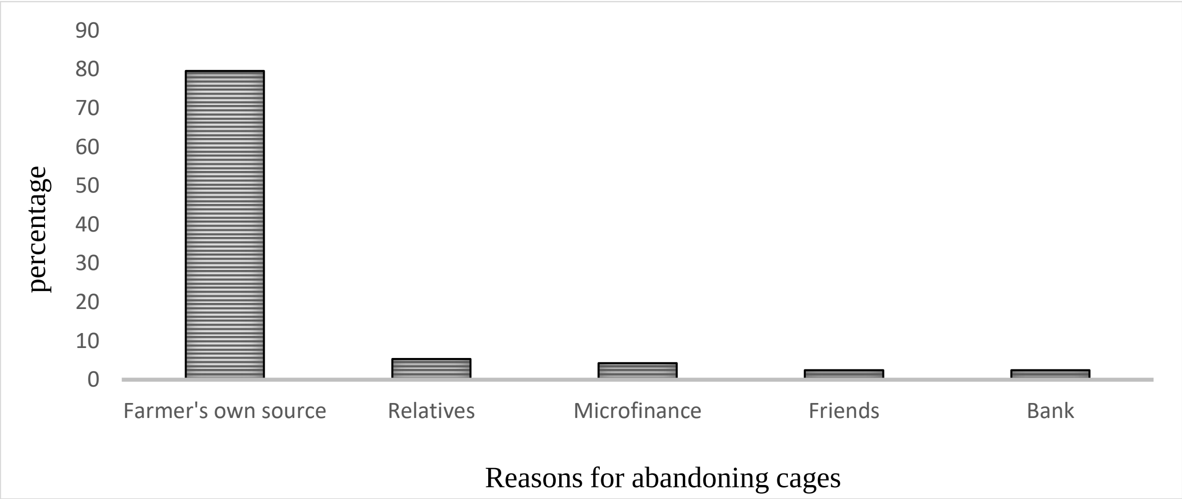

Figure 4.1: Reasons for abandoning cage tilapia aquaculture

Source: Field survey, 2019

4.4 Constraints of Cage Tilapia Aquaculture

The results in Figure 4.2 indicate the constraints faced by tilapia producers. The farmers indicated high cost of feed (38%) as the most pressing challenge followed by lack of funds (22%). The third most pressing constraint was high rates of fish mortality (18%). Other constraints include poor price determination process, poor water quality, theft, poor fingerlings quality, lack of training for fish farmers and lack of extension visit in that order.

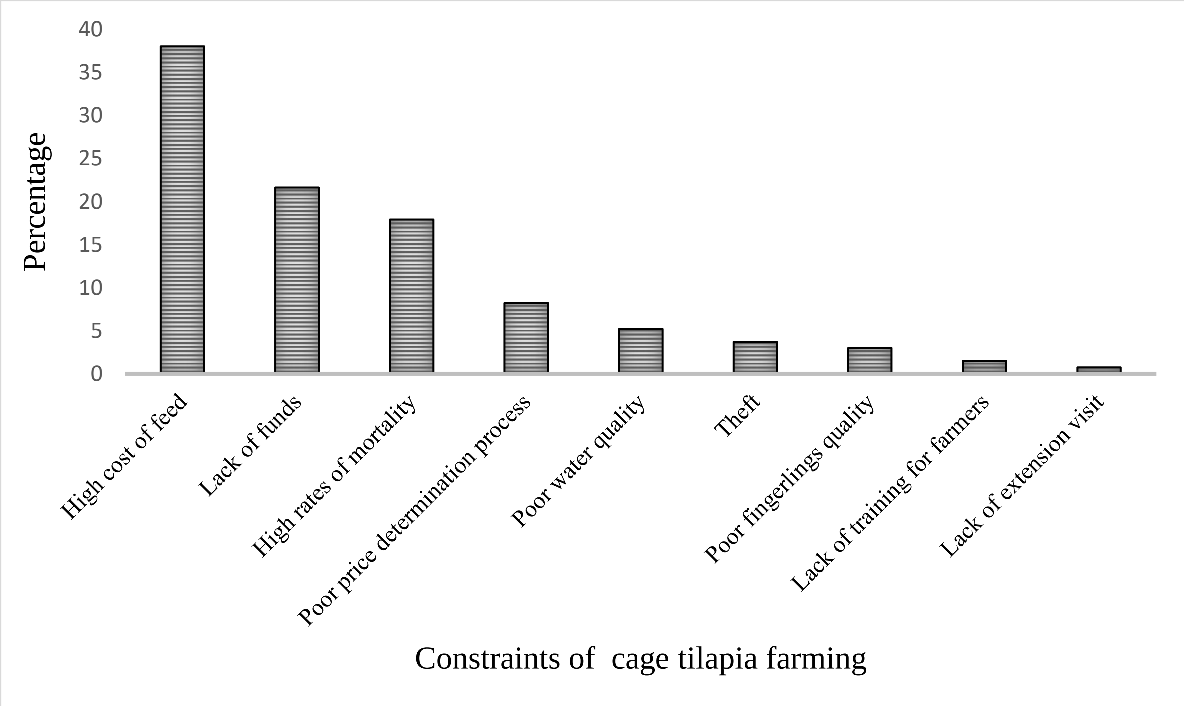

Figure 4.2: Constraints of cage tilapia farming

Source: Field survey, 2019

The high cost of feed may be attributed to the fact that almost all the materials for feed manufacturing are imported alongside few feed-manufacturing mills. Fish farmers try to reduce cost by either opting for a low-quality feed or underfeed the fish, ensuing lower output. Farmers indicated that it is difficult to get investors who are interested in investing in cage tilapia aquaculture. Fish farmers further mentioned that, formal financial institutions have very cumbersome processes and high interest rates, making it difficult to access credit from such institutions. Furthermore, farmers attributed fish mortality to poor water and fingerlings quality. This result confirms the findings of Jansen *et al.* (2019) who reported that above 80% mortality have been reported from affected areas of Tilapia Lake Virus including Sub-Sahara Africa. This result also confirms the report by a number of studies on fish production in Ghana (Asmah, 2008; Anane-Taabea *et al.*, 2015; Antwi *et al.*, 2017 and

Asiedu *et al*., 2017). Due to the high cost of input, fish farmers get low profit margin (Antwi *et al*., 2017) resulting in discouragement from investing in tilapia farming by fish farmers.

4.5 Suggestions Made by Farmers for Addressing Tilapia Farming Constraints

Fish farmers were probed to elicit their suggestions with regards to the constraints in tilapia farming. The result in Figure 4.3 indicates the various suggestions put up by farmers to address the stated constraints. Feed subsidy (41%) was mostly suggested by fish farmers.

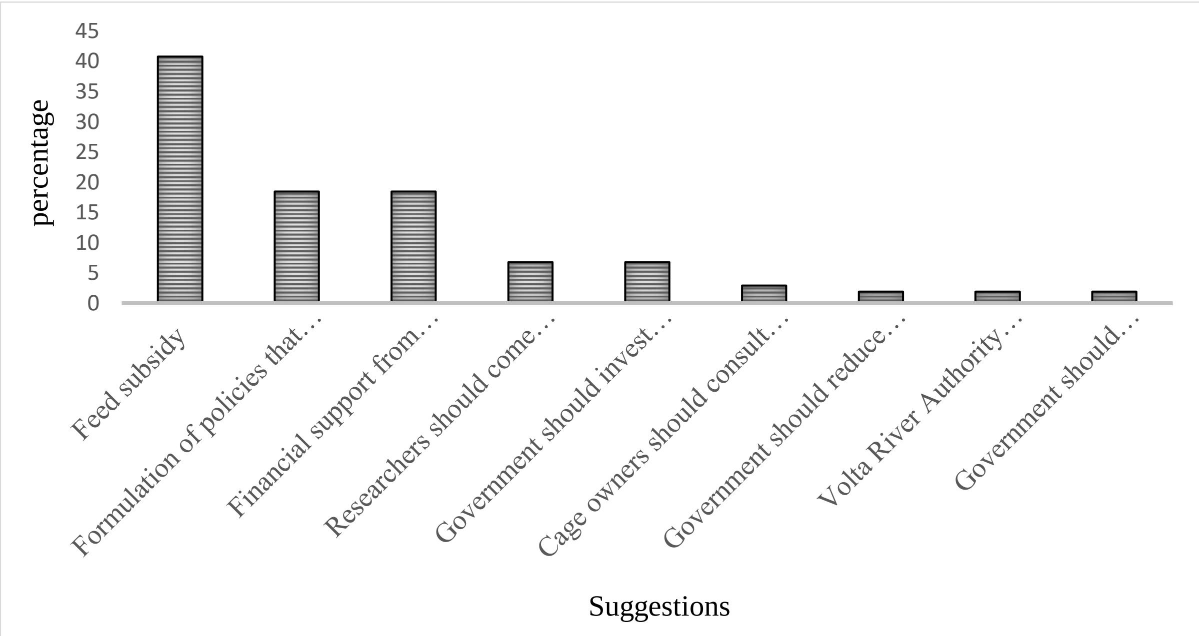

Figure 4.3: Farmers suggestions for addressing tilapia farming constraints

Source: Field survey, 2019

Again, formulation of policies to protect farmers and financial support from government were each suggested by 18% of the respondents. Other suggestions include good tilapia strain that are resistant to diseases, investment in aquaculture research, consultation of community leaders before employing workers to avoid theft, reduction of taxes on imported fish feed and materials, alert from Volta River Authority (VRA) before opening the Dam and simplification of the process of permit acquisition and other documentation processes.

Fish farmers further mentioned that unlike crop farmers who receive fertilizer subsidy and free pesticides spray for cocoa farmers, fish producers do not have such subsidies. Feed subsidy has the potential to attract investors and improve upon the profit margin of fish farmers. It was also mentioned by farmers that current policy is on fisheries in general but not aquaculture.

4.6 Fish Farmers' Perceptions on Cage Tilapia Aquaculture

Fish farmers were probed for their perceptions on cage fish farming. The result in Figure 4.4 indicates that majority (59%) of the farmers perceived cage tilapia aquaculture as profitable. About 14% of the farmers stated that cage fish farming is capital intensive. This result is consistent with that of Naziri (2011) who postulated that establishment of intensive fish farming in Egypt is extremely costly. Additionally, cage tilapia aquaculture was perceived each by 8% of the respondents as risky and difficult. Only about 3% of the farmers perceived cage aquaculture as time demanding. Understanding of farmers' perception about a new technology is very important since adoption decisions are influenced by how potential adopters perceived the new technology.

This finding is in agreement with the findings of Anane-Taabea (2012) who reported that more than half (57%) of fish farmers in Southern Ghana perceived cage fish farming as profitable.

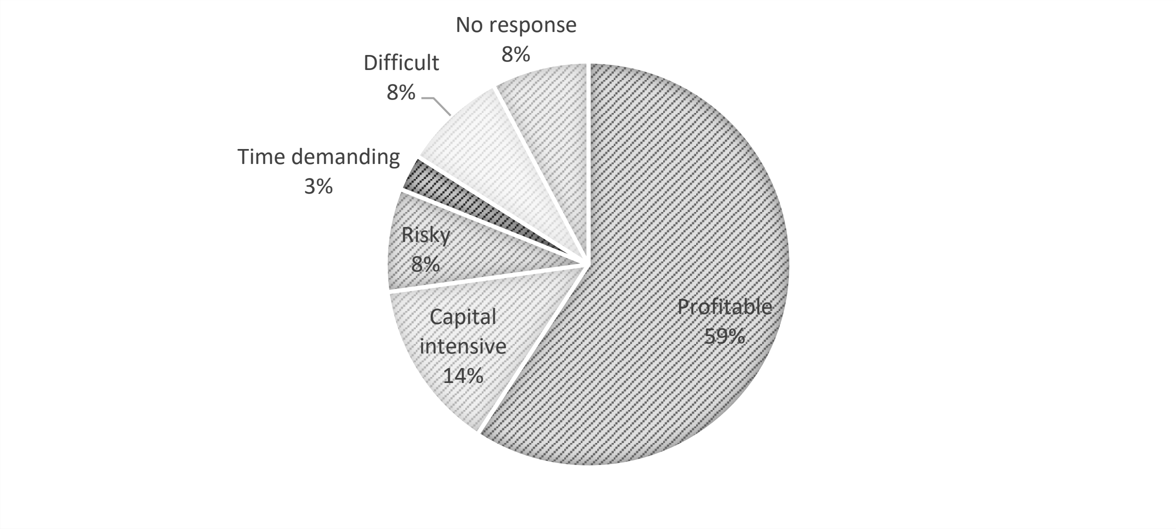

Figure 4.4: Perceptions on cage tilapia farming

Source: Field survey, 2019

4.7 Market Incentives

4.7.1 Price Determination of Harvested Tilapia

Size requirements play a very important role in price determination of tilapia in Ghana. Harvested tilapias are sorted into different sizes and prices are determined based on the sizes. Table 4.3 indicates the sizes of tilapia and their corresponding mean prices per kilogram. Locally known and accepted sizes of tilapia from biggest to the smallest are S2 (size 2), S1 (size 1), Regular, Eco (Economy), SS (Secondary school boys), SB (School boys) and Rejected. The average price per kilogram of "S2" was GhȻ12.50 (US$2.55), "S1" was GhȻ12.00 (US$2.45), Regular was GhȻ11.00 (US$2.24), "Eco" was GhȻ10.20 (US$2.08), "SS" was GhȻ9.00 (US$1.84), SB and Rejected were GhȻ8.50 (US$1.73) and GhȻ7.00 (US$1.43) respectively at the time of the field survey. Overall, tilapia prices were uniform in most of the farms visited. Buyers of fresh tilapia, especially first level wholesalers and retailers furnish fish farmers with their size requirements before fish are harvested and supplied.

Table 4.3: Price determination of harvested tilapia

Size	Description	Weight range (g)	Mean price per kg (GhȻ)	% of preferred size
S2	Size two	800 - 1000	12.5	16.7
S1	Size one	500 – 800	12	25.9
Regular	Regular size	300 – 500	11	3.7
Eco	Economy size	200 – 300	10.2	48.2
SS	School	150 – 200	9	1.9
SB	School Boys	100 – 150	8.5	3.7
Rejected	Rejected size	< 100	7	0

1 USD = 4.9 GhȻ

Source: Field survey, 2019

Fish farmers were further probed for the preferred sizes demanded. The result indicates that "Eco" (48%) was mostly preferred followed by "S1" (26%). About 17% of the respondents indicated "S2" as preferred size, 4% indicated Regular and "SB" while only 2% said "SS". None of the respondents indicated the "Rejected" as preferred tilapia size demanded. Upon interrogation, it was realized that fish traders buy the biggest sizes (S2 and S1) from the large-scale tilapia farmers at relatively lower prices. This could be the reason for the "Eco" being indicated by farmers as the preferred size demanded.

Almost all fish farmers (99%) interviewed sold their harvested tilapia fresh (live). Fish farmers attributed this to the fact that they lacked cold storage facilities, however it also served as cost saving strategy. About 91% of fish farmers had contracts with buyers. Farmers explained that having contracts with fish traders provide ready market, reduce post-harvest loss and give assurance of cash payment at the farm gate. This result is consistent with the findings of Anane-Taabea *et al*. (2015) and Karikari *et al*. (2016) who asserted that tilapia prices in Ghana are set based on the sizes.

4.7.2 Influence over Tilapia Price Determination

The result in Figure 4.5 indicates the levels of influence farmers have over tilapia price determination. The result showed that majority (46.30%) of the respondents had little bargaining power over price determination process. About 44% fish farmers said they had moderate bargaining power, 5% had nearly equal bargaining power and only 2% of the farmers had equal bargaining power. Again, 3% of the fish farmers mentioned that they had no bargaining power over tilapia price determination. It was found upon interrogation that tilapia prices are determined by the large-scale commercial producers. Prices of tilapia could also be affected by periods of shortages. This may also be attributed to the fact that most fish farmers operate individually. Kirsten *et al.* (2008) argued that farmers who belong to farmer associations have high social capital and better bargaining power as compared to individual farmers. This is because farmers who are in groups enjoy economies of scale and have better access to market. Most traders prefer to buy from farmer groups due to relatively lower transaction cost and compliance with food safety measures.

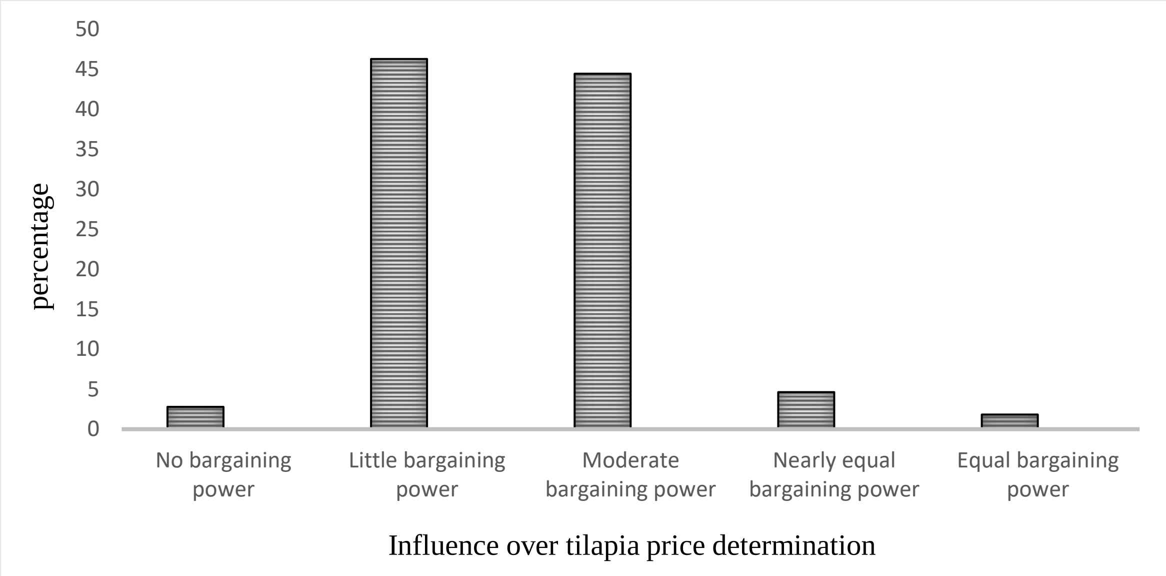

Figure 4.5: Influence over tilapia price determination

Source: Field survey, 2019

4.7.3 Fish Farmers level of Trust for Fish Traders

Fish farmers were asked to rate the level of trust they have with their customers (traders). The result in Figure 4.6 shows that most (42%) fish farmers had little trust for fish traders while 38% fish farmers moderately trusted the fish traders. About 11% and 7% fish farmers had little and much trust for fish traders respectively. Only about 2% of the farmers mentioned that they had very much trust for fish traders. Detailed analysis showed that about 48% of the fish farmers reported that fish traders sometimes failed to pay for tilapia bought. Further interrogation revealed that trust forms the basis for good relationship and contracts between fish farmers and traders. This finding is consistent with that of Anane-Taabea *et al*. (2015) who found tilapia farmers in Ghana to have weak linkages and little trust for fish traders.

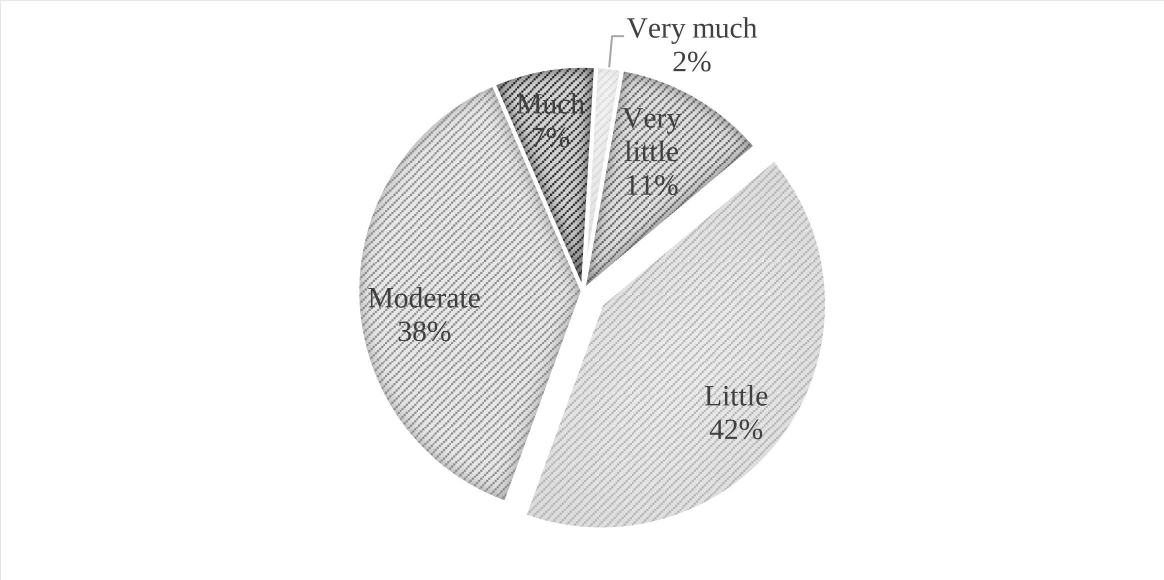

Figure 4.6: Levels of trust with tilapia traders

Source: Field survey, 2019

4.7.4 Quantities and Prices of Tilapia Sold by Farmers to Trader

Three categories (first level wholesalers, retailers, second level wholesalers (village dwellers)) of farmed tilapia traders were identified (Table 4.4). Retailers offered the best price (GhȻ10.17) (US$2.08) per kilogram of farmed tilapia followed by second level wholesalers (village dwellers) GhȻ9.85 (US$2.01). The first level wholesalers offered the least price (GhȻ9.40) (US$1.92); however, they purchased the highest quantity (9,112 kg). It was also identified that some first level wholesalers also retail. Further discussions with farmers revealed that they prefer to sell to first level wholesalers because they buy all the harvested tilapia and also pay cash at the farm gate. Similarly, Anane-Taabea *et al.* (2015) found that commercial tilapia farmers in Ghana sold their fish to wholesalers, retailers and restaurants. Commercial fish farmers in Ghana prefer to sell to wholesalers due to cash payment (Karikari *et al*., 2016).

Table 4.4: Trader category and average quantity and prices of tilapia

Trader category	Mean quantity bought (kg)	Mean price offered (Gh₵) per kg
Retailers	1075.98	10.17
First level Wholesalers	9111.67	9.40
Second level wholesalers (Village dwellers)	12.36	9.85

1 USD = 4.9 Gh₵

Source: Field survey, 2019

4.7.5 Major Sources of Market Information

Farmers were asked to indicate their major sources of market information. It was revealed as shown in Figure 4.7 that, majority (43.52%) of the fish farmers sourced market information from fish traders followed by other fish farmers (30.56%). Close to 18% and 6% farmers sourced market information from farmer associations and the media respectively. Only about 2% of the respondents received market information from government officials. This implies that fish farmers have limited access to market information. Fish farmers level of education and group membership in the study area is relatively low and this could be a possible reason for the limited access to market information.

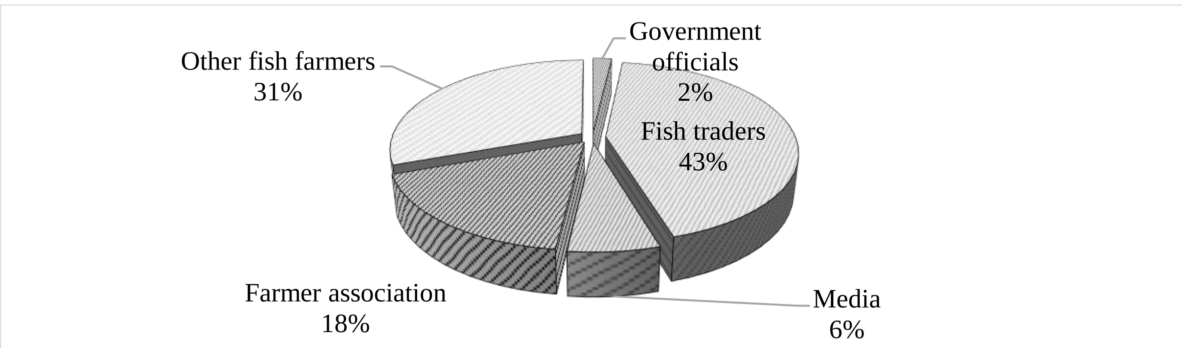

Figure 4.7: Sources of market information

Source: Field survey, 2019

Fish farmers were further probed on ease of access to market information. Figure 4.8 shows how fish farmers rated access to market information. Majority 59% indicated that access to market information was moderate, 33% easy, 6% difficult and 1% very easy as well as very difficult. Ease of access to market information could also be associated with farmers level of education. Nunoo *et al.* (2014) found fish farmers with higher levels of education to have better access to information than their counterparts with little or no formal education.

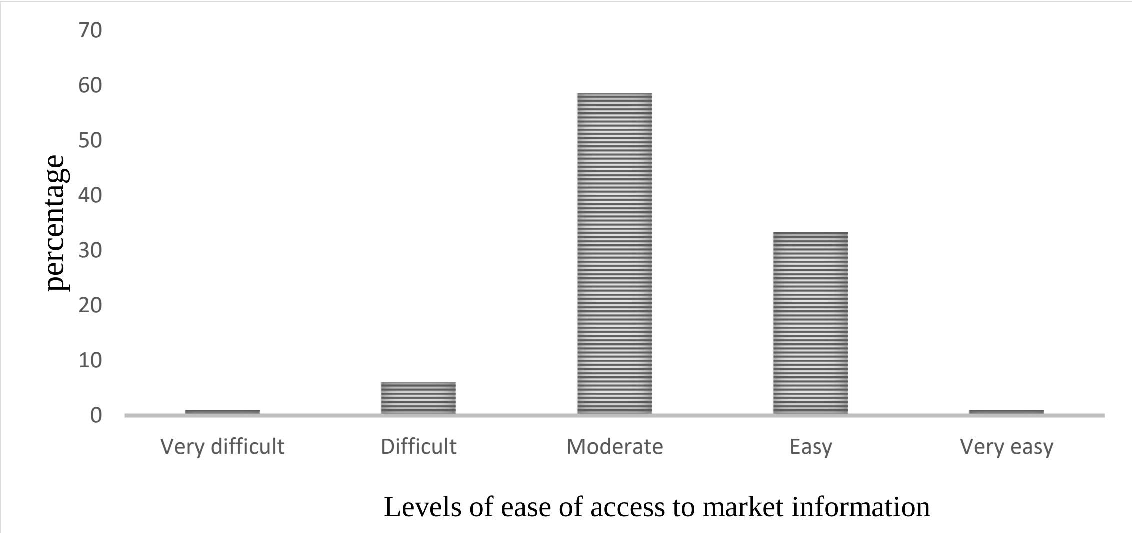

Figure 4.8: Levels of ease of access to market information

Source: Field survey, 2019

4.8 Reasons for Non-Membership of Farmer Groups

The result in Figure 4.9 revealed the various reasons for which farmers did not belong to farmer groups. More than half, 53% of the respondents stated non-existence of farmer groups. Close to 28% of the farmers indicated that they were not interested. Time wasting (11.56%) and corruption in the groups (8%) were also stated as reasons for non-membership of farmer groups. This implies that farmers would have joined the groups if they existed. Kirsten (2008) argued that organisation of farmer associations depends on trust and groups formed by farmers themselves were more likely to be effective.

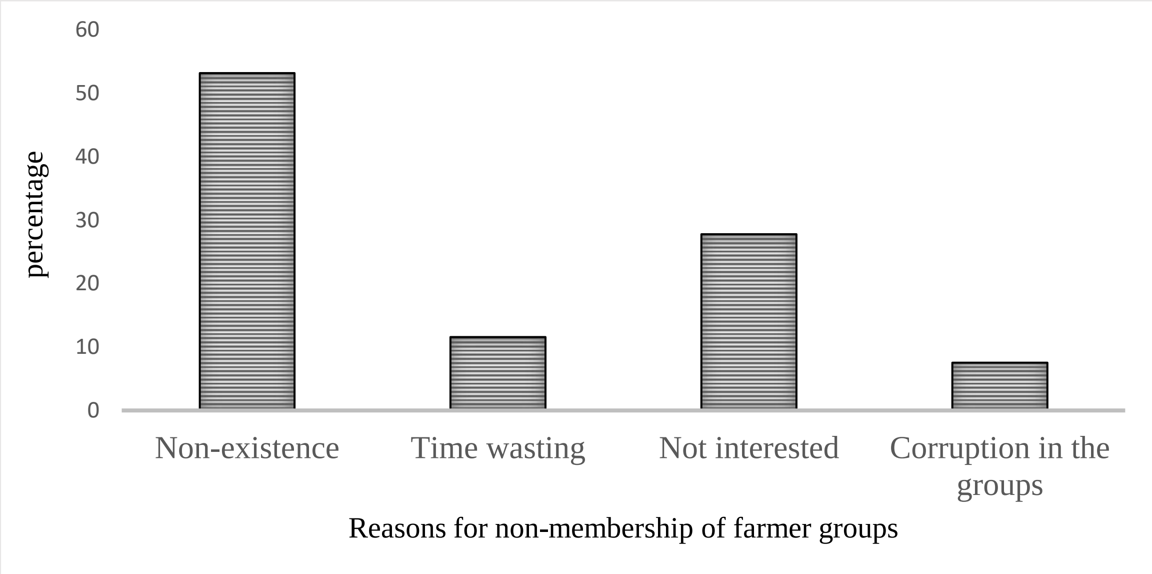

Figure 4.9: Reasons for non-membership of farmer groups

Source: Field survey, 2019

4.9 Sources of Finance for Fish Farmers in Southern Ghana

The result in Figure 4.10 shows the various sources of credit for fish farmers. It was revealed that most (80%) fish farmers used their own funds for tilapia farming. Other sources include relatives, microfinance institutions, friends, money lenders, farmer groups and NGO. Only 2% fish farmers sourced credit from the bank. Further interaction with farmers revealed that cumbersome procedure and high interest rate requirements by the formal financial institutions make it difficult to access credit. Other reasons include the fact that fish farming is very risky, resulting in fear of default. This result agrees with Ansah (2014) and Asiedu *et al*. (2017) who reported that over 70% of fish farmers in Ghana used their own funds for fish production. However, Ansah (2014) reported that, tilapia farmers in Ghana who obtained

50% or more of their operating capital as loans were more likely to produce tilapia at a loss as compared to fish farmers using their own funds who could make up to 50% profit. This may be attributed to the high interest rates on loans from the formal financial institutions.

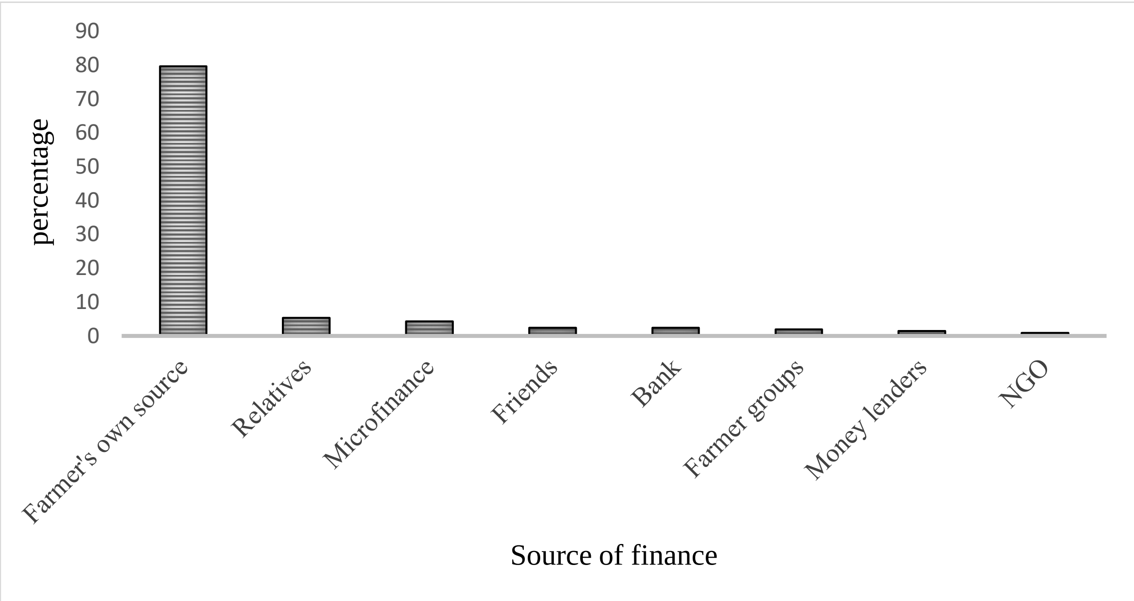

Figure 4.10: Sources of finance for fish farmers

Source: Field survey, 2019

4.10 Profitability of Cage Tilapia Farming

Table 4.5 indicates the cost and returns of an average fish farmer who reared tilapia for one production cycle (6 months) in a 5x5x5(m^3) cage. Total revenue of Gh₵13,939.04 (US$2,844.70) per 5x 5x 5($m^3$) cage was realized. An average quantity of harvested tilapia was 1,322.49 kg sold at an average price of Gh₵10.54 (US$2.15) per kg. The mean weight of tilapia was 300g. The average weight of harvested fish is very important because it has a direct influence on total output. Tilapia eaten at home, given out as gift and paid out in kind were included in the total tilapia output. This followed Asmah (2008) who included fish paid out in kind and eaten at home in total fish output.

Table 4.5: Cost and returns to 5x5x5(m^3) cage for one production cycle (6months)

Item	Description	Amount (GhȻ)	% of total cost
Total revenue	1,322.49 kg @ 10.54per kg	13,939.04	
Variable cost			
Labour cost		604.23	4.61
Feed cost	123.44 bags@ GhȻ77.0 per bag	9,504.64	72.50
Fingerling cost	6,983 @ GhȻ0.16	1,117.28	8.52
Transportation cost		89.95	0.69
Other cost		137.83	1.05
Total		11,453.90	87.37
Gross Margin		**2,550.03**	
Fixed cost			
Cage		841.93	6.42
Canoe		208.52	1.59
Platform		46.08	0.36
Building for feed storage		245.44	1.87
Interest on loan		267.28	2.04
Miscellaneous		46.50	0.35
Total		1,655.75	12.63
Net Fish Income		**829.39**	

1USD = 4.9 GhȻ

Source: Field survey, 2019

Total variable cost comprised labour, feed, fingerlings, transportation and other costs. The other cost component comprised of harvest cost, occasional net mending and communication costs. Fish famers used one or the combination of the following labourers: hired, family and security. A total variable cost of Gh₵11,453.90 (US$2,337.53) was obtained with feed alone constituting 72.50 percent of the total cost of production. Average feed cost per bag (20kg) of commercial feed was Gh₵77.00 (US$15.71). A fish farmer used on average 123.44 bags of feed per one production cycle (6 months). The average unit cost of a 2g fingerling (sex reversed) was Gh₵0.16 (US$0.03). On average, fish farmers stocked 6,983 fingerlings per cage. Transportation cost includes the cost of transporting fingerlings from the hatcheries, feed and other equipment. The results also revealed a positive gross margin of Gh₵2,550.03 (US$520.41).

Total fixed cost included cage, canoe, platform for sorting fish, building for feed storage, miscellaneous and interest on loan where applicable. A total fixed cost of Gh₵1,655.75 (US$337.91) was realised. Total cost of production (TVC + TFC) on average was Gh₵13,109.65 (US$2,675.44). On average, net fish income (NFI) of Gh₵829.39 (US$169.26) per 5m x 5m x5m cage was obtained. This is an indication of a profitable firm. Nunoo *et al*. (2014) obtained a high positive net return for pond fish farmer in the Western region of Ghana. Similarly, FAO (2005) obtained positive net returns for fish producers in Ghana. This result is consistent with that of other studies such as Asmah (2008); Macfadyen *et al*. (2012); and Ansah (2014) who found tilapia farming in Ghana to be profitable. Contrary to this result, Anane-Taabea *et al*. (2015) reported that cage fish farmers along the Lake Volta made losses with a gross margin of US$-6893. They further postulated that input suppliers in the tilapia value chain accrued most of the margins generated along the chain. They attributed the losses to poor price determination process by fish farmers. The finding of this study is also consistent with that of Ansah (2014) who reported an average weight of 300g of harvested tilapia for farmers who used commercial feed. Feed cost constituted over 70 percent of total cost of fish production in Ghana (Anane- Taabea *et al*., 2015; FAO, 2018).

4.11 Determinants of Adoption of Cage Tilapia Farming

The sample selection hypothesis and overall fit of the model was tested to justify the use of Heckprobit over standard probit using STATA 14. The Wald test of independent equations and the level of significance of the coefficient of the rho (Wald chi^2 (1) 6.87, p> 0.008) agree to propose that the null hypothesis of no correlation between the error terms of the outcome (disadoption) and selection (adoption) equations is rejected. This implies that estimating determinants of disadoption without controlling for selection bias would generate biased results. Furthermore, the loglikelihood was significant at 1 percent (Wald chi^2 =162.068, prob > chi2 = 0.000), showing a high explanatory capacity of the model.

The results of the selection (adoption) equation in Table 4.6 showed that access to credit, policy information and extension services positively correlated with adoption of cage tilapia farming. Also, distance to fingerlings source (hatchery) and residing in Shai Osudoku District correlated positively with adoption of cage tilapia farming. On the other hand, land size was found to have a negative relationship with adoption of cage tilapia farming. Specifically, a unit increase in farmers' access to credit improved the likelihood of adoption of cage tilapia farming by 24 percent. Access to credit helps farmers especially smallholder farmers to adopt new technology and participate in input markets to improve productivity (Feder *et al*., 1985).

Furthermore, the result revealed that a unit increase in farmers' access to aquaculture policy information increases the probability of adopting cage tilapia farming by 39 percent. Similarly, Norman *et al*. (2016) reported that access to policy and regulatory incentives have a high potential of attracting investors including farmers to invest in Agriculture in Ghana. Consistent policies with proper enforcement mechanisms promote investment as well as technology adoption (Norman *et al*., 2016). Feder *et al*. (1985) also postulated that policy interventions like input subsidies, credit programs and affordable interest on loans provide incentives for technology adoption by farmers.

Table 4.6: Parameter estimates and marginal effects of adoption of cage tilapia farming

Dependent variable	**Selection Equation (Adoption of cage tilapia farming)**		
Independent variable	**Coef.**	**Std. Err.**	**dy/dx**
Age	0.008	0.055	0.000
Age squared	-0.000	0.001	-0.000
Years of schooling	0.034	0.031	0.009
Access to credit	**0.833***	0.482	0.240
Access to policy information	**1.342*****	0.328	0.387
Price/kg of harvested tilapia	-0.183	0.131	-0.053
Access to extension service	**0.413***	0.212	0.119
Distance from water source	-0.120	0.248	-0.034
Membership of groups	0.074	0.385	0.021
Cost of fingerlings	-1.374	1.424	-0.396
Distance to fingerlings source	**0.877*****	0.316	0.253
Land size	**-0.049*****	0.011	-0.014
District			
Lower Manya	0.530	0.334	0.140
Shai Osudoku	**0.882*****	0.311	0.239
Con	-0.681	2.115	

****** $p<0.01$, ** $p<0.05$, * $p<0.1$.*** **Note: Reference district is Asuogyaman**

Source: Field survey, 2019

The results also showed that access to extension services increased the probability of adoption of cage tilapia farming by 11.9 percent suggesting that extension is instrumental for adoption decision. This result could be attributed to the fact that extension services provided timely and effective information on practices as well as new technologies. Small-scale farmers in Zashuke, who had access to extension services were found to have better potential of adopting no-till conservation Agriculture (Ntshangase *et al*., 2018). Similarly, (Ansah *et al.*, 2014; Asiedu *et al.*, 2017) reported that extension contacts play significant role in technology adoption in Ghana.

Contrary to the a priori expectation, distance to the nearest fingerling source (hatchery) increased the likelihood of adoption of cage tilapia aquaculture. This implies that farmers who are distant from the hatcheries had an increased likelihood of adopting cage tilapia farming. This is because most of the private hatcheries in Ghana are not located close to the Lake Volta. However, cage fish farming is done on the Lake Volta.

Land size reduced the likelihood of adopting cage tilapia farming. Specifically, an increase in the size of farm land by one acre reduced the likelihood of adoption by 1.4 percent. This could be due to the fact that farmers who have large farm land are more likely to invest in crop farming than cage fish farming. Furthermore, the results showed that farmers located in the Shai Osudoku District have more likelihood of adopting cage tilapia farming. This can be attributed to the fact that the district is located closer to most hatcheries, the only fish feed manufacturing mill and major fish markets in the country. Farmers in the district are more likely to receive training and relevant information on aquaculture from these input suppliers which is likely to influence their adoption behaviour. This result concurs with the findings of D'Emden *et al.* (2006) who reported that geographical location has significant influence on adoption of technologies.

4.12 Determinants of Disadoption of Cage Tilapia Farming

The second stage of the Heckprobit model (outcome equation) analysed the determinants of disadoption of cage tilapia farming. The results in Table 4.7 showed that age of respondent and distance from the Lake Volta increased the likelihood of disadopting cage tilapia farming. On the other hand, price of harvested tilapia, membership of farmer groups and cost of fingerlings negatively correlated with disadoption of cage tilapia farming. Specifically, a unit increase in respondent's age by one year increased the likelihood of disadopting cage tilapia farming by 1.2 percent. This implies that older farmers have a higher probability of disadopting cage tilapia farming. The probability of age exhibits decreasing return as shown by its squared term. Cage fish farming requires daily activities such as feeding using canoe and occasional alteration of cage net through diving. Older famers may lack the strength for carrying out such activities. This result corroborates with that of Hassen (2015) who reported that age of farmers increased the probability of disadoption of technologies.

Market price of harvested tilapia per kilogram negatively correlated with disadoption of cage tilapia aquaculture. For every GHC1.00 increase in market price of harvested tilapia, the probability of disadoption decreased by 7 percent. This could be associated with improvement in gross margins. Similar to this result, Wetengere (2011) found significant relationship between choice of fish species among producers in Tanzania and premium related to size and fish price. This finding also concurs with that of Kumar and Engle (2017b) who specified that the proportion of land allocated to split-pond system improved under stable output price conditions on catfish farms.

Table 4.7: Parameter estimates and marginal effects of disadoption of cage tilapia farming

Dependent variable	Outcome Equation (disadoption of cage tilapia farming)		
Independent variable	Coef	Std. Err.	**dy/dx**
Age	**0.058*** **	0.002	0.062
Age squared	**-0.001** **	0.000	-0.001
Years of schooling	-0.001	0.011	-0.002
Access to credit	0.153	0.172	0.064
Access to policy information	0.064	0.125	-0.145
Price/kg of harvested tilapia	**-0.100** **	0.039	-0.070
Access to extension service	-0.022	0.100	-0.040
Distance from water source	**0.278*** **	0.091	0.309
Membership of groups	**-0.261** **	0.121	-0.236
Cost of fingerlings	**-1.618*** **	0.419	-1.360
Distance to fingerlings source	0.130	0.102	0.080
Con	-1.216	0.737	-

****** p<0.01, ** p<0.05, * p<0.1***

Source: Field survey, 2019

Distance to water source (Lake Volta) positively correlated with the likelihood of disadopting cage tilapia farming. Specifically, one-kilometre increase in the distance from the Lake Volta increased the probability of disadopting cage tilapia farming by 30.9 percent. Farmers who are distant from the Lake Volta have a higher likelihood of increased transaction cost which is likely to reduce their gross margins. This finding agrees with that of Wakeyo and Gardebroek (2015) who found a significant relationship between distance to water source and disadoption of pond fish farming technologies in Ethiopia.

The result also revealed that membership of farmer groups reduced the likelihood of disadopting cage tilapia farming. Specifically, farmers who belonged to farmer groups have a decreased probability of disadopting cage tilapia farming by 23.6 percent. This can be due to the fact that fish farmers who are in groups can better be facilitated on demonstration of new technologies. Kirsten *et al*. (2008) emphasised the importance of collective action. Famers in groups have better access to credit and high social capital. Farmers who belong to farmer groups have better prices and higher bargaining power than those who do not (Guthiga & Mburu, 2006).

Surprisingly, market price of fingerlings (seed) negatively correlated with the likelihood of disadopting cage tilapia farming. This is because as adoption increases, demand for fingerlings increases as well, hence the increase in the price of fingerlings and the vice versa. A bioeconomic model developed by FAO, based on experience from China to show how optimal arrangements of farming operations can improve the technical and economic performance of tilapia aquaculture indicated that the cost of seed (fingerlings) and labour has smaller impact on profitability (FAO, 2018).

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND POLICY RECOMMENDATION

5.1 Summary

Fisheries and aquaculture provide livelihood for millions of people around the globe. The fisheries sector in Ghana supports about 10 percent of the population. Ghana is considered one of the highest fish consuming nations in sub Saharan Africa with per capita fish consumption of 26 kg. However, annual fish deficit is about 55 percent leading to persistent importation of fish to supplement domestic supply. Meanwhile the major source of fish supply (capture fisheries) have been declining over the years due to increasing population and over exploitation. Aquaculture development therefore is critical for sustainable fish supply.

The introduction of cage fish farming on the Lake Volta is a means of improving fish productivity. However, low adoption and disadoption of cage fish farming raises concerns about its suitability. Adoption of aquaculture technology has the potential to improve fish productivity but the decision to adopt technology by farmers is complex with several influencing factors. Moreover, a lot of attention have been given to other agricultural technologies while only few studies focused on aquaculture technology adoption. Thus, this study specifically evaluated profitability of cage tilapia farming and assessed demographic, socioeconomic and institutional factors that influence adoption and disadoption of cage tilapia farming among smallholder farmers in Eastern and Greater Accra regions of Southern Ghana.

Multistage sampling technique was used to collect primary data from 206 respondents. Eastern and Greater Accra regions were purposively selected due to high concentration of cage fish farming. Three districts (Lower Manya, Asuogyaman and Shai Osudoku) were selected purposively because of similar characteristics and dominance of cage tilapia farmers.

Eleven communities from the three districts were randomly selected by the help of fisheries officers. Three respondent groups (adopters, disadopters and non-adopters) comprised the selected sample of the study.

Gross margin (GM) and net fish income (NFI) were used as performance indicators for profitability analysis. Heckprobit model was used to analyze determinants of adoption and disadoption of cage tilapia farming.

5.2 Conclusion

The result revealed a positive gross margin and net fish income, indicating cage tilapia farming is a profitable venture. Feed cost constituted the highest proportion of cost of tilapia production. The selection equation of the Heckprobit model showed that access to credit increased the likelihood of adopting cage tilapia aquaculture. The result also revealed that access to aquaculture policy information and extension services increased the probability of adopting cage tilapia aquaculture while land size reduced the likelihood of adopting cage tilapia farming. On the other hand, the outcome equation result revealed that market price of tilapia, membership of farmer groups and cost of fingerlings reduced the likelihood of disadoption of cage tilapia farming while those who lived far from the Lake Volta were more likely to disadopt. Older farmers were found to have an increased likelihood of disadopting cage tilapia farming than younger farmers.

Majority of the respondents had attained basic school education. It was also found that fish farming in the study area is male dominated. Farmers were found to have limited access to credit due to high interest rate and cumbersome procedures for loan acquisition. Majority of the respondents did not belong to any farmer group as a result of non-existence and lack of trust or interest.

The results further revealed high mortality, lack of funds and high feed cost as major reasons for cage abandonment. Majority of the farmers had little bargaining power with regards to fish price determination. Farmers complained that tilapia prices were usually determined by the large-scale tilapia producers. The major sources of market information were fish traders, other fish farmers and farmer associations.

5.3 Recommendations

Based on the empirical results of the study, the following recommendations were made. The result of the study revealed that cage tilapia aquaculture is economically viable and therefore has the potential for job creation and improve the livelihood of fish farmers. Stakeholders in the industry should therefore promote cage tilapia farming to attract potential financiers and investors, especially the youth to venture into cage tilapia farming. The positive influence of access to extension services, aquaculture policy information and credit on adoption of cage tilapia farming shows the need for enhancement of access to these resources. The Government of Ghana and Non-governmental Organizations (NGOs) should provide credit for fish farmers at affordable rates and favorable payment terms. Extension services such as trainings, demonstrations, fish field day and provision of relevant information on policy and new technologies will provide fish farmers with adequate information which will improve their adoption behavior. Currently there are few private extension service providers for fish farmers. The Government of Ghana can partner with private organizations who are interested in investing in cage fish farming to support fish farmers through provision of information and training.

The result also revealed that older farmers were more likely to abandon cage fish farming. Policy instruments should be directed toward young farmers to enhance adoption and productivity. Gender sensitivity should be considered in aquaculture technology formulation in order to encourage women to engage in fish farming. The negative relationship between membership of farmer groups and disadoption of cage fish farming shows the important role farmer associations play in technology adoption. Fish farmers should be encouraged to form farmer groups to facilitate access to information and credit facilities.

5.3.1 Suggestions for Further Research

Further studies should be conducted on adoption of more than one aquaculture technology to give insights on farmers' adoption behavior of other improved aquaculture technologies. Further research should consider more rigorous analyses such as Net Present Value (NPV) for long term investment such as cages.

REFERENCES

Adesina, A. A., & Chianu, J. (2002). Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. *Agroforestry systems*, *55*(2), 99-112.

Anane-Taabeah, G. (2012). *Harnessing the opportunities and overcoming constraints to widespread adoption of cage aquaculture in Ghana.* MSc. Thesis, faculty of the Virginia Polytechnic Institute and State University. Blacksburg, Vsirginia. pp.124.

Anane-Taabeah, G., Quagrainie, K.K., & Amisah, S. **(**2015). Assessment of farmed tilapia value chain in Ghana. *Aquaculture International*. DOI 10.1007/s10499-015-9960-1

Anderson, D. R., Sweeney, D. J. & Williams, T. A. (11^{th} edition) 2011. *Statistics for Business and Economics*. South-Western, Cengage Learning, USA.

Ansah, Y., Frimpong, E., & Hallerman, E. (2014). Genetically-Improved tilapia strains in Africa: Potential benefits and negative impacts. *Sustainability* 6:3697-372.

Ansah, Y.B. **(**2014). *Enhancing the profitability of pond and aquaculture in Ghana through resource management and environmental best management practices*. Virginia Polytechnic Institute and State University, Blacksburg, USA. (PhD dissertation).

Antwi, D. E., Kuwornu, J. K. M., Onumah, E. E. & Bhujel, R. C. (2017). Productivity and constraints analysis of commercial tilapia farms in Ghana. *Kasetsart Journal of Social Sciences* 38 (2017) 282-290.

Antwi-Asare, T. O., & Abbey, E. N. (2011). Fishery value chain analysis—Ghana. *Food and Agriculture Organization, Fisheries*.

Asiedu, B., Nunoo, F. K. E., & Iddrisu, S. (2017). Prospects and sustainability of aquaculture development in Ghana, West Africa. *Cogent Food & Agriculture*, *3*(1), 1349531.

Asmah, R. (2008). *Development potential and financial viability of fish farming in Ghana*. PhD Thesis. University of Stirling, Stirling, UK. pp. 289.

Asmah, R., Karikari, A., Falconer, L., Telfer, T., & Ross, L. (2016). Cage Aquaculture in Lake Volta, Ghana. Guidelines for a sustainable future. Retrieved from https://storre.stir.ac.uk/handle/1893/24680

Asrat P. & Simane B. (2017b). Adapting smallholder agriculture to climate change through sustainable land management practices: empirical evidence from North-West Ethiopia. *J Agric Sci Technol* 7:289–301. https://doi.org/10.17265/ 2161-6256/2017.05.001

Asrat, P. & Simane, B. (2018). Farmers' perceptionof climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes*, 7:7 https://doi.org/10.1186/s13717-018-0118-8

Brooks, S., Gelman, A., Jones, G., & Meng, X. L. (Eds.). (2011). *Handbook of markov chain monte carlo*. CRC press.

Chinabut, S. (2002). A case study of isopod infestation in tilapia cage culture in Thailand. *FAO Fisheries Technical Paper*, 201-202.

Chuchird, R., Sasaki, N., & Abe, I. (2017). Influencing factors of the adoption of agricultural irrigation technologies and the economic returns: A case study in Chaiyaphum Province, Thailand. *Sustainability*, *9*(9), 1524.

Cobbina, R. **(**2010). Aquaculture in Ghana: economic perspectives of Ghanaian aquaculture for policy development. *The United Nations University Fisheries Training Programme, Final Project, 4.*

Dasgupta, S. (1989). *Diffusion of agricultural innovations in village India*. Wiley Eastern Limited, New Delhi, p: 231.

D'Emden, F.H., Llewellyn, R.S. and Burton, M.P. (2006). Adoption of conservation tillage in Australian cropping regions: an application of duration analysis. *Technical Forecasting and Social Change* 73, 630–647.

Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M. & Ringer, C. (2008). Analysing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin of Ethiopia. *IFPRI Discussion Paper* 00798

Deressa, T.T., Hassan, R.M. & Ringer, C. (2011). Climate change and Agricultural Paper: perception of and adaptation to climate change by farmers in the Nile Basin of Ethiopia. *Journal of Agricultural Science*, 149, 23-31, DOI:10.1017/S0021859610000687

Engle, C. R. (2010). Aquaculture economics and financing: management and analysis. Wiley-Blackwell, Ames, Iowa, USA

Engle, C. R. (2012). *Determining the profitability of an aquaculture business: using income statements and enterprise budgets*. Stoneville, MS: Southern Regional Aquaculture Center.

Engle, C. R., & Neira, I. (2005). *Tilapia farm business management and economics: a training manual* (p. 41). Corvallis, OH: Aquaculture CRSP, Oregon State University.

Failler, P., Beyens, Y., & Asiedu, B. (2014). Value chain analysis of the fishery sector in Ghana. *Mission Report, Trade Capacity Building Project for Ghana, UNIDO/MOTI TCB Project, Accra, Ghana*, 106.

FAO (2005) Results of the 2003–2004 Baseline Survey of Ghanaian Fish Farmers. FAO Regional Office for Africa, Accra, Ghana 77pp

FAO. (2012). State of World Fisheries and Aquaculture 2012. Food and Agriculture Organization of the United Nations, Rome, Italy

FAO. (2014). National Aquaculture Sector Overview Ghana, 1999.

FAO. (2016). The state of world fisheries and aquaculture 2016. Contributing to food security and malnutrition for all. Rome. https://doi.org/92-5-105-177-1

FAO. (2018). *The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition*. Rome, FAO

Feder, G., Just, R. E. & Zilberman, D. (1985). Adoption of Agricultural Innovation in Developing Countries: "A Survey". Economic Development and Cultural Change 32: 255-298.

Frimpong, E.A. & Anane-Taabeah, G. (2017). Social and economic performance of tilapia farming in Ghana. *In* J. Cai, K.K. Quagrainie & N. Hishamunda, eds. *Social and economic performance of tilapia farming in Africa*, pp. 49–90. FAO Fisheries and Aquaculture Circular No. 1130. Rome, Italy.

Frimpong, E.A., Ansah, Y.B., Amisah, S., Adjei-Boateng, D., Agbo, N.W. & Egna, H. **(**2014). Effects of two environmental best management practices on pond water and effluent quality and growth of Nile tilapia, *Oreochromis niloticus. Sustainability*, 6: 652–675.

Gachucha, M., Njehia, B., & Mshenga, P. (2014). Opportunities in adoption of commercial fish farming as a new enterprise for small scale farmers in Kisii County, Kenya. *Journal of Advanced Botany and Zoology*, *1*(1), 1-5.

Ghana Business News (GBN). (2015). *Ghana's fsheries sector said to generate more than GH¢1b annually*. Retrieved June 30, 2016, from https://www.ghanabusinessnews.

com/2015/06/11/ ghanas-fsheries-sector-said-to-generate-more-thangh%C2%A21b-annually/

Ghana Statistical Service (GSS). (2008). Ghana Demographic and Health Survey 2008: https://doi.org/10.15171/ijhpm.2016.42

Ghana Statistical Service**. (**2012). *2010 population and housing census–final results*.

Ghana Statistical Service (GSS), Ghana Health Service (GHS), and DHS Program. (2014). *Ghana demographic and health survey 2014* (p. 45). Accra:

Ghana Statistical Service. (2014). *2010 population and housing census report*. Ghana Statistical Service.

Ghana Statistical Service (GSS). (2015). Revised 2015 annual gross domestic product (p.9). Accra.

Grabowski, P.P., Kerr, J.M., Haggblade, S. and Kabwe, S. (2016), "Determinants of adoption and disadoption of minimum tillage by cotton farmers in Eastern Zambia", *Agriculture, Ecosystems and Environment, Vol*. 231, pp. 54-67.

Greene, W. H. (2000). Econometric Analysis, 4th ed. Prentice Hall, Upper Saddle River, New Jersey: Prentice-Hall

Gujarati, D. N. (2004). *Basic Econometrics*. Tata McGraw-Hill Education.

Guthinga, P. and Mburu, J. (2006). Survival of the commons: Mounting Challenges and New Realities. 1-29

Habanyati, E. J., Nyanga, P. H., & Umar, B. B. (2018). Factors contributing to disadoption of conservation agriculture among smallholder farmers in Petauke, Zambia. *Kasetsart Journal of Social Sciences*.

Hassen, S. (2015). “Disadoption, substitutability, and complementarity of agricultural technologies: a random effect multivariate probit analysis”, Environment for Development Discussion Paper Series, EfD DP 15-26, Washington, DC, available at: www.rff.org/files/document/file/EfD-DP-15-26.pdf

Heckman, J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals of Economic and Social Measurement* 5: 475–492

Heckman, J.J. (1979). ‘Sample Selection Bias as a Specification Error’, *Econometrica*, 47(1), 153-162.

Hiheglo P. K. (2008). *Aquaculture in Ghana: Prospects, challenges, antidotes and future perspectives*. Tromso: Department of Social Science and Marketing Studies, Norwegian College of Fishery Science, University of Tromso

Jansen, M. D., Dong, H. T., & Mohan, C. V. (2019). Tilapia lake virus: a threat to the global tilapia industry?. *Reviews in Aquaculture*, *11*(3), 725-739.

Kaliba, A.R., Ngugi, C.C., Mackambo, J.M., Osewe, K.O., Senkondo, E., Mnembuka, B.V. & Amisah, S. (2007). Potential effect of aquaculture promotion on poverty reduction in sub-Saharan Africa. *Aquaculture International: Journal of European Aquaculture Society*, 15(6): 445–459.

Karanja, D. D. (2010). Securing Africa’s Food Security: Current Constraints and Future Options. In *New Security Threats and Crises in Africa* (pp. 111-127). Palgrave Macmillan, New York.

Karikari, A. Y., Asmah, R., Ofori, J. K., Agbo, N. W. & Amisah, S. (2016). Characteristics of cage aquaculture in Ghana: A case study of Lake Volta at Asuogyaman District. *Journal of Ghana Science Association, 17(1).*

Kashem, M. A. (2005). Factors affecting the adoption of aquaculture technologies by the farmers. *Bangladesh Journal of Fisheries Research*, *9*(1), 77-79.

Kassam, L. (2014). Aquaculture and food security, poverty alleviation and nutrition in Ghana. Case study prepared for the aquaculture for food security, poverty alleviation and nutrition project. World fish, Penang, Malaysia. Project Report: 2014-48. https://doi.org/10.13140/RG.2.13164.6485

Kirsten, J. (2008). The case of interdisciplinary research and training in Agriculture Economics in South Africa.

Kirsten, J., Doward, A., Poulton, C., and Vink, N. (2008). *Institutional Economics, Perspectives on African Agricultural Development*. Published by International Food Policy Research Institute; 2033 K Street, NW Washington, D.C. 20006-1002, U.S.A

Kumar, G**. (**2015). Economics and adoption of alternate catfish production technologies. PhD dissertation. University of Arkansas at Pine Bluff, Arkansas, USA

Kumar, G. and C. R. Engle. **(**2017b). Optimal investment pathways for adopting alternate catfish production technologies: a recursive programming approach. *Aquaculture Economics and Management 21*(1):144–162.

Kumar, G., Engle, C. and Tucker, C. (2018). Factors Driving Aquaculture Technology Adoption. *Journal of the world Aquaculture Society, 49*(3), 447-476. doi:10.1111/jwas.12514.

Kwikiriza, G., Mwesigwa, T., Barekyel, A., Abaho, I., Aheisibwe, A. R., & Mwesige, R. (2018). Prospects of Cage Fish Farming in South Western Uganda. *Agriculture Forestry and Fisheries, 7*(2), 52-57.

Lancsar, E. and Savage, E. (2004). Deriving welfare measures from Discrete Choice Experiments: Inconsistency between current methods and Random Utility and Welfare Theory. *Health Economics*, 8(1): 3-20.

Macfadyen, G., Nasr-Allah, A.M., Al-Kenawy, D., Fathi, M., Hebicha, H., Diab, A.M., Hussein, S.M., Abou-Zeid, R.M. & El-Naggar, G. (2012). Value-chain analysis: an assessment methodology to estimate Egyptian aquaculture sector performance. *Aquaculture*, 362–363:18–27.

Marenya P. P., and Barrett C. B. (2007). Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy* 32(4): 515536.

Ministry of Finance and Economic Planning (MoFEP). (2011). New minimum wage announced. Retrieved from http://www.mofep.gov.gh/ news270110_1.htm

MoFAD. (2019). Annual report 2018. Ministry of Fisheries and Aquaculture Development, Ghana.

Ministry of Fisheries and Aquaculture Development. (MoFAD). (2016). 2015 Annual report (p.78). Accra. Author.

MoFAD. (2014). Annual report 2013. Ministry of Fisheries and Aquaculture Development, Ghana.

Moser, C. M., and Barrett C. B. (2006). The complex dynamics of smallholder technology adoption: The case of SRI in Madagascar. *Agricultural Economics* 35(3): 373-388.

Muema, E., Mburu, J., Coulibaly, J & Mutune, J. (2018). Determinants of access and utilization of seasonal climate information services among smallholder farmers in Makueni County, Kenya. *Heliyon* 4 (2018) e00889

NAFAG. (2014). *Types of fisheries*. National Fisheries Association of Ghana. Available from: http://bit.ly/1tGe90c.

Naziri, D. (2011). Financial services for SME aquaculture producers: Egypt case study. *Output report for the German Agency for Technical Cooperation (GTZ) for the benefit of developing countries*.

Neill, S. P. and Lee, D. R. (2001). Explaining the adoption and disadoption of sustainable agriculture: The case of cover crops in northern Honduras. *Economic Development and Cultural Change*, 49 (4) 793 – 820.

Norman, M., Darko, E., Whitley, S., Bawakyillenuo, S., & Nyamedor, F. (2016). Mapping current incentives and investment in Ghana's agriculture sector: Lessons for Private Climate Finance. *London: ODI*.

Ntshangase, N., Muroyiwa, B., & Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal Province. *Sustainability*, *10*(2), 555.

Nunoo, F. K. E., Asamoah, E. K. and Osei-Asare, Y. B. (2014). Economics of aquaculture production: a case study of pond and pen culture in southern Ghana. *Aquaculture Research*, 2014, 45, 675–688. doi:10.1111/are.12003

Ogunremi, J. B., Oladele, O. I. (2012): Adoption of aquaculture technology by fish farmers in Lagos State, Nigeria. *Life Science Journal*, 9, 2, 430-434

Okoronkwo, M. O., & Ume, S. I. (2013). Evaluation of the socioeconomic factors influencing adoption of catfish production technologies in Anambra State, Nigeria. *International Journal of Agriculture and Rural Development*, *16*(1), 1425-1430.

Olaoye, O. J. and Oloruntoba (2010). Determinants of aquaculture technologies adoption among fish farmers in Obafemi – Owode Local Government Area of Ogun State, Nigeria. *Journal of Humanities, Social Sciences and Creative Arts* 2010, 5(1):37-48

Olaoye, O. J., Ezeri, G. N. O., Akegbejo-Samsons, Y., Awotunde, J. M., Ojebiyi, W. G. (2016): Dynamics of the adoption of improved aquaculture technologies among fish farmers in Lagos State, Nigeria. *Croatian Journal of Fisheries,* 74, 56-70. DOI: 10.1515/cjf-2016-0012

Onumah, E. E., & Acquah, H. D. (2010). Frontier analysis of aquaculture farms in the southern sector of Ghana. *World Applied Sciences Journal*, *9*(7), 826-835.

Pedzisa, T. (2016). *Determinants of yield impact and adoption of conservation agriculture among smallholder farmers in Zimbabwe* (Doctoral dissertation, University of Pretoria).

Ragasa, C., Andam, K. S., Kufoalor, D. & Amewu, S. (2018). A blue revolution in sub-Sahara Africa? Evidence from Ghana's tilapia value chain. Working Paper 49. Washington DC: IFPRI

Rurangwa, E., Agyakwah, S. K., Boon, H., & Bolman, B. C. (2015). *Development of Aquaculture in Ghana: Analysis of the fish value chain and potential business cases* (No. C021/15). IMARES.

Sanou, B., Savadogo, K. and Sakurai, T. (2017). Determinants of adoption and continuous use of improved maize seeds in Burkina Faso. *Journal Agricultural Economics* 19: 21-26

Sartori, A. E. (2003). An estimator for some binary-outcome selection models without exclusion restrictions. *Political Analysis*, *11*(2), 111-138.

Simtowe, F. and Mausch, K. (2018). Who is quitting? An analysis of the disadoption of climate smart sorghum varieties in Tanzania. *International Journal of Climate Change Strategies and Management* 3(2019), 341-357

Teklewold, H., Kassie, M. and Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics* 64(3): 597-623.

Ume, S. I., Uloh, V. E., & Okoronkwo, M. O. (2009). Adoption of improved rice production technologies by farmers in Anambra State. *Ebonyi technology and vocational education journal*, *3*(1), 1-7.

UNCTAD, T. (2013). Development. *Investment and Value Added Trade in the Global Economy, United Nations*.

Van de Ven, W. P., & Van Praag, B. M. (1981). The demand for deductibles in private health insurance: A probit model with sample selection. *Journal of econometrics*, *17*(2), 229-252.

Wakeyo, M. B., & Gardebroek, C. (2015). Empty pockets, empty ponds? Disadoption of water harvesting technologies in Ethiopia. *Journal of Arid Environments*, *120*, 75-86.

Wandji, D. N., Pouomogne, V., Binam, J. N., & Nouaga, R. Y. (2012). Farmer's Perception and Adoption of New Aquaculture Technologies in the Western Highlands of Cameroon. *TROPICULTURA*, *30*(3), 180-184.

Weeratunge, N., Snyder, K. A., & Sze, C. P. (2010). Gleaner, fisher, trader, processor: understanding gendered employment in fisheries and aquaculture. *Fish and Fisheries*, *11*(4), 405-420.

Wendland, K. J., & Sills, E. O. (2008). Dissemination of food crops with nutritional benefits: Adoption and disadoption of soybeans in Togo and Benin. In *Natural Resources Forum* (Vol. 32, No. 1, pp. 39-52). Oxford, UK: Blackwell Publishing Ltd.

Wetengere, K. (2011). Socio-economic factors critical for intensification of fish farming technology. A case of selected villages in Morogoro and Dar es Salaam regions, Tanzania. *Aquaculture international*, *19*(1), 33-49.

APPENDICES

Appendix I: Variance inflation factors (VIF) results for multicollinearity test.

Variance inflation factor

	VIF	1/VIF
District	1.76	0.56
Distance to source of fingerling	1.53	0.65
Access to policy information	1.50	0.66
Membership of farmer group	1.42	0.70
Price of tilapia/ kg	1.33	0.75
education	1.29	0.77
Cost of fingerlings	1.22	0.81
Distance to water source	1.22	0.82
Land size	1.21	0.82
Access to extension service	1.16	0.86
Access to credit	1.12	0.88
Age	1.08	0.92
Mean VIF	1.32	.

Source: Author’s calculation, field survey, 2019

NB: There was no multi-collinearity as VIF for all explanatory variables is below 5

Appendix II: Correlation matrix for explanatory variables hypothesized to influence adoption of cage tilapia aquaculture

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) ADOPTION	1.000													
(2) age	0.037	1.000												
(3) education	0.175	-0.081	1.000											
(4) distancewater	-0.064	0.021	0.006	1.000										
(5) extserv	0.190	0.039	0.030	0.141	1.000									
(6) finglingcost	-0.098	0.130	-0.010	0.049	-0.201	1.000								
(7) pricekg	0.023	-0.026	-0.135	0.113	0.082	-0.270	1.000							
(8) credit	0.097	0.054	0.067	-0.061	-0.054	0.125	0.017	1.000						
(9) membgrp	0.178	0.148	0.117	0.014	0.247	-0.039	-0.046	0.249	1.000					
(10) distacefingerln	0.197	0.218	-0.034	0.242	0.022	0.191	-0.046	0.127	0.288	1.000				
(11) polaware	0.411	0.044	0.225	0.060	0.160	-0.153	0.268	0.064	0.271	0.306	1.000			
(12) agesquared	0.031	0.981	-0.074	-0.002	0.052	0.132	-0.023	0.057	0.147	0.195	0.046	1.000		
(13) landsize	-0.337	0.081	-0.248	0.073	-0.061	0.121	-0.216	-0.003	-0.084	0.029	-0.260	0.104	1.000	
(14) district	-0.110	-0.064	-0.286	-0.283	-0.086	-0.004	-0.134	-0.174	-0.390	-0.424	-0.416	-0.049	0.204	1.000

Appendix III: Computation of fixed cost of cage tilapia farming

Fixed cost calculations						
Item	Useful life	Initial investment	Annual depreciation	Average interest	Annual cost	% of total cost
Cage	5 years	3238.17	647.64	194.29	841.93	
Canoe	5 years	790.44	158.09	47.43	208.52	
Platform	2 years	82.28	41.14	4.94	46.08	
Building for feed storage	5 years	943.98	188.80	56.64	245.44	
Interest on loan	1 year	534.55	-	267.28	267.28	
Miscellaneous	4 years	150.00	37.50	9.00	46.50	
Total					1,655.75	

Appendix IV: Household Survey Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF AGRICULTURAL ECONOMICS

ANALYSIS OF PROFITABILITY AND DETERMINANTS OF ADOPTION AND DISADOPTION OF CAGE TILAPIA FARMING IN SOUTHERN GHANA

HOUSEHOLD SURVEY QUESTIONNAIRE

Respondent Consent and Purpose of the Survey

Thank you for giving us a chance to speak to you. We are researchers from the University of Nairobi, Kenya. The reason for conducting this field survey is to get some insights on adoption and disadoption of Cage Tilapia production, marketing and incentive that are available to producers. You have been randomly selected to participate in this study, and your voluntary participation in answering questions on these issues is highly appreciated. Your responses together with those from about 200 other households in three districts of Eastern and Greater Accra regions will be analysed, and the findings will be used to inform policy on better strategies for improving farm incomes, increased productivity and access to profitable markets in these regions specifically, and in Ghana in general. All the information obtained will be treated with utmost confidentiality and will only be used for the purpose of this survey, which is strictly academic. This interview will take approximately **ONE HOUR** to complete. Please note that your participation in this study is purely voluntary. You can decide to withdraw anytime or not answer any question you do not want to. In case you decline/withdraw, your lack of participation will not have any negative consequence on you. **We would, however, be very grateful if you can answer every question and complete the interview**. Your name or contact will not be revealed or reported.

I request your permission to start now. For any further clarification, please contact Vida Mantey (0248888018). Thank you.

SECTION A: GENERAL INFORMATION

1. **Enumerator code………………………….. Date:………………………………….**
2. Respondent ID………………………………………………… 3. Name of fish farm……………………………

Region (1= Eastern; 2= Greater Accra)	
District (1=Asuogyamang; 2= Lower Manya 3= Shai Osudoku)	

Town/Village ……………………………	

A1. Household Identification

Type of Household (1= Male Headed Household, 0=Female Headed Household)	
Name of the respondent	
Gender of the respondent (1=male 0= female)	
Relationship to household head? (1= hhold head, 2=spouse, 3=son/daughter, 4=son/daughter in-law, 5= grandson/daughter, 6= others (specify) …………………..	

SECTION B: HOUSEHOLD DEMOGRAPHIC INFORMATION:

Please list all HH members (all those under the care of HH head in terms of food and shelter provision)

1	2	3	4	5	6	7	8	9	10	11
	Name of HH member	Gender Male=1 Female=0	Relationship with HH head (1= hhold head, 2=spouse, 3=son/daughter, 4=son/daughter in-law, 5= grandson/daughter, 6= other (specify ……………….	Age in years	Level of education in years………………....	Marital status 1=married, 2=single, 3=divorced, 4=widowed	Religion 1=Christianity, 2=Muslim 3=Traditionalist	Ethnic group	Main occupation; 1= Fish farming; 2= Animal rearing; 3=Salaried worker; 4= Trader; 5= Artisan; 6=Farming; 7=Others(specify) ……………..	Minor occupation: 1= Fish farming; 2= Animal rearing; 3=Salaried worker; 4= Trader; 5= Artisan; 6=Farming; 7= Others(specify)
1										

2										
3										
4										
5										
6										
7										
8										
9										
10										

B1. To which of these groups do you belong? 1. Currently farming tilapia 2. Used to farm tilapia 3. Has never farmed tilapia

BI: section to be answered by respondents who used to farm tilapia

B2. If you used to farm tilapia, when did you start? ……………..

B3. Which year did you stop farming tilapia? …………

B4. How do you perceive tilapia farming activity? ………………………

B5. Why did you stop farming tilapia? ………………………………………………

B6. Will you like to go back into tilapia farming? 1.Yes 0. No

B7. If yes, why? …………………………………………………

B8. How would you like to be helped to re-join tilapia farming? ……………………………….

BII: Section to be answered by respondents who had never farmed tilapia

B21. If you have never farmed tilapia, why not? ………………………………………………

B22. How do you perceive tilapia farming activity?

B23. Would you like to go into tilapia production? 1. Yes   0. No

B24. If yes, why? ……………………………………………………

B25. If yes, how would you like to be helped to join tilapia farming? ……………………………….

BIII: Access to services, facilities and resources.

(NB: to be answered by all respondents)

B31. How close are you to the Lake Volta (km) ?…………

B32. How close are you to the nearest fish market (km)? ……………

B33. How close are you to the nearest source of fingerling/ hatchery (km)? ………..

B34. How close are you to a source of feed?

B35. How close are you to a motorable road (km)? ………………………….

B36. How close are you to a financial institution (km)? ………………………….

SECTION C: LAND HOLDING IN ACRES

(NB: this section should be answered by all respondents)

C.1. How much land do you own in acres?..............................

C.2. How much of your total land is under tilapia production?.........................

C.3. How did you acquire the land? (1= own land; 2= Rent/ lease; 3= government; 4=inherited; 5=others (specify))……………..

C4. If rent/lease, how much do you pay per month?..

C5. If rent/lease, what are the terms of acquisition? ………………………….

SECTION D: INSTITUTIONAL ARRANGEMENTS

D1.: Tilapia Production Activities

(NB: this section should be answered by respondents who used to or currently producing tilapia)

Nursery cages/ pond(s):

No. of cages/ponds	Year constructed	Size of cage/pond	Method of construction	Cost of construction

Rearing cages:

No. of cages/ponds	Year constructed	Size of cage/pond	Method of construction	Cost of construction

Total number of cages/ ponds ……………………………………………….

D(i): LABOUR AND INPUT USE

Di1	Type of labour employed; 1=family 2=hired	
Di2	No. of labourers; Permanent (……….) Casual (……...)	
Di3	Which year was your farm established? …………………..	
Di4	How many years of experience do you have as a fish farmer?	
Di5	Type of production system employed? 1=extensive 2= semi-intensive 3=intensive	
Di6	Do you rear any other fish species apart from tilapia? 1=yes 0=no	If yes, name them …………

Di7	Do you mix different sexes of tilapia in the same cage?1=yes 0=no	If yes, why? 1=limited ponds 2=reduces cost 3=others(specify) …………………
Di8	Source of fingerlings? 1=own farm 2= private hatcheries 3=input dealers 4= fisheries department 5= ARDEC Akosombo 6= others (specify)…………..	
Di9	What is the reason for your choice of source of fingerlings? 1=quality 2=easy access 3=affordability 4=others(specify)………….	
Di10	Do you always get your demand for fingerlings? 1=yes 0=no	If no, why? 1=not available 2=others (specify)….
Di11	How many times in the year do you stock your pond? 1= once 2=twice 3=others(specify)…………	
Di12	What type of feed do you use? 1= local 2=imported 3=others(specify) …….	
Di13	Where do you obtain your feed? 1=commercial suppliers 2=own source 3=others(specify) …………………	
Di14	What is your reason for the source of feed? 1=quality 2=affordability 3=easy access	

	4=others(specify)	
Di15	Do you often get the quantity demanded for feed? 1=yes 0= no	If no, why? 1=not available 2=others(specify) If yes, do you get it on time? 1=yes 2=no If no, why? 1=poor road network 2=distance 3=others(specify) ………………………
Di16	How many times do you feed the fish in a day? 1=once 2=twice 3=others(specify) …………………….	
Di20	How many times do you harvest fish in a year? 1=once 2=twice 3=others(specify)……………….	
Di21	Which month(s) of the year do you harvest fish?..........................	
Di22	Do you keep any production records of your activities? 1=yes; 0=No	
Di23	What strain of tilapia do use for your production?	
Di24	What informed your decision on the type of strain? 1=market demand 2=resistance to	

	pest& diseases 3=readily available in the market 4=others(specify) …………………..	
Di25	What kind of health arrangement do you have for your tilapia? 1. None 2. Vet visit 3. Local treatment 4. Others	If others, please specify
Di26	What common diseases affect your tilapia	

D(ii): Annual production and revenue

	Quantity	Unit cost	Revenue
Production sold			
Consumed on farm			
Gift			
Total			

D(iii): Monthly operating cost

	Quantity	Type	Unit cost	Total cost	% of total cost
Variable cost					
Hired labour **-permanent** **-temporary**					
Feed					
Seed/fingerlings					
Electricity					
Fuel					
Water rates					
Others					
Fixed cost					
Operators salary					
Lease cost					
Maintenance costs **-cage**					

-equipment					
Water rent					
Marketing cost **-preservation** **-processing** **-storage** **-transport** **-commissions** **-waste**					

D(iv): Cost of farm tools and equipment used in tilapia production

Equipment	Number	Cost of item	Estimated life span	Cost for production

SECTION E: MARKET INCENTIVES

(NB: this section should be answered by respondents who used to or currently farming tilapia)

E1	**E9**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
At the time of harvest, how many fish is equivalent to 1kg	What are the prices of harvested fish per kg?	Who sells your product after harvest? 1=self 2=spouse 3=other family members 4=fish dealers	Where is your fish sold after harvest? 1=on-farm 2=fish market 3=regular market 4=others(specify)	In what form are your fish sold? 1=live 2=fresh 3=frozen 4=salted 5=smoked 6=others(specify)	Who determines the price of your product? 1=self 2=retailer 3=others(specify) …………..	How are the prices determined? 1=prevailing market price 2=based on cost of production 3=arbitrarily	Are you satisfied with the price process? 1=yes 0=No	What influence do you have on price agreement? 1=no bargaining

		5=others(specify) ……………….	………………	……………		4=others(specify) …………….		power 2=little bargaining power 3=moderate 4=nearly equal 5=equal
<2								
3								
4								
5								
6								
>6								

E9. Which size of tilapia is mostly preferred by buyers? ……….

E10. Do you have a contract with buyers? 1= yes 0= No

E11. If yes, what are the terms of the contract?1= Pay immediately 2= pay after some duration 3=advance of inputs + cash 4=Other, (specify).....

E12. What is the level of trust with your buyers? 1=very little 2=little 3=moderate 4=much 5=very much

E13. Has your buyer ever failed to pay for your produce? 1= yes 0= No

E14. Have you ever failed to sell all your produce? 1=yes 0=No

E15. If yes, what could be the reason?..

E16. What proportion of your produce did you fail to sell in the last two production seasons?

E17. How do you receive market information? 1=government officials 2=traders 3=media 4=farmer association 5=others(specify)

E18. Buyer information by category

Buyer	**Amount bought in kg**	**Unit price offered per kg (Gh₵)**	**Total sale (Gh₵)**	**Proportion of total sale**

SECTION F: EXTERNAL SUPPORT

(NB: this section should be answered by all resondents)

F(i): Extension Services

F1. Did you access extension services During the last two production seasons? (1=Yes, 0=No) if **YES** fill details in the table below

Fi1	**Fi3**	**Fi4**	**Fi5**	**Fi6**	**Fi7**	**Fi8**
Source	Frequency over the last 12 months 1=once 2=twice 3=others(specify)	What kind of information did you receive from this source: 1=pests and diseases, 2=markets & prices, 3=government initiatives, 4= good fish farming practices, 5= others specify(………..)	Was this information timely (1= Yes, 0=No)	Was this information reliable (1= Yes, 0=No)	Was this information helpful/relevant to your farming activities (1= Yes, 0=No)	Who requested for this information: 1= own initiative 2= farmer group 3= government initiative 4=others(specify)..

Extension officer (govt)						
Farmer association						
Researchers						
Media						
Others						

F(ii): Credit Access

Fii1	Fii2	Fii3	Fii4	Fii5	Fii6	Fii7	Fii8	Fii9	Fii10	Fii11
Source of credit	How much did you obtain from the source (s)? …… **(Gh₵)**	Did you obtain the credit at the right rate? 1=yes 0=No	What is the reason for your choice of source? 1=lower interest rate 2=easy access 3=others(specify) …………….	What qualifies you to obtain loan from this source? 1=membership of farmer group 2=level of education 3=farm size 4=low default rate 5=trust 6=Age limit 7=collateral 8=others(specify**)** **………..**	**Main** use of credit: 1=farm inputs 2=school fees 3=food 4=land 5=labour 6=offset a problem one had 7=others specify	Did you use ALL of the credit for the intended purpose: 1= Yes 0=No	**If NO, how else did you use this credit:** 1=farm inputs 2=school fees 3=food 4=land 5=livestock 6=offset a problem one had 7=Farm implements/eq	**If you** did not get the requested amount, what could be the reason? (**MAIN**): 1=high default rate 2=lacked guarantors 3=didn't adhere to all requirements 4=lacked collateral	Have you started repaying this loan? (1=Yes, 0=No)	If **YES** What proportion have you repaid: 1=1/4, 2=1/2, 3=3/4, 4=all

					………		uipment 8=non -farm business/trade 9=buy livestock 10=other, specify …………….	5=couldn't access lender 6=Age limit 7=don't know 8=Other(specify		
Farmer groups / cooperative										

Bank										
Susu										
Microf inance										
NGO										
Friend s										
Family memb er										
Money lender										
Own funds										
Others (specif										

y) …...										

SECTION G: ORGANIZATIONAL INCENTIVES

(NB: this section should be answered by all respondents)

G(i): Social capital and credit access

G.1. Are you a member of any development group since 2016? (1= Yes 0= No) If **YES** please fill the details in the table below: If **NO** skip to the next question.

Type of group	Duration of membership	Who made the decision to join this development group: 1=own 2=others(spe	What is the main function of the group? 1=produce marketing 2=input access 3=savings and credit 4=farmer	Role in the group: 1=official 0=ordinary member	Are you still a member now: 1=Yes, 0=No	If **NO,** reasons for leaving group: 1=group was not profitable 2=poor mgt & corrupt officials

		cify) ……….	trainings 5=transport services 6= information on markets & prices 7=others (specify) ……….			3=unable to pay annual subscription fee 4=group ceased to exit 5.=other, specify
Women group						
Microcredit group						
Farmer group/cooperative						

Producer and marketing groups						
Youth group						
Susu						

G.2. If you are **NOT** a member of any development group/organization, why not? (1=Not available, 2=time wasting, 3=Doesn't want to be a member, 4=corruption in the group, 5=other, specify…………………………...........

G(ii): Collective Action

(NB: this section should be answered by respondents who used to or currently farming tilapia)

Gii1. Do you belong to a farmer association producing fish? 1= Yes 0=NO

Gii2. If yes, which year did you join this group?

Gii3. Name of the association? …………………

Gii4. What are the association's activities? ………………………..

Gii5. Are members of your group cooperative? 1= very uncooperative 2=uncooperative 3= moderately cooperative 4= cooperative 5=very cooperative

Gii6. How often do you attend meetings in a month? ……………….. days

G(iii): Access to Agricultural Information

(NB: this section should be answered by all respondents)

Giii1. Have you been receiving production/ market information? 1= yes 2= No

Giii2. If yes, what is the source of this information? 1= Agric officer 2=farmer association 3= other farmers 4= others(specify) ………….

Giii3. How often do you get the information? 1=daily 2=twice a week 3=weekly 4= monthly 5= others(specify)

Giii4. From whom do you get information about price and required quality? 1=fish traders 2= farmer association 3=government officials 4= family members 5= others(specify) ………………..

Giii5. Describe how easy it is for you to get information related to market, policy, and new technologies on production and marketing? 1= very difficult 2= difficult 3= moderate 4= easy 5= very easy

SECTION H: POLICY INCENTIVES

(NB: this section should be answered by all respondents)

H1	H2	H3	H4	H5	H6	H7	H8
Type of policy	How do you get information on these policies? 1= extension officers 2=researchers 3=farmer group 4= media 5= others(specify) …………..	What regulations are associated with these policies?	What measures are put in place to ensure compliance? 1= sanctions 2= rewards 3= both 4= others(specify) ……………..	How will you rate the level of compliance? 1=very good 2= good 3= not certain 4= poor 5= very poor	What benefits do you obtain from these regulations?	Are there negative effects of these regulations on production and marketing? 1= yes 0=No	If yes, name them

SECTION I: FINANCIAL SUPPORT

(NB: this section should be answered by all respondents)

Have you received financial support (monetary or non-monetary) from these sources in the last two years? If yes, fill the details below;

Sources of financial support services	What type of financial support have you received from this source(s)? 1=credit	Was this support relevant? 1=yes 0=no	If yes, was it timely? 1=yes 0=no	State two main benefits you obtained from this	How was this support received? 1=farmer groups 2=individuals	What qualifies you to obtain this financial support? 1=membership of farmer	Who requested for this financial support? 1= government	How close are you(km) to a financial institution?	

	2=subsidy on fingerlings 3=subsidy on feed 4=exemption from tax 5=training 6=others(specify)			support?	3= others (specify)	group 2= level of education 3= farm size 4= experience 5= others (specify) …..	initiative 2= farmer group 3= others (specify) …		
Government									
NGO									
Researchers									
Farmer groups									
Others (specify) ….									

SECTION J: Cultural and social norms

(NB: this section should be answered by all respondents)

J1. Are there any cultural barriers to tilapia production? 1. Yes 0. No

J2. If yes, what are they? ……………………………………..

J3. What other barriers to tilapia farming elsewhere do you know of? ……………………………….

J4. Are there specific challenges to women in tilapia production? 1. Yes 0. No

J5. If yes, what are they? …………………………………….

SECTION K: Challenges in production and marketing of tilapia

(NB: this section should be answered by all respondents)

Challenge	Suggestion

Thank You

SECTION Q: Guiding questions on key informant interviews

Q1: Traders

Q1.Name of Business………………………………...…Date…………..……………...

Q2. Name of respondent ………… ……………….. Sex ……………….……………

Q3. Role of respondent …………………………………………………………..…….

Q4. Location of business…………………..……..District/Region ……………………

Q5. Type of Business: 1=Wholesaler 2=Retailer 3= Intermediate

Q6. What year was the business started? ……...…………………………………

Q7. Where do you get your supply of tilapia from (Please tick as many as applicable)?

1=Fish market 2=Fish farm 3=Fish Wholesaler 4=Others (Please specify) …………………

Q8. Please give the name and location of the fish market, fish farm, or fish wholesaler from whom you get your supply. ……………

Q9. Where do you sell your fish? ………………………………………………….

Q10. How often do you buy it? 1= daily 2= more than once a week 3=weekly 4= less than once a week 5= monthly

6= less than once a month. 7= others(specify) ……………………….

Q11. In what forms do you buy it? 1= Live 2=fresh 3=frozen 4= smoked

12. In what form do you sell it? 1=Live 2=fresh 3=frozen 4=Smoked salted (koobi) 5=Others (specify) ………………

13. What size of fish do you normally buy, (number of fish per kg)? <2; 2; 3; 4; 5; 6; or >6

14. What quantity do you buy each month? …………………………..…………(Kg)

15. How much does it cost? …………………………………………………(**Gh₵)**

16. Do current supplies satisfy your demand? 1=Yes 0=No

17. What factors determine the price at which you buy the fish? 1=Uniformity in size 2=State of the fish (Freshness) 3=Others (specify)

18. In your opinion which fish species do you consder the closest substitute of tilapia?………………………………………………

SECTION Q2: Government

1. What policies govern tilapia and fish production in general?
2. What support services are available for tilapia producers?
3. How are government initiatives on tilapia production and marketing disseminated to tilapia producers?
4. How are rules governing fish production enforced?
5. What are the major structures put in place to ensure improvement in fish production?