UNIVERSITY OF CAPE COAST

THE AVAILABILITY OF INPUTS IN THE DEVELOPMENT AND SUSTAINABILITY OF AQUACULTURE PRODUCTION IN GHANA: A CASE STUDY OF FARMERS IN ASUOGYAMAN AND LOWER MANYA DISTRICTS.

GIDEON ABOAGYE

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BY

GIDEON ABOAGYE

THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, SCHOOL OF AGRICULTURE, UNIVERSITY OF CAPE COAST, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE

JUNE 2012

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Name: Gideon Aboagye:

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

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Name: Prof. Fred N. A. Odoi

Signature……………………… Date …………………......

Co-Supervisor's Name: Dr. K. S. Awuma

Signature…………………………… Date ……………………...

ABSTRACT

Aquaculture in the sub-Sahara Africa will grow by 8.3 percent from its current 1.2 percent over the next 20 years. The growth trend will lead to high demand for inputs for fish production, especially fishmeal and fish oil, and can threaten the sustainability of fish farming in Ghana. There is the need to consider cost of production because of high protein needs of tilapia and other fish species currently being farmed. This study intended to investigate the cost and availability of inputs for sustainable aquaculture in Ghana. Content validated questionnaire and an interview guide were used to conduct the survey within six selected Metropolitan, Municipal and District Assemblies (MMDAs), in the Greater Accra and Eastern Regions. In all, sixty four (64) fish farmers, ten (10) feed mills, forty (40) animal productions input suppliers and ten (10) fingerling producers were interviewed. Pearson's correlation was used to analyse the relationship between variables.

The results of the study showed that age, sex, level of education of fish farmers had a positive effect on production. Fish farmers do not have access to all the inputs required for production. Input supply is erratic, expensive and unavailable. Feed millers do not have the required capacity to produce floating fish feed locally.

The study recommends that animal production input suppliers and feed millers should be equipped with the necessary resources to boost their capacity to produce and supply fish feeds locally. Also, more certified hatcheries should be set up to produce high quality fingerlings for fish farmers.

ACKNOWLEDGEMENTS

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Finally, I wish to show my appreciation to my family and to all individuals who contributed in diverse ways toward the successful completion of this thesis.

DEDICATION

I dedicate my work to Gilead Kwadwo Aboagye and Condoleeza Akosua Aboagye.

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LIST OF ACRONYMS

ARDEC	Aquaculture Research and Development Centre
BLUE	Best Linear Unbiased Estimator
B.Sc	Bachelor of Science
CLRM	Classical linear Regression Model
CP	Crude Protein
CSIR	Council for Scientific and Industrial Research
DNA	Deoxyribonucleic Acid
DoF	Department of Fisheries
EU	European Union
FAO	Food and Agriculture Organisation
FASDEP II	Food and Agriculture subsector Development Policy two
FAOSTATS	Food and Agriculture Organisation Statistics
FC	Fisheries Commission
FCRs	Feed Conversion Ratio
FFA	Fish Farmers Association
GDP	Gross Domestic Products
GH₵	Ghana cedi
IDRC	International Development Research Centre
LCA	Life Cycle Assessment
LDC	Least Developed Countries
MMDA	Metropolitan Municipal and District Assemblies

MoFA	Ministry of Food and Agriculture
MT	Metric Tonne
OLS	Ordinary Least Squares
PMT	Per Metric Tonne
SPSS	Statistical Product and Service Solutions
USAID	United States Agency for International Development
WRI	Water Research Institute

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The decline in the world's naturally occurring fish stocks has lead to an increasing demand for fish from fish farming. As a measure of attaining food security, nations across the globe have outlined policies that will help revamp fish production as one of their main policy directions. As the saying goes, "a healthy nation is a wealthy nation"; food security can only be achieved through provision of cheap protein foods and adequate carbohydrates. However, aquaculture has now become a substantive global industry, supplying a significant proportion of the finfish and shellfish consumed (FAO, 2004).

Aquaculture production of seafood remains the most rapidly increasing food production system worldwide to 2025 (FAO, 2004).

A sustainable approach to the development, management and regulation of aquaculture can ensure that both the environment and industry provide long-term economic and social benefits. With respect to feeding the fish, much can be said in terms of choosing sustainable ingredients and optimizing the bioavailability of feed nutrients.

In Ghana, aquaculture has been practised over the years on a small scale by farmers who have the knowledge in fish farming. In the late 1990, Ghana introduced commercial production of aquaculture in the Northern, Eastern and Volta Regions of the country (Fisheries Commission, 2004). It is estimated that total marine production of fish in 2007 was 290,686 metric tonnes, while aquaculture brought in 3,257 metric tonnes. However, Ghana's fish need has grown from 676,000 tonnes in 1995 to 840,000 tonnes in 2007. The deficit between fish requirement and production is therefore a prime motivation in the development of aquaculture and its related industries. According to Mrs. Gladys Asmah (Former Minister for Fisheries), Ghana imports US$200,000,000 worth of fish annually to make up for the deficit and suggested that aquaculture could produce enough fish to offset this deficit (Fisheries Commission, 2006).

The Atlantic Ocean which washes the coast of Ghana is seen as where most of the fish caught in the wild come from. Currently, the oil production in the western section of Gulf of Guinea will negatively affect the fishing activities in the area greatly. This is because fishes will be attracted to the rig area due to the lights on the rig. Since fishermen are prohibited from fishing close to the rig, fish catch away from the rig is likely to be affected. Aquaculture therefore could become an ideal substitute to sea fishing. Though compensation would be an acceptable reward, aquaculture should be looked into as an alternative employment for most of the fishermen living along the coastal area close to the oil production sites (Fisheries Commission, 2006).

Moreover, tilapia, which is mostly reared by those engaged in aquaculture, has gained popularity in Ghana. *"Koobi"* (as it is locally known) used to be the poor-man's fish but since then it shed its local name for "Tilapia", it has become the toast of many celebrities and a never-to-be missed item on the menu of eateries in Ghana. Most Ghanaians have developed a great taste for this Nile tilapia because of its unique taste and are ready to pay a premium price for it. In addition, special eating joints have been created in the cities where tilapia is served spiced with local dishes e.g. *"banku"* and grilled tilapia.

The main feed ingredients for farmed carnivorous fish species are fishmeal and fish oil, at inclusion levels of about 50 percent and 30 percent respectively. These two ingredients supply essential amino acids and fatty acids required by the fish for normal growth. More recently, small quantities of fishmeal and fish oils (3-5 percent and 1-3 percent respectively) have been included in feeds for omnivorous and herbivorous fish. Manufactured fish feed utilizes 35 percent of fishmeal and 55 percent of the fish oil produced annually. The rest is used in manufacturing of feeds for terrestrial farm animals and poultry. Carnivorous fish converts these manufactured feeds into edible flesh with maximum efficiency. For example, farmed salmon converts approximately 1.2 kg of feed into 1 kg of flesh. Poultry converts between 2 to 3 kg to 1kg of meat, whereas pigs convert approximately 5 to 8 kg of feed to 1kilo of flesh. This means that fish farming is very efficient in terms of the conversion of feed proteins, which an ecological advantage in light of the sustainability of fish is feed resources (FAO, 2004; Koeleman, 2010).

One of the most frequently cited challenges with the sustainable development of aquaculture is the capture of other fishes as raw material for fish feed production, in the form of fishmeal and fish oil. It is seen as a challenge because the food production sector partly relies on captured fish for the supply of raw materials for the production of food products, canned fish, fish powder and fish oils in food supplements. However, forage fish species that are small, oil rich, bony, pelagic ideal for human consumption is being processed into fishmeal and fish oils. Two decades ago, substantial amounts of fishmeal and oil were used around the world to make feeds for domesticated farm animals. At present, over 50 percent of fishmeal and over 80 percent of fish oil are used for aquaculture. If aquaculture is to fill the gap in demand for sea foods, then an important sustainability issue to be addressed has to do with the availability of products and services for the industry to reduce the over reliance on certain products. For instance, fishmeal and fish oil production has been and is likely to remain, relatively constant, at 6 million and 0.9 million metric tonnes per year, respectively. However, as the demand for fishmeal and fish oil for aquaculture has increased, so have the prices of fishmeal and fish oil, thereby affecting the cost of feeding other farm animals such as poultry that rely on fishmeal as a major source of protein (Tacon & Jackson, 1985).

1.2 Statement of Problem

It is being forecasted that aquaculture in sub-Sahara Africa is likely to grow by 8.3 percent, from its current state of 1.2 percent over the next 20 years, with leading producers like Egypt, Nigeria, Madagascar and Ghana taking a leading role (FAOSTATS, 2004). By this growth trend, some analysts are concerned that rising demand for inputs used in fish production, especially fishmeal and fish oil, can threaten the sustainability of fish farming. Already, the current supply of fishmeal is threatening stocks of fish used in preparing feeds for terrestrial animals (Delgado *et al.,* 2003). Moreover, the expansion of fish farming will in turn increase the already high cost of fishmeal on the world market.

Another challenge that is emerging is the issue of sustainability and the impact of fish farming on the environment. Today, poultry and other terrestrial farmed animals have gone through a lot of transformation, and this has increased their acceptance of a wide variety of feeds from plant sources; this has reduced the over reliance on aquatic sources of protein. Major environmental impact, has been associated mainly with high output of residue in intensive systems of fish farmed in raceways, and in cages in rivers and streams. This includes discharge of suspended solids (faeces and uneaten food), antibiotics, other drugs, disinfectants, algaecides, waterweeds and other compounds into water bodies (Koeleman, 2010).

Koeleman (2010) found "elevated zinc, copper, cadmium and manganese levels in sediments under the sea and solid wastes generated by land-based fish farms which leached into water sources. This was attributed to carnivorous diets that contained high proportions of fishmeal and marine products supplemented with minerals at higher concentrations than required. Contributing further to this is the limited information on fish mineral requirements and bioavailability from feed ingredients. Several attempts have therefore been made to find adequate substitutes to all the pressing demands in the sector, such as use of aqua weeds as plant protein replacers, and larvae of insects as fishmeal replacers, with varying success. In addition, there are emerging industries that will come into the value chain, to make sure that there is better utilization of final products as well as an industry prepared to meet the challenges posed by aquaculture production. However, research is also being conducted into substitutes with similar properties as marine oil in the diet for carnivorous species (Ferstad *et al.*, as cited by FAO (2004); with the use for example of genetically modified rapeseed as fish feed.

Another emerging problem is the cost of production; due to high protein needs of tilapia and other fish species currently been farmed, there is the need for the cost of production to be taken into consideration. This can help to prevent some of the pitfalls that have befallen the poultry industry in Ghana which has suffered from dumping of poultry products on the market thereby killing almost entirely, local broiler production. Currently some of the leading countries in tilapia production have adopted methods that have made it possible to produce at cheaper cost which has enhanced their work greatly. FAO (2004) indicated that, whereas it is costing over $ 2.00 to produce a kilogram of tilapia in Ghana, countries such as the Philippines, China, Indonesia and Bangladesh were producing a kilogram of tilapia at $0.99, $1.30, $0.43 and $ 0.16 respectively. This study is therefore, intended to investigate the cost and availability of inputs for sustainable aquaculture in Ghana.

1.3 General Objective of the study

The general objective of the research was to investigate the availability of inputs to Ghana`s aquaculture development: a case study of the Ashaiman Municipal, Tema Metropolitan Assembly, Accra Metropolitan Assembly, Ga East Municipal, Asuogyaman and Lower Manya Districts.

1.3.1 Specific Objectives of the study

The specific objectives of the study were to:

1. evaluate the influence of socio-economic characteristics of fish farmers in the lower parts of the Volta basin (i.e. areas on and after the Akosombo and Kpong Hydro Electric Dams) on aquaculture production;
2. assess the availability and cost of inputs fish farmers used in their production;
3. identify the challenges fish farmers faced with supply of inputs
4. evaluate the potential of local feed mills for producing fish feeds in Ghana.

1.4 Scope of the Thesis

This study used survey design and sought to investigate the availability of inputs for sustainable aquaculture in Ghana. The study covers the Asuogyaman and Lower Manya Districts in the Eastern Region; Ashaiman and Ga East municipalities, Tema and Accra metropolis in the Greater Accra Region. Pilot survey was carried out within the Sekondi-Takoradi Metropolis in the Western Region.

1.4.1 Justification of the Thesis

Fish is one of the major sources of protein for Ghanaian households, both in the rural and urban setting, and the expansion of fish farming will improve protein supply to the wider population. Fish harvest from the marine and inland water bodies is dwindling and so there is a need for fish farming to meet the shortfall. Freshwater fish production is gradually becoming the preferred farming enterprise in most African nations, and Ghana is no exception. During 2004-2009, aquaculture production in Ghana grew from 1000 metric tonnes to over 7,203 metric tonnes, with high potential for further growth (Felix, 2009). Statistics from FAO (2004) indicated that by 2050, aquaculture will overtake poultry production as the largest animal farming occupation in the world. This means that the demand and cost of aquaculture feeds and other inputs would increase and the impact on the environment is likely to be great. This can affect the unit cost of freshwater fish produced and so it calls for alternative sources of feeding fish that will reduce the reliance on fishmeal as the main protein source in fish feeds. (FAOSTAT, 2004).

The government of Ghana under FASDEP 2 has outlined a policy strategy for inland fishing and aquaculture development. The policy targets inland water bodies as a source that will help increase fish production, increase income and employment, protect the fisheries resources and the environment, and build capacity of relevant institutions. Some of the specific points of this strategy have to do with;

- Improved management of declining fish resources
- Development of under-exploited fisheries resources
- Improved product utilization and marketing
- Improved socio-economic infrastructure and opportunities
- Promoting inter-sectoral cooperation

This aquacultural strategy covers issues of inputs, institutions and production systems. It further went on to say that input delivery would be private sector- led. The institutional strategies also cover greater engagement of the private sector, training, extension and formalization of public links amongst private sector institutions. The success of this policy rests on the ability of the players in the sector to provide the needed support for sustainability of aquaculture. That is what the researcher seeks to investigate.

1.4.2 Organization of the Thesis

The thesis was organized into five chapters. Chapter One covers introduction, which is made up of background of the study, statement of the problem, objectives, scope of the thesis, justification of the thesis, and chapter organization. Chapter Two constitutes a review of relevant theoretical and empirical literature related to this study. Chapter Three covers methodology used in the study, including an overview of data collection techniques, a description of the study sites and details about key variables. Chapter Four covers analyses, and presentation and discussion of the data collected from the field. Chapter Five presents the summary, conclusions, recommendations, limitations of the study and suggested directions for future research.

1.4.3. Limitations of the Study

These restrictions are likely to affect the degree of control and generate for some internal and external threats to the validity of results of the study and question generalization of the results for the entire country.

The first relates to data collection. Poor record keeping, memory lapses, and unwillingness to disclose information by some farmers were common problems encountered during the data collection. The study also encountered difficulties during interview, due to low awareness level of the farmers who do not keep good records of aquacultural information that is needed for the purpose of this study. To overcome this problem, more time had to be spent with respondents in discussing the various economic factors affecting production of fish in the areas visited.

Another problem encountered during the data collection was that some respondents were not willing to assist. Some respondents were not willing to give information about their business to the extent that some even refused the research team entry. In spite of the above mentioned problems data collection went on smoothly.

Resources and time constraints were the other major problems encountered. Material resources and finance available for the study were limited. Therefore, only three out of the ten political regions of Ghana were covered. Another limiting factor for this survey was time. The study was conducted within a limited academic time frame. This also did not allow the research team to sample a large number of individuals that would permit a more valid generalization of findings and inferences from the sample about the entire population.

Another limitation had to do with inability to conduct the OLS regression to show the relationship or correlation and the magnitude effect of change between the explanatory variables and the dependent variable, due to the inadequate nature of information available on the dependent variable.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews related literature on various issues which serve as basis for this work. It reviews existing related literature such as issues about the agriculture sector and issues on aquaculture in Ghana and the world as whole. However, empirical works done by various authors in the field were reviewed, and lessons drawn from them.

2.1.1 Agriculture

Schultz (1965) stated that population growth has been the best–known problem of economic development and it has provided the most publicized argument for expanding agricultural production. This author positions agriculture throughout the world, in accordance with its contribution to economic growth. For this purpose, economic growth means simply increases in Gross Domestic Products (GDP) or national income. Agriculture is then one of the sources of national income. There are countries which practice traditional agriculture, and others modern agriculture. Generally peasant farms produce in excess of what the farm family can consume and sell the surplus in the market, in order to purchase non-farm goods and services. This surplus varies among farms, regions and nations. Farm size also varies, likewise state of technology used and the degree of specialization in production.

Schultz (1965) stated that agriculture is treated as a source of economic growth and it acts as an engine of development, but the important issue had been the form of investment for the realisation of this goal. To increase agricultural production, incentives to reward and guide farmers are seen as an important component of the investment. Also transforming traditional agriculture into highly productive and profitable enterprise will depend on the kind and form of investment made in the sector. According to Schultzs (1965), once traditional agriculture is established, the equilibrium is not readily changeable. He further stated that there were comparatively little inefficiency in the allocation of production factors especially in traditional agriculture.

Lloyd (1975) asserts that agriculture plays a role as resource reservoir, which can be drawn on to supply food, labour, and finance to fuel the growth of urban activities. In a study conducted, Southworth and Johnston (1974) found that agriculture was by large margin the largest single sector of production in many least developed countries (LDC) such as Kenya. In Kenya, agriculture was responsible for almost two thirds of total national employment in the year 1979 and this was superior to other sectors of the economy.. Agriculture has contributed significantly to Kenya's success e in achieving rapid economic growth without running into major balance of payments crises during the first fifteen years of independence.

For increasing production, labour is seen to be the primary instrument within the framework of traditional agriculture. According to Mellor (1974), it is quite possible that in low-income societies, the marginal productivity of labour will be so low that, even under the most favourable circumstances as regards the supply and display of consumer goods, it will not equal the slope of the utility curves once the traditional subsistence level has been reached.

Hayami and Vernon (1971) confirms that the relative availability of labour and land in the agricultural sector is as a result of original resource endowments and the resource accumulation associated with historical growth processes of each economy. For instance; Australia a relatively inelastic supply of labour represented the most significant constraint on growth of agriculture production. In order to ease the limitations set; farmers try to economize on the use of the limiting factors of production or to substitute man–made inputs for it, e.g., fertilizer for land and tractors for labour. The growth path followed by the countries in the new continents seems to reflect a process of easing the limitation set by labour.

Schultz (1965) found that, technological possibilities have become increasingly more favourable but the economic opportunities required for farmers in most less developed (low-income) countries to realize their potential were far from favourable. Schultz suggested that government intervention could be the primary cause of lack of optimum incentives. It was therefore important to determine the conditions that were both necessary and sufficient to attain the optimum increase in agricultural productivity. Clayton (1964) noted that it is important to know the problem facing peasant agriculture (farmers in general) if they were related to raising agricultural productivity.

According to Clayton (1964) unsatisfactory marketing arrangements for farm produce and long distances or poor communication resulting in high transport cost hamper the farmer as these may make the sale of goods unnecessary and not worth while, thus hindering agricultural growth.

Poor farming practices are further difficulty in peasant agriculture. In Rwanda labour is an abundant resource. The total supply of rural labour was so high that there was little correlation between labour input and level of output until the production increases to a point that, the average output of labour drops close to subsistence level (US Census Bureau, 2005).

Hayami and Vernon (1971) divided the resources of productivity into three broad categories:

(i) Resource endowments which include the original land resource endowments, internal capital accumulation and development, livestock, inventories, and so forth.

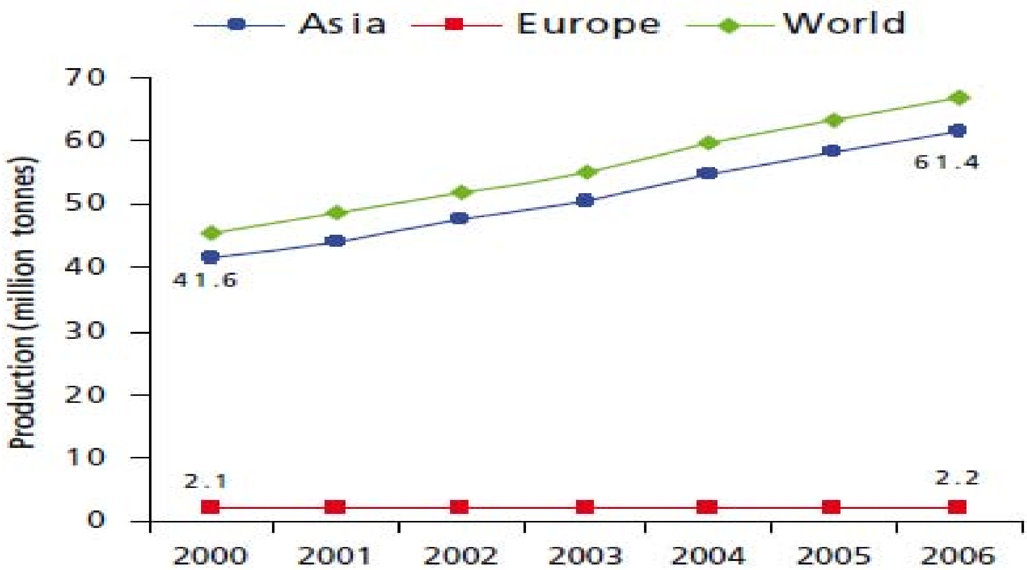
(ii) Technical inputs which include the mechanical devices, the biological and chemical materials purchased from the industrial sector.

(iii) Human capital which is broadly conceived to include the education, skill, knowledge, and capacity embodied in a country's population.

2.2 Global Overview of Aquaculture

The fisheries sector plays an essential role in human welfare and economic growth in most countries in the world, including Ghana. The nutritional benefits of fish as food has been well recognized in the world, especially as a source of protein, fatty acids and minerals. In addition, the contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic organisms cannot be over-emphasized. For instance, in 1970, fish from aquaculture excluding aquatic plants formed 3.9 percent of the total global production, by weight increasing to 27.1% by the year 2000 and still growing. By 2004, aquaculture production formed almost a third of the global production by weight, and this represented 32.4 percent (FAO, 2004).

Global aquaculture production reached 66.7 million tonnes in 2006, growing at an annual rate of 9 percent, and continues to increase its proportional contribution to total fisheries output, Thus, aquaculture continues to make a significant contribution to total fisheries production over the last few decades. This increasing contribution, however, is largely an Asian phenomenon, because Asia accounted for 61.43 million tonnes or 92 percent of total world aquaculture production in 2006, while Europe contributed 2.17 million tonnes or 2.2 percent (Figure 1)



Source Adapted from FAO (2008a)

Figure 1: Recent Trends in Aquaculture Production.

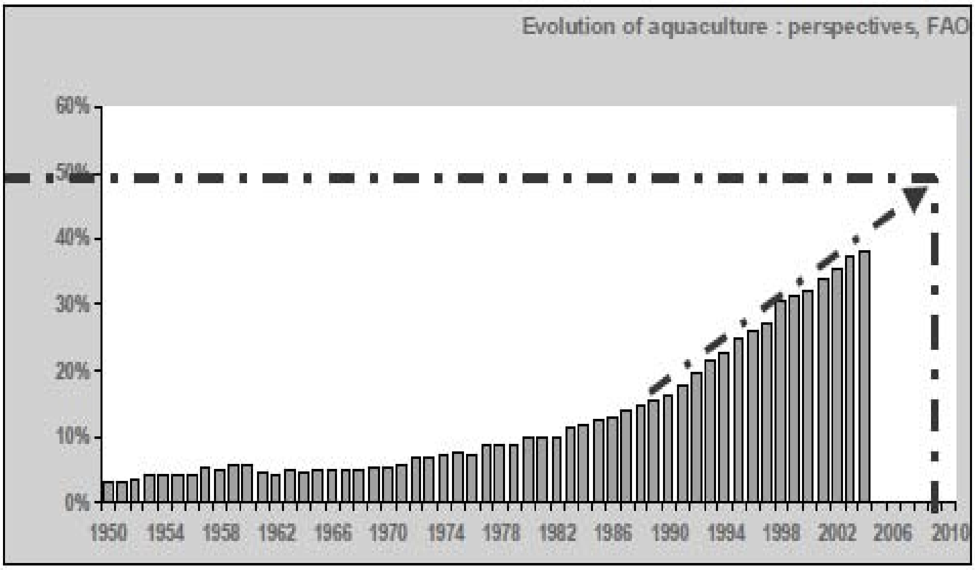
An FAO (2007) report shows that aquaculture continues to grow more rapidly than all other animal producing sectors; and it has been estimated that by 2025 it will beat any form of animal farming by weight, except cattle. In an assessment conducted on the growth rate since 1970, aquaculture per year has grown worldwide, on average basis at a rate of 8.8 percent; whilst captured fisheries and other terrestrial farmed meat production systems have grown at 1.2 percent and 2.8 percent respectively, over the same time period.

Koeleman (2010) stated that aquaculture's "contribution by weight" increased from 73 percent in 1979 to 90 percent in 1998 in most developing countries, though this dramatic increase in production has been skewed on regional basis in favour of Asia. For example, in 1998, aquaculture productions by weight, according to region, were as follows: Europe, about five percent; South America, less than two percent; Africa and Oceania, about 0.5 percent each. Moreover, the numbers of fish farmers in the world increased from 7.07 million in 1998 to 7.47 million in 2000. The regional breakdown for 1998 and 2000 by region were: Asia, 6.67 (7.13) million; North and Central America, 191,000 (190,000); Africa 56,000 (75,000); South America, 41,000 (41,000) and Oceania 5,000 (5,000). From the above figures, Africa continues to be a minor player in the global aquaculture industry even though the continent has a natural potential for aquaculture production. The production of tilapia which is even native to the continent has not experienced any significant growth.

The FAOSTATS (2004) report shows that the African continent however has some encouraging signs. These include the black tiger shrimp (*penaues mondon*) in Madagascar, *Eucheuma* seaweed in Tanzania and abalone (*Haliotis spp*) in South Africa. Moreover, Egypt is now the largest producer of tilapia in Africa, and only second in the world after China. Egypt contributes 78 percent of total tilapia produced in Africa followed by Uganda, Nigeria, Madagascar and Ghana.

2.2.1 Fish Farming Development in Africa

The sustainable development of Africa's natural resources is today increasingly linked to human security. Food security is known to be the foundation for human security in every region. Hence, it has become crucial for investments in natural resources such as water, fisheries and extractives should be both public and private sector-driven in order to take into account the longer-term goals of sustainable development and food security. This is particularly true in the fisheries and aquaculture sector for a region like West Africa, where the majority of the population depends on fish-based resources for their daily sustenance. The local demand for fish products in the region will continue to increase. Moreover, commercial fishing vessels supplying international markets in Asia and Europe will see higher demand. This pressure will always generate a need for seafood dealers to diversify their fish sources, including turning to aquaculture. With the fast evolution of the world seafood market in terms of trade, especially for "eco-labelled" products, aquaculture has become the major player in the seafood industry. From 1989, there was a global stagnation of fisheries production; but as fisheries demand increased, the result was then a fast increase in aquaculture production, starting in 1992 (FAO, 2003).



Source :FAO (2003)

Figure 2: Evolution of Aquaculture as percentage of total production (1950-2010)

Figure 2 shows the trend of acceptability by farmers to engage in aquaculture from the 1950s to 2005.

From figure 2 above, aquaculture by 2010 – 2012, it is projected to constitute 50 percent of world seafood production, or to produce about 90 to 100 million tonnes of fresh water fish as compared to about 3,1 to 7.1 millions of tonnes per year between 1992 to 2004 (FAO, 2003). The annual rate of aquaculture fish consumption has increased by two percent since 1992. However, due to environmental concerns and consumer pressure, sustainable practices have mostly superseded over non-sustainable practices, as strict trade rules on origin and labelling have become indicators for marketing success. Thus, aquaculture have become diversified and grown enormously over the last decade, with the production being fine-tuned with new technologies and best management practices (FAO, 2003).

Aquaculture has come a long way in Africa since its first inception in the 1960s. In comparison to the rest of the world, aquaculture production in Africa is still insignificant at the global level and accounts for only about 0.9 per cent (404,571MT) of the total global aquaculture production in 2000 (FAO, 2003). However, African aquaculture is going through an exciting phase of growth and evolution after several false starts which did not result in any meaningful aquaculture development. This insufficient development exists against a backdrop of conditions that would benefit greatly from the rapid development of aquaculture on the continent namely high incidence of poverty, malnutrition and unemployment (Hecht, 2000).

However, reasons for the lack of growth have been reviewed in several studies (Huisman, 1990; Harrison, 1995; Brummett & Williams, 2000) some of which include overzealous and unplanned promotion of aquaculture that placed emphasis on technical research and technology transfer, without regard to the natural resource base and the socio-cultural and economic context within which the technologies were being promoted. It became apparent that technical research and technology transfer had to fit within the local conditions (natural resources, socio-cultural and economic) of the specific area where aquaculture development was being planned.

Since the early 1980s, some international development agencies and advanced research institutes have been promoting aquaculture within the context of integrated agriculture, and have begun addressing socio-cultural and economic factors that have been impeding aquaculture development. This approach resulted in sustained aquaculture growth in some African countries, such as La Côte d'Ivoire, Egypt, Ghana, Malawi, Nigeria and Zambia (FAO, 2003). Additionally, according to FAO (2003), changes in macro-economic environments, development of domestic and export markets for fish, and the stagnation of inland capture fisheries in Sub-Saharan Africa have made investment in aquaculture attractive. Private investment in commercial aquaculture production and growth of this sector have been reported in Egypt, Kenya, Namibia, Nigeria, Malawi, South Africa, and Zimbabwe. However, in order for aquaculture to register further growth and meet its potential of bridging the gap between fish supply from capture fisheries and the demand for fish, the direction of aquaculture development in Africa will have to be refocused with large emphasis on the role of input suppliers in the value chain process. This would enable the problems faced in aquaculture production to be tackled more effectively.

Jamu & Ayinla (2003) reported that, there is a wide variety of production systems, such as cage, pond, tank and raceway systems that are being used for aquaculture production in freshwater and marine environments in Africa. Jamu & Ayinla further said that, these systems are being used in small, medium and large scale operations, and at various levels of intensity. The authors further emphasized that currently, the dominant production system which were used in Africa is the earthen pond system. A major proportion of public sector research and development effort has been directed towards increasing the productivity of pond systems, with little public sector research and development geared towards improving and understanding other production systems such as brush parks, cages, and culture-based enhancement fisheries in flood plains, rivers and lakes. The authors further suggested that that in order to increase the production potential of aquaculture in Africa, research and development should be focused on a wider range of production systems for fish farming and on increasing the intensity of production in fishponds to help farmers achieve higher yields at a reduced production cost.

According to Jamu & Ayinla (2003) fish feeds, one of the major inputs of fish production, become a significant factor in increasing the productivity and profitability of aquaculture, as aquaculture production becomes more and more intensive. The viability of aquaculture is determined by feed management as it accounts for at least 60 percent of the cost of fish production. Currently, high cost and low quality fish feeds are major factors limiting the development of aquaculture in Africa, and this is likely to remain so in the near future. Hence, nutrition research that helps to reduce the cost of fish feeds without reducing their quality will be crucial to the successful development and commercialization of aquaculture in Africa.

De Silva (2001) stated that fish nutritional research conducted so far, was concentrated on the replacement of animal protein by plant proteins, with a view to reducing the cost of supplemental feeds.

Hecht (2000) argued that research on inexpensive feed ingredients did not contribute greatly to aquaculture development in Africa and suggested that more effort should be put into research on how plant proteins can best be used in the feeding of fish. Recognizing that ponds will remain the major aquaculture production system in Africa for the foreseeable future, developing nutritional strategies that will maximize the contribution of natural and supplemental feeds in fish ponds will help to expand aquaculture production. This necessitates the development of revolutionary feed and fertilization regimes that will increase the nutritive value of fish diets (both supplementary and natural), and increase profitability and productivity without degrading the environment.

Goldburg and Triplett (1997) stated that both aquaculture and captured fisheries have caused much public concern about their sustainability and influence on the environment. Hence in response to such concerns, several systems have been developed to rate the sustainability of “wild-caught” seafood and aquaculture products; among them are Seafood Watch, Sea Choice and Guide to Ocean Friendly Seafood.

Mungkung *et al.* (2006) used life-cycle assessment (LCA) as one quantitative method for a more comprehensive approach to compare aquaculture with terrestrial agriculture systems; but to date, such assessments have not included the impacts of species decline caused by non - native species’ escape from aquaculture and becoming predatory to the native fish, thereby threatening the environment. This comparison is necessary to understand what constitutes environmentally friendly seafood production and to promote conservation practices while still producing food. This assessment methodology, including calculations of costs, and greenhouse gas emissions, is however closer than any other available methodology to being an appropriate quantitative method for comparison of food production systems.

Tacon and De Silva (1997) stated that, aquaculture has been an important recycler of agricultural food wastes, particularly within China and the Asian region where they have integrated farming systems for over two millennia. The authors further stated that, it was important to build on the experiences gained from these largely semi-intensive farming and feeding practices, and develop these further. For example, fisheries and agricultural food-processing wastes that have been successfully recycled and used within industrially compounded and farm-made aquafeeds include (in order of nutritional and potential feed value): fish offal's, poultry droppings, rice bran and wheat bran.

2.3.1 Challenges Faced in Aquaculture

2.3.1.1 Feeds and Feeding

Rana (2009) stated that aqua-feeds usually account for 50 –70 percent of production costs. Hence, for most farming operations, the price of fish is influenced by the expenditures for inputs such as feeds and feed ingredients. Generally, low-value freshwater species are cultured in extensive or semi-intensive systems that needed great volumes of water and land area. Inputs may be limited to fertilizers and single-ingredient farm-made aqua-feeds. As a result, productivity is lower than that of higher value-species cultured in intensive systems using commercially formulated aqua-feeds. Water resources and land, however, are mostly in short supply in many leading aquaculture producing countries due to land tenure structures, urbanization and industrialization, and competing demands for land and water for irrigation, compounded by increasing human population.

Stirling Aquaculture (STAQ) (2004) reported that feeding methods and technologies used in most intensive aquaculture were based on dry compounded feeds. These are convenient to handle, have a relatively long shelf life and are of consistent quality. Over the past decade, pelleting and the over-oiling of fish feeds have provided further benefits such as better feed conversion and reduced waste. The current generation of expanded diets are less dense and more robust, sinking more slowly, allowing the stock more opportunity to eat and produce less waste. A further advantage is that high pressure feed delivery systems can be used to disperse such feeds to the fishes over a large area without the feed breaking up. Other advances have been in the introduction of feed attractants and stimulants in the feeds, new pigmentation enhancers and more stable forms of vitamins. Non-expanded pellets tend to disintegrate in such systems producing fine particulates, which are not eaten but adversely affect water quality, damage gills and reduce feed conversion ratio (FCRs).

STAQ (2004) further reported that most species respond positively to being fed small amounts of feed frequently, which with traditional hand feeding, is laborious and expensive, though many producers still do so, to observe stocks during feeding and adjust rations according to their reaction. Regardless of the feeding strategy, with increasing size of production units, a range of systems is used to distribute feed. These are Automatic feeders, feed blowers or water/air cannons operated from boats are commonly used in large cages and tractor mounted blowers in large ponds. The reaction of stock to feed is one of the few means to judge health and environment; even with sophisticated systems, it may be necessary to use observation to adjust feeding rates and rations. However, computerized feeding systems that can adjust feed quantities depending on temperature, season and time of day are increasingly common in the intensive aquaculture sector. A further refinement is to use sonic or video monitors to judge stock movement and behaviour, or to monitor levels of uneaten food, and thereby control feeding rates even more accurately.

2.3.1.2 Technical, Management and Social Problems

Zaman *et al.* (2006) stated that in Bangladesh, fish farmers under different types of management were found to be facing many technical, social and economical problems. Technical problems were related to production techniques and technology such as lack of scientific knowledge and suitable technology, less extension services on aquaculture training, turbidity, non availability of quality fish seeds at proper time, occurrences of fish diseases, water scarcity during drought season and pond water irrigation for crop fields. Social problems were related to management complications of multi ownership of ponds, loss of fish due to poaching, fear from enemies likely to poisoning fish in culture pond and negligence in use of fertilizers.

Bose *et al.* (1991) affirmed that fishmeal is produced from cooking, pressing, drying and milling both whole fish derived from captured fisheries and fish trimmings from fish processing plants. Fishmeal production results in the production of fish oils and approximately 90 percent of the fish species used to make fishmeal and oil is termed “forage fish” (e.g mehenden, sardines and anchovy) and this is presently unmarketable in large quantities as human food. Since the supply of fishmeal and fish oil ultimately depends on captured fisheries; their supply is primarily governed by allowable quotas and is subject to seasonal variation.

2.3.1.3 Planning / inter-disciplinary Approach

Brugère *et al.* (2010) affirmed that with the dramatic recent growth of aquaculture, the planning of its development has become increasingly important. Proper planning will stimulate and guide the evolution of the sector by providing incentives and safeguards, attracting investment and boosting development. It will also help to ensure the long-term economic, environmental and social sustainability of the sector, and its ultimate contribution to economic growth and poverty alleviation. Central to successful planning in the aquaculture sector are coherent in the planning process and an emphasis on interdisciplinary approach which is beyond sectoral remit, through institutional collaboration, human capacity development and participation. It is also necessary to embed the chosen approaches and instruments in the principles of good governance. Together, these key elements will ensure the soundness and effectiveness of aquaculture development policies and the positive contribution of the sector.

2.3.1.4 Labour and Finance

Lazard (1996) stated that a model for farmers must not be capital intensive. Thus, it must encourage the use of the most abundant production factors as opposed to ones that are scarce. However in most African environments, farmers are faced with inadequate capital as a factor of production. Hence, the most efficient systems are those making intensive use of the most abounding production input, in this case, labour. Lazard advised that a chosen model should rely on productive combinations that take into account the limitations in factors of production such as financial, labour, land and marketing constraints. Regarding financial constraints, models requiring an important working capital are not suited for rural aquaculture development. Peri-urban areas are characterized by their proximity to the fish and input markets, hence several technical models could be considered. Results show clearly that the most efficient, in terms of profitability, is not the one which uses the most performing fish feed. Moreover, it shows that the only models having a positive profit are the ones which are using an all-male stocking (hand sexing with police-fish) or use hormones to change the gonadal properties before they grow into clearly differentiated male or female fish. Heavy extension support is required, probably on a long term basis.

In the report by the International Development Research Centre [IDRC] (2010) farmers described fish farming as a labour-intensive enterprise, and success required the active involvement and commitment of the household heads as well as involvement of the other household members. Labour input was an essential component for success. In fact, fish farming was often understood to be a family business, and family members were involved in predation control, fry production, input purchase, slashing of weeds, marketing, and pond management. Hired labour was an alternative that was sought after when it came to difficult tasks, such as pond construction. The family was the most important source of small-scale fish-farming labour, while hired labour was employed at community and commercial sites that involved large investments. Activities, such as feeding, applying fertilizers and other necessary activities were in the domestic domain where women and children dominated, while men did mainly the harvesting and marketing. Gender was not the most important criterion for the division of labour among the fisher folk; other variables, especially ownership of the instruments of production and distribution which in turn hinged on capital outlay were more crucial in determining the division of labour (Madanda, 2003).

Beveridge and Little (2002) reported that the primary set of ecological interactions in most aquaculture systems comprises those that drive energy and nutrients towards targeted production. These are commonly the concern in management and relate to the fertilizing and feeding strategies just outlined, together with the metabolic output and recycling features. However, a range of other, often less tractable interactions can be described at times creating significant constraints. In a general perspective, these tend to be more important in more energy and nutrient-dense (i.e. more intensive) systems, but this is not always so.

2.3.1.5 Technical Know-how

Adeogun *et al.* (2007) observed that some of the factors militating against the development of aquaculture can be categorized as economical, technical, ecological and institutional. The most commonly expressed problems facing aquaculture development in Nigeria is the technical know-how. The authors further explained that, producers in the urban zones ranked this factor as the highest major constraint negating the old norm whereby fish feed used to be a major challenge to the farmers.

2.3.1.6 Land

Awity (2005) stated that the production of aquaculture was expected to expand in the future, and this would necessitate the allocation of even more land at the expense of the limited agricultural lands used for food and cash crop cultivation.

2.3.1.7 Feed / Marketing of Inputs

Roy *et al.* (2002) stated that supplementary feed plays a vital role in fish growth and increase in productivity. The main components of feed are de-oiled rice bran, groundnut cake, soya bean and cotton seed cake, and fishmeal and fish oils. The farmers practice two types of crop cycle, 10 to 12 months and 15 to 16 months. Marketing of fish, the transfer of product from producer to consumer involves three classes of middlemen: the contractors, the wholesalers and the retailers who take a major share of the consumer's price.

2.3.1.8 Aquatic Health Management

Ghittino *et al.* (2003), reported that finfish and shellfish diseases are widely accepted as one of the most serious threats to the commercial success of aquaculture. Stock losses of more than 20–30% can occur in serious disease outbreaks, and for especially sensitive stocks or life-cycle stages, complete mortality can result if disease is untreated. If stocks survive, they may be damaged physiologically or reduced in market quality, both of which represent serious financial loss to the farmer.

Ghittino *et al.* (2003) further contended that disease treatment varies considerably with species, disease status and husbandry conditions, ranging from simple measures to improved water quality and reduced stress, cleaning out sources of contamination and disease transfer, application of drugs and other chemicals, orally, by immersion or by injection, with specific or general control of pathogens, and increasingly, vaccination.

Corsin *et al*. 2002 reported that, complete eradication and sterilization may be required for particularly dangerous pathogens. There continue to be significant problems in many areas of aquaculture, with little respite from continued vigilance, research to identify pathogens and their strains, appropriate and effective methods of treatment, and longer-term approaches to maintaining stock and industry health status. Although there have been many useful advances in disease diagnosis and treatment, the greatest impact has probably been through immunology, with techniques applied in two major areas of aquatic disease control—diagnosis and vaccine development.

Villena (2003) reported that the development of antibody probes to pathogens provides useful tools for rapid diagnosis using techniques such as immunohistochemistry, immunofluorescence and enzyme-linked immunosorbent assay. Initial prevention from infection is the optimal strategy for disease control, and vaccination has proved highly effective in improving survival rates for salmon, with a very significant reduction in antibiotic usage.

Penman *et al.* (2002) reported that fish vaccines have become much more sophisticated, with a trend for the development of subunit recombinant vaccines, in preference to killed whole cell preparations, as the latter was not successful for many important diseases, and attempts to produce attenuated vaccines in general have encountered safety concerns. The most recent development is direct DNA vaccination, which appears to offer efficacy and low in cost, is being developed commercially for infectious salmonid anaemia and virus in salmon. Another molecular genetics technique is the polymerase chain reaction method of DNA amplification. This is increasingly used to detect the presence of pathogens (e.g. specific viruses, bacteria and parasites) in the culture species or environment before the appearance of clinical disease, greatly improving the prospects for managing the problem before an outbreak occurs.

MacRae (1998) reported that in the less intensive and lower-value aquaculture sectors, disease management has proved to be much more difficult to implement. Apart from routine disinfection and preventative treatments for hatchery stock, limited attempts were made to control and possibly quarantine introduced stocks, has generally had much less impact. This has been a significant challenge, as the majority of production risk and productivity losses would appear to be associated with nonexistent or poor health management. Furthermore there have been a number of epidemic conditions such as white spot virus in marine shrimps and epizootic ulcerative syndrome in freshwater fishes which have caused substantial losses, driving out significant numbers of producers and for which it has been impossible to provide effective management responses.

Corsin *et al*. (2002) reported that recent work on developing epidemiological techniques has however shown potential and this is now being extended to explore how these may be used to change institutional processes from the traditional focus on pathogen diagnosis, with very limited effective feedback, to more solution- and outcome driven approaches.

2.3.1.9 Food Safety Issues

Howgate *et al*. (2002) reported that another area of concern relates to food safety as related to aquatic and ecosystem health, with increasing potential for contamination and bioconcentration in many peri-urban and rural areas, particularly in developing countries.

Sadhukhan *et al*. (1996) reported that food safety and ecological issues may be accentuated by a relatively lack of awareness of risk, limited analytical capacity, poor policy response and generic under-investment in sanitation in areas that aquaculture has been promoted.

Reilly & Kaferstein (1997) also reported that the increasing interest in developing aquaculture for export and foreign exchange earnings, will however lead to greater sensitivity, with considerable commercial risk being attached to rejection of product or market closures. This may increasingly become an issue of competition in global markets, with local lobbying to restrict imports because of suspicions about safety (Young & Muir 2002).

2.4 Farming Systems Distribution and Characteristics in Ghana

Ghana is an African country delineated by latitudes 4°12' N, and 11°7' N and longitudes 1°12' E and 3°14' W. On the northern border is Burkina-Faso, on the east is Togo, on the west is La Cote d'Ivoire, and to the south is the Gulf of Guinea of the Atlantic Ocean. There are ten administrative regions, and each comprises several districts. The surface area of Ghana is 236,539 km^2. It is 500 km along the widest stretch and 715 km along the north-south axis. The coastline is 536 km long with a narrow continental shelf. According to Vanden Bossche *et al*. (1990), the Upper-East and Upper-Western Regions Northern Region have eight months of dry season. Fish farming is seen to be possible but only at irrigation sites in these regions. Culture-based fisheries are, however, possible in the numerous reservoirs in the three regions (Fisheries Commission, 2006).

A district-wide assessment in 1991 by FAO of the availability of land, water and rice bran, and the economics of organic manure (cattle, pig, and poultry) as criteria for the viability of fish farming development found that parts of the Brong-Ahafo, Ashanti, Eastern, Western, Central and Volta Regions were suitable. However, these farming units were very small and highly dispersed. Existing pond sizes varied from 15 m^2 to about 480 m^2. Appropriate aquaculture sites were not concentrated in one area but were dispersed throughout the southern and middle belts of the country. Generally, most of them depended on seepage of water from the pond bottom to fill the ponds; hence bottom of ponds cannot be dried fully before the next culture of fish, and this adversely affects production (FAO, 1991).

2.5 Overview of Ghanaian Aquaculture

Inland fishing, an aspect of aquaculture, has a lot of occupational potential but is largely under-exploited. Though there are traditional and management methods such as *'atidjas'* (brush parks in lagoons and reservoirs), *'hatsis'* (fish holes), '*whedos'* (mini dams in coastal lagoons) and the culture of fresh water clams (*Galatea paradoxa*) in the lower Volta (Anon, 2003). More modern forms of aquaculture were introduced in the early 1990s in Ghana and it is being promoted in at least seven of the 10 regions comprising Greater-Accra, Ashanti, Western, Brong-Ahafo, Volta, Eastern and Central Regions; and the highest concentration of fish ponds is found in the Greater Accra and Ashanti Regions (Anon, 2003). *Tilapia niloticus* (Nile Tilapia) is the main species cultured with *Clarias gariepinus* (catfish), *Heterobranchus* and other endemic species found in lagoons and dams. There is a clam (*Galatea paradoxa*) fishery in the lower Volta River.

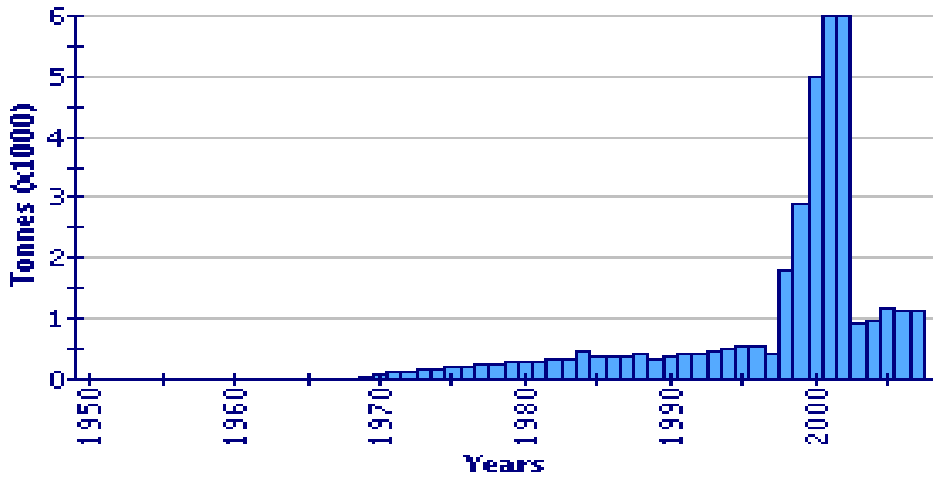
Fish farming started when fishponds were built in 1953 in the northern parts of Ghana. These were to serve as hatcheries to support the culture-based reservoir fishery development programme of the colonial administration, and as a way of supplementing the national demand for fish and increasing livelihood opportunities. Fishing skills were taught to members of communities living near small reservoirs, which were not traditionally used for fishing. After independence in 1957, the national government adopted a policy to develop fish ponds within all irrigation schemes in the country. State-owned irrigation facilities were to be developed, as far as it was technically possible, under a policy of converting 5 percent of the scheme into fish farms (Fisheries Commission, 2006).

Ghana's policy was to allocate five percent of all irrigatable lands for pond construction and to enjoy some satisfactory level of patronage; but this was not very successful due to a number of reasons. These myriad reasons included poor site selection, ponds not being drained and farmers not having any business focus. Also, there are a lot of constraints to the expansion of aquaculture in Ghana; for instance, constraints like lack of adequate supply of fish seed, lack of high quality fish seed, lack of suitable feed and weak extension support. There are also the problems of credit and organized markets. Shortage of trained staff and less motivated practitioners are also part of the problem. The question one may ask is; how are developing countries in Asia able to make it?

Between 1990 and 2004, the technology of fingerling production improved tremendously. Fingerlings were being produced from concrete tanks and hapas, in addition to earthen ponds as was the practice in the previous years (Fisheries Commission, 2006). Though fish seed is still being obtained from rivers and reservoirs in the remote areas, private commercial entities produce fingerlings of tilapia far in excess of their requirements and are willing to sell the surplus to grow out farmers. All-male tilapia culture is becoming widespread due to their large size at maturity. Fish is produced mainly from earthen ponds and one cage culture establishments in the Volta Lake. There are no marine or brackish water aquaculture establishments in the country. All the commercial operators grow Nile tilapia (*Oreochromis niloticus)*. The small-scale operators produce various species in addition to the major species of *O. niloticus, Clarias gariepinus* and *Heterotis niloticus,* (FAO, 2005).

According to FAO (2005), aquaculture in Ghana is based on mainly Nile tilapia, *O. niloticus* and the African catfish, *C. gariepinus*. In Ghana, tilapia forms about 80 percent of aquaculture production without any algae, shrimps, crabs and frogs being farmed.

A survey by the Department of Fisheries (DoF) in 2004, estimated aquaculture fish production at 950 tonnes per annum. Although production has not been disaggregated by species, it is known that *O. niloticus* is the dominant species. Farmed fish is cheaper in the villages than in the towns. Both tilapia and North African catfish sell at ¢15,000 (US$ 1.63)/kg in Kumasi, Ghana's second largest city. In Accra, the largest city and the capital of Ghana, the cage culture farm sells tilapia at GH¢3.5 (US$ 3.80)/kg at its sales outlets, while *Clarias* spp. sells for GH¢5 (US$ 5.44)/kg. Given the estimated production of 950 tonnes, sold at an average price of GH¢1.5 (US$ 1.63)/kg at the farm gate, the estimated income generated by aquaculture is about GH¢1,425.0 Million (US$ 1.5 million). Figure 3 below shows the total aquaculture production in Ghana according to FAO (2003) statistics.



Source:Fisheries Commission 2005

Figure 3: Reported Aquaculture Production in Ghana from 1950 – 2000

2.6 Contribution of Fisheries and Aquaculture

2.6.1 Contribution of Fisheries and Aquaculture to the Economy of Ghana

The contribution of aquaculture to the economy of Ghana has not been separated from the overall contribution from the fisheries Sub-Sector. Livelihood opportunities identified are usually those related to marine and inland captured fisheries. Ten percent of the population is involved in the fishing industry from both urban and rural areas; and women are key players in post-harvest activities.

Aggrey-Fynn (2001) observed that, fish is recognized as the most important source of animal protein in Ghana. Moreover, of the various sources of protein, fish stands out as the most important in terms of food security because its lower price, relative to the price of other high quality protein sources such as milk, meat and eggs. It is also the only source of high quality protein whose shelf-life can be readily enhanced through low-cost sustainable technologies such as smoking, drying and salting. It is not uncommon to encounter smoked fish which has been stored for 3-6 months in rural markets in Ghana. Average per capita consumption of fish in 2004 was 27.2 kg.

Onumah *et al.* (2010) stated that Ghana's fisheries industry contributes 5 per cent of the nation's agricultural gross domestic product (GDP) and provides employment to about two million people. However, consumption of fish in the country ranges from 20 to 30 kg per capita with average per capita consumption of 27.2 kg per annum, turning Ghana into one of the highest fish-consuming countries in Africa. However, aside these benefits, the growth of the fishery industry face myriad challenges. Some of the challenges outlined are, lack of inputs and high production cost (e.g. hapas, specialized cages, cost of floating feeds, and availability of sex reversal hormones).

Fish is Ghana's most important non-traditional export commodity. Export earnings from fish and fishery products in 2002, amounted to nearly US$ 96 million. The export destination is mainly EU countries. Fish and seafood exports from Ghana are made up of tuna (whole, loins and canned), frozen fish (mostly demersal species), shrimps, lobsters, cuttlefish and dried/smoked fish. Mensah *et al.* (2003) stated that fish exports remained among the top three most important non-traditional exports, with regards to foreign exchange earnings. Apart from canned tuna, the other important fish products exported are the African catfish which seem to have a good market in Europe and other western countries. A wide variety of fish, including tilapia and shark fin classified together as “frozen fish”, “salted fish” or “smoked fish” (depending on the form of presentation) are also exported. Key on the export destination list for Ghana’s fish are the European Union, Japan, United States of America, Canada, Togo, Mali, Cote d’Ivoire, Burkina Faso, Benin, Nigeria, Hong Kong and Singapore.

Although the majority are small-scale operators, several fish farmers consider fish farming as a source of income, and fish produced are sold as opposed to being consumed by the fish farmer's family. Aquaculture also provides labour for family members and neighbours (FAO, 2005). Other opportunities for value-addition that have been identified include fish processing, such as frying, salting and smoking, which is done in most villages. The Department of Fisheries (DoF) has also trained 17 pond construction gangs across the country, each consisting of ten members, to construct ponds for a fee. Each gang was provided with a set of hand tools (such as pick axe, spade, mattock, measuring tape and spirit level) to facilitate its work (Fisheries Commission, 2006).

2.6.2 Contribution of Fisheries and Aquaculture to Agriculture

The dominant sector in Ghana employing about 60 percent of the labour force is that of agriculture. Agriculture (predominantly smallholder, traditional and rain-fed) contributes 45-50 of the GDP, and about 75 percent of export earnings of Ghana. Accounting for 5 percent of the country’s agricultural GDP is the fisheries sub-sector. With a per capita consumption of about 27.2 kg per annum, fish is a preferred source of animal protein in Ghana. Fish is expected to contribute 60 percent of animal protein intake of Ghanaians. About 75 percent of the total domestic production of fish is consumed locally. Ghana's fishery industry is based on resources from the marine and inland (freshwater) sectors, coastal lagoons and aquaculture (FAO, 2005).

FAO (2005) stated that there are about 1,000 fish farmers and over 2000 ponds with a total surface area of about 350 ha currently, with total annual aquaculture production standing at about 1,000 mt. However, the Government of Ghana has taken some measures to accelerate the development of fish farming in the country. For instance, a crawler dozer has been acquired for the Ashanti Fish Farmers Association (FFA) to be paid for on hire purchase basis, and a modern hatchery has been established near Kumasi to provide good quality fish fingerlings to fish farmers. However, the majority of farmers are small-scale operators using extensive fish farming practices. The five commercial operators, two of whom are women have entered the arena in the last five years. They undertake intensive fish farming practices and feed their fish with balanced diets which they prepare themselves. Currently, Dizenghoff Ghana Ltd in partnership with Ramona feed mill in Israel is importing floating and slow sinking fish feed for all production stages into Ghana and most of the commercial farms located on the Volta River are using these feeds. Ghana Agro Foods Company did produce fish feed for trials at the Water Research Institute but has been abandoned for unexplainable reasons and so most fish farmers have to rely on their own formulations to prepare feed which may end up not to be of any high quality and would not have any floating properties to feed their farms. In 2004, total production from fish farming was 950 tonnes, valued at GH¢1,425 Million (US$ 1.5 million).

On the average, production from culture-based fisheries in the reservoirs is 150 kg/ha/yr. Average productions from the ponds of small-scale operators is estimated at 2.5 tonnes/ha/yr and the total value of production by small-scale operators is US$ 0.463 million. The estimated production from the commercial cage culture facility is 200 tonnes/ha/yr valued at US$ 0.316 million. The production from a commercial fish farm of 8.7 hectares was 85 tonnes valued at US$ 0.134 million (FAO (2005).

Aquaculture has been often cited as a major means, among the various systems (such as sustainable fisheries through managed exploitation and importation of fish products to supplement domestic production) for efficiently increasing fish production. This has made the development of aquaculture very vital to many governments as a strategy to bridge the gap between domestic demand and supply of fish, and to produce surpluses for export. Due to the above, most banks have directed their efforts to provide funds for pond construction at a subsidised interest rate, even as at the early 80's. This has resulted in the attraction of a number of farmers into the industry and has also gone a long way to increase the use of agricultural land for aquaculture in most countries including Ghana (Onumah *et al.*, 2010).

2.6.3 Contribution of Fisheries and Aquaculture to Human Resources

FAO (2005) indicated that there are 46 professional officers with basic university qualifications (at least B.Sc.) in the fisheries sub-sector; 29 of whom have specialist postgraduate training in aquaculture and are dedicated to aquaculture duties. These 29 are in various aspects of aquaculture including shrimp culture and hatchery management. However, other staffs dedicated to aquaculture are high school graduates. In 2003, the Directorate of Fisheries carried out a survey which covered 77 administrative districts in Ghana and recognized a total of 709 small-scale fish farmers, operating in 1,380 ponds with a total area of 112.28 hectares. The farmers contended that, extension support services for fish farming was nonexistent, due to little or no knowledge of fish farming and its practises. There is the need for the government to increase training of extension staff whose core duties would be to provide technical support services to fish farmers so that they can improve their yield and expand their farms.

FAO (2005) came out with the following observations in another study of 161 out of a total of 324 fish farmers in four districts of Ghana that females constituted about 5 percent of the fish farmers and in three of the four districts, less than 40 percent of the farmers considered aquaculture as a principal activity. There were five full-time commercial fish farmers, four of whom had earthen pond farms of 10.0, 8.8, 8.7 and 3.1 hectares respectively. The fifth had eight cages, each with a diameter of 15 metres and depth of 4 metres. The fish cage establishment and the 3.1 hectares earthen pond farm were owned and managed by women. The cage facility and one of the commercial earthen pond farms had employed a full-time technician each to manage their technical operations. The technician on the earthen pond facility was a German. In the same study, it was found that about 9 percent of farmers had 1-6 years of education, 10 percent had completed secondary school and 8 percent had been to university, while 10 percent of respondents had no formal education. Male fish farmers were generally better educated than the female. These results could be a reflection of the situation and characteristics of fish farmers in the whole country (FAO, 2005).

Aside these contributions are some constraints. Ofori & Prein (1996) stated that only a few fish farms are functioning well today in Ghana. The authors further contended that, production is very low due to inadequate sitting, construction and management of farms. Moreover, fish farmers and extension personnel have little knowledge of appropriate technology. Education, training and follow-up are necessary to create this knowledge among farmers and to enable success stories. Currently, the many unsuccessful experiences with fish farming have discouraged further activities. New entrants into smallholder integrated agriculture-aquaculture pose the most imminent and viable option for an increased and sustained level of aquaculture production in Ghana.

Moreover, several systems of aquaculture are found in Ghana; these vary from intensive (commercial), to semi-intensive and extensive, with the latter two most commonly found. Most farmers rely totally on the natural productivity of the ponds to achieve their production, while others use agricultural by-products. To a very large extent, the small-scale fish-farmer uses artificial feedstuffs in unbalanced proportions to feed tilapia in earthen ponds. Hence fish growth is slow in this system and most fish farmers in the country fall into this category (FAO, 2005).

One other problem that is affecting fish farming in Ghana is the tilapia fish seed which are often obtained from less desirable sources such as fish production ponds of colleague farmers that are not drained for several years; and other common sources like reservoirs and rivers. These fingerlings are of very poor quality. Tilapia in production ponds which are not caught in the net during harvesting because of their stunted growth are also used as fingerlings. Fish caught as fingerlings from rivers and reservoirs are either mature or of poor genetic quality and health, or are undesirable species. However, there are now few up and coming small-scale seed producers who are turning out good quality seeds of both tilapia and the North African catfish from hatcheries (Fisheries Commission, 2006).

The Fisheries Commission (2006) reported that aquaculture should be looked into as an alternative livelihood employment for most of the fishermen living along the coastal area close to the oil production site, since the lights on the rig attract fishes close to the rig and that makes it tempting for fishermen to fish in that area. Aquaculture is seen to become the ideal substitute for sea fishing. Tilapia has become a delicacy, more eateries coming up specializing in tilapia meals. More food rendezvous are being trained in the informal sector, engaged in its distribution processing and sales.

According to the Fisheries Commission (2006), more research is needed to promote aquaculture by looking at the role that inputs play in the overall promotion and sustainability of fish farming in Ghana. If all the major inputs such as fish feed, fishmeal, cages, hapas, hormones are imported, then the prices of these products are controlled internationally, thereby increasing unpredictability of availability and pricing of such products. Alternatively, if a higher proportion of inputs are localized, then the projected expansion can be managed with local resources and that would result in producing fish that is of high quality and affordable to all. Having a large consumer front can also be an incentive for fish farming expansion in Ghana and that is what, all stakeholders in the sector must aim at, to sustain fish farming and make it attractive as a farming venture with a lot of potential for years to come.

2.6.4 Socio-Economic Characteristics of Fish Farmers

Aquaculture practice has become a promising and gainful means to attaining self-sufficiency in the food sector and also to alleviate poverty in Bangladesh (Zaman *et al.,* 2006). A livelihood is sustainable when it can cope with and recover from stress and shocks, and can be maintained to enhance its capabilities and assets both now and in the future (Chambers & Conway; as cited by Zaman *et al.,* 2006). The social content is especially important, particularly access arrangement and assessments of benefits to livelihood (Azucena *et al.* 2004 *as* cited in Zaman *et al.,* 2006).

According to Zaman *et al.* (2006), although income for farmers were derived from farming sources, including apiculture, vegetables, aquaculture and livestock production, disposable income amongst farmers were low. Most fish farmers had improved their living standard through aquaculture practices as majority of them used electricity in their houses. In another study by, El-Naggar *et al*. (2008), stated that the job status of the majority (66.7%) of the respondence was mainly farming while other job categories were engineering, trading, etc (6.7%). The majority of these being farmers will no doubt bring more concentration to the fish farming systems in the study area as a way of enhancing fish farming productivity.

In the study by Zaman *et al.* (2006) majority of the fish farmers (14.4%) were educated up to primary level followed by secondary level (8.9%) and higher secondary or above (6.7%) levels, while 27.8% persons could only write their names. Although no conclusion was drawn for the implication for development of the educational status (with 40.0 percent being the majority of the fish farmers with no schooling or only medium level schooling), El-Naggar *et al*. (2008) also expressed fear that the adoption of new technology/innovation by such farmers would be low and is likely to reduce the expected productivity of fish farming in the area. Having a large number of non specialists as managers in a field of operation or study might translate to imminent doom for the sustainability of such ventures. This might also not be unconnected to the level of education of the fish farmers which fall between no school and medium level schooling.

Out of 90 fish farmers interviewed in Bangladesh, 90 percent were Muslims and the rest were Hindus. It was also found out that 87.8 percent were married and 12.2 percent unmarried farmers, which proved, most of the fish farmers were family people. The active age groups varied from 15-19 to 55-59 years (Zaman *et al.,* 2006). El-Naggar *et al*. (2008) concluded that the tendency for more productivity in fish farming would be high when their study revealed a majority of the fish farmers falling within the age range (21-40) and (41-60) years respectively. This implied that, most farmers within these age ranges were in their active age and therefore, stood the chance of developing aquaculture production better in the study area. The good thing about having many married people practicing aquaculture was explained to mean the use of more family labour in the fish farming operations, thereby leading to a reduction in the use of hired labour, thereby enhancing productivity (El-Naggar *et al*., 2008).

Majority of the farmers in the study by El-Naggar *et al*. (2008) rented the land from their government for their fish farming activities, implying that this might have impacted on the level of efficiency and dedication to farm profitability based on the fear or uncertainty of government policy on the usage of the land vis-a vis, revocation, review of land rent fee, tax imposition etc on the rented land.

2.7 Inputs used in Aquaculture

The main constraints in improving living standard of fish farmers in Bangladesh was found to be due to the lack of inputs and the persistent indebtedness of the farmers to the usurious traditional credit system (Zaman *et al.,* 2006).

2.7.1 Fish Seed

Viswanathan (2001) observed that, inputs for aquaculture, such as fish seed, fish feed and equipment for harvesting were of primary importance in Uganda. For instance, fish ponds cannot be established without sufficient fingerlings of reasonably good quality. Furthermore it was demonstrated that, shortage of fish fry production centres, was a seriously limiting factor for the growth and development of aquaculture in Uganda. Therefore efforts were being made to establish fry production centres across the major tilapia production centres.

The United States Agency for International Development [USAID] (2010) reported that, although fingerling production has increased since 2007 in Cambodia, it was still far from meeting the requirements of aquaculture producers. Since NGO financed fingerling producers move in and out of the business, huge gaps were left in the value chain. This situation is less widespread now than in the last five years, as the sector has a growing understanding of the potential damage of direct intervention. Attempts to create separate enterprise in the fingerling supply sector such as hatchery, nursery, or trade failed. Some purely hatchery business closed down while purely nursery operators integrated hatchery operations into their business. Since aquaculture production volumes are yet small, fingerling producers still find it viable to carry out all three functions, even making delivery to clients to keep in touch with clients' requirements and canvass for new business. Two distinct gaps have emerged in the development of vital areas in this value chain link:

a). The lack of business development information for fingerling suppliers that would show them how to apply technical information, invest, keep records and grow in a way that will make a profitable long term business. This makes them dependent on NGO projects to develop and sustain their businesses.

b). The lack of even moderately advanced technical information on fingerling production. The costs of obtaining such training are very high and require overseas travel. There is a need to share best practices in fingerling production, as applied in the Cambodian context, and provide information on the culture of high value species (USAID, 2010).

2.7.2 Feed and Fertilizer

Feed and fertilizer are also critical inputs to production; returns on these inputs are high, said Hazell *et al.* (2000*)* as cited in Viswanathan, (2001). Viswanathan (2001) further stated that fish yields significantly improve when fish ponds are appropriately fertilized and the fishes are well fed. Fish will consume feeds that are unpalatable or cannot be digested by most land animals. Farmers without a household or local supply of fishmeal or feed probably would dependent upon pellet and seed production centres that may be far from the production sites (Viswanathan, 2001).

Yildiz (2005) mentioned that, the feed requirements of cultured fish in Turkey were met by commercially available aqua feeds. Of about ten (10) companies in aqua-feed business, two of the mills produced feeds only for their own fish farms. Fish farmers preferred extruded feed to pelleted feed hence pelleted feed was limited and had little scope to grow.

USAID (2010) reported that the more widespread application of correct feed and feeding techniques has seen the market for feed supplies develop over the last three years in Cambodia. Small scale producers now prepare their own fish feed. Feed cost is of concern when raw material prices increase. A potential development is the local production of fish feed for small/medium scale producers.

Of the inputs used in fish feed production, grain and bran were the inputs that had high opportunity cost. The inputs have many competing uses thereby reducing its availability for fish feed utilisation. The result of the study by Wetengere (2010) in eastern Tanzania indicated, the most commonly used feed ingredients were maize and rice bran, local brew leftovers, kitchen-leftovers, plant leaves and spoiled fruits for the culture of fish.

Wetengere, (2010) reported that about 11% of the farmers did not feed their fish because 77% of the fish were eaten by animals or stolen in Tanzania. About 38% of the fish were stunted due to poor quality fingerlings. About 35% of fish farmers said that fish farming had not proved to be profitable. Ponds were located too far from homesteads 31% and some farmers 31% lacked time to feed. There were also farmers who did not know whether fish needed to be fed 15%, pond owner travelled away 15% and other (lacked feeds). Most respondents 64% utilized inputs used for feeding fish in other competing uses. Most respondents used fish feeds for feeding animals 84%, to make local brew 8%, and for both uses 8%. These activities were considered more profitable than fish farming (Wetengere, 2010).

2.7.3 Technical / Extension Services

The findings of IDRC (2010) revealed that an extension service is one of the important inputs in the development of aquaculture. This is because in areas where there was little technical support and monitoring from either district or extension workers, information dissemination was poor, and the farmers had little or no opportunity to be trained by government workers. This poor information flow had two main implications: either the farmers continued to practice fish farming in a traditional way or they had to travel long distances in search of information.

2.7.4 Equipment

Finally, appropriate nets and other harvest technologies will be important to fish farm production. These can be costly and should be considered when evaluating the potential costs of production (Fisheries Commission, 2005).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the study location, the study design, as well as sample and sampling procedure. It also describes the methods of data collection, data analysis and presentation that were used to achieve the objectives of the study. The estimation techniques used in the study are outlined with the coefficients of the variables of interest.

3.2 The Study Area

The study covered seven districts within three (3) regions in Ghana, namely the Greater-Accra, Volta, and Eastern Regions. These districts were selected purposively because of the perceived concentration of fish farmers and big aquaculture business centres located there. In all, two districts were selected from the Eastern Region, four districts from the Greater Accra Region and one district from the Volta Region. These districts are all located in the southern part of Ghana and are characterized by the presence of several inland water bodies in which aquaculture is carried out and many aquaculture business centres are located where inputs are mostly sold.

Four (4) districts, namely Ashaiman Municipal, Tema Metropolitan, Accra Metropolitan, and the Ga-East Municipal Assemblies were selected from within the Greater-Accra Region as a the study area for animal production input suppliers. Some of the communities visited in these districts were Ashaiman Timber Market, Tema Fishing Harbour area, Kwame Nkrumah Circle, Kaneshie, Darkuman, Osu, La, Madina and Abokobi. The

Greater-Accra Region has a coastline of approximately 225 kilometers stretching from Kokrobite in the West to Ada in the East (RCC, 2011). It has Accra as the capital with ten (10) Metropolitan-Municipal and District Assemblies. The Greater-Accra Region is the most densely populated Region in Ghana. It has some of the major trading centres/markets in the country, as well as several fish farms.

Two (2) districts, namely the Asuogyaman District Assembly and Lower Manya Krobo Districts were selected within the Eastern Region due to the presence of several inland water bodies in which aquaculture is actively carried out. Some of the communities visited in these districts were Atimpoku, Akosombo, Mpakadan, south Senchi, Akrade and Akuse. The Eastern Region occupies a land area of 19,323 kilometres and constitutes 8.1 percent of the total land area of Ghana. It is the sixth largest region in terms of land area. It lies between latitudes 6^{o} and 7^{o} North, and between longitudes 1^{o}30 West and 0^{o}30 East. The region shares common boundaries with the Greater-Accra, Central, Ashanti, Brong-Ahafo and Volta Regions. It has Koforidua as its capital (Ministry of local government, 2007).

3.3 The Study Design

The study used survey design to investigate the availability of inputs in the development and sustainability of aquaculture production in Ghana: a case study of the Asuogyaman and Lower Manya Districts in the Eastern Region, Ashaiman and Ga-East Municipal Assemblies, Tema and Accra Metropolitan Assemblies in the Greater Accra region. The major advantage of this survey approach is that it can be used for both descriptive and exploratory purposes, and allows for direct contact between the researcher and the respondents in the process of collecting data for the study (Singleton *et al.* 1993). Moreover, this approach can also be used to obtain detailed and precise information about different groups of people.

Nevertheless, according to Singleton *et al*, (1993) one disadvantage of this form of study design as compared to other designs, relates to the possibility of respondents not giving out true nature of events or state of affairs. This is due to the fact that in survey design the researcher depends on reports of behaviour rather than observation of respondent's behaviour. Hence, there exists measurement error produced by respondents' lack of truthfulness, misunderstanding of questions, and inability to recall past events accurately, and by the instability of their opinions and attitudes.

3.3.1 Population

Target population for the study comprised of fish farmers, agro-input suppliers, feed millers within selected communities in the Asuogyaman and Lower Manya Districts of the Eastern Region, Ashaiman and Ga-East Municipal Assemblies and Tema and Accra Metropolitan Assemblies of the Greater-Accra Region. The population was made up of heterogeneous groups of individuals. Fish farmers that were part of the population were those in the records of the Ghana Fisheries Directorate and/or the records of the Regional Animal Production or Veterinary Services Directorates. However, in the event where such records were not available, referrals from identified fish farmer and agro-input suppliers in the region were used.

3.3.2 Sampling Procedure and Sample Size

Purposive sampling was used to select the regions and districts of the target population. These regions were selected purposively due to the supposedly large number of fish farmers located in them, as well as medium to large-scale feed mills. Also, the capital towns of these regions have large concentrations of agricultural input suppliers. Census was used to collect data from the fish farmers and animal production input suppliers within selected districts. Census was used since all the fish famers and animal production inputs suppliers within them target population were interviewed. Sixty four (64) fish farmers were selected from the Eastern Region and 10 feed mills, 40 input suppliers and 10 fingerling producers were selected from the Greater Accra Region constituting a sample size of one hundred and twenty four (124).

3.3.3 Source of Data

Primary data were collected and the broad types of questions posed to respondents addressed activities on the farm, inputs fish farmers use in production, cost of production, challenges faced by the fish farmers and input suppliers, aquaculture and socio-economic characteristics of respondents. Secondary data were collected from documents, records and reports from the officials of MOFA/Fisheries Directorate.

3.4 Research Instrument

The main instruments for the survey were a content validated questionnaire and interview guide used to obtain information on a wide range of items including, the demographic characteristics, activities on the farm, inputs used in production, cost of production, challenges faced by the fish farmers, aquaculture, and input suppliers, etc. There were also supplementary questionnaires, one each for the officials of the Ministry of Food and Agriculture and the Fisheries Commission. The questionnaires (see Appendix A) contained well structured questions with various responses (largely close-ended questions were used). The reason was to allow for easy retrieval, translations and to further explain questions to respondents where these were not clear to them. A gender-disaggregated data were collected by way of interview using a structured interview guide. This allowed for examination of the behaviour of both female and male respondents.

This instrument was chosen due to the fact that it:

i) can be used to generate both qualitative and quantitative data from respondents,

ii) can be self-administered or presented in an interview format,

iii) offers respondents the opportunity of responding to the questions in their own convenient time and

iv) is less expensive and less cumbersome to administer.

3.4.1 Reliability Test

A reliability statistical test was conducted to determine the extent to which the instrument produces consistent results. The reliability analysis was conducted using the SPSS programme.

Table 1: Expected Signs of the Variables

Dependent variable	Explanatory Variables	Expected signs	Explanations of the relationship
Output (Q)	Number of cages (N)	+	Output is positively related to number and size of cage. As more cages are brought under fish production, output is increased
	Labour (L)	+	Output is positively related to labour. The more farmers use hired labour, the more the increase.
	Fertilizer (Fert)	+	Output is positively related to fertilize. The more fish farmers use fertilizer, the more they increase output.
	Education level (Ed)	+	Output is related to education. This means that the more the fish farmers are educated, the more output will increase.
	Years of experience (Ye)	+	Output is positively related to years of experience. The more the farmer has engaged in the production, the more the output will increase.

Table 1 continued

Dependent variable	**Explanatory Variables**	**Expected signs**	**Explanations of the relationship**
Output (Q)	Marital status (Ms)	+	Output is positively related to marital status. When the fish farmer is married, more of family labour is used in the fish farming operations thereby leading to reduction in the use of hired labour thereby enhancing productivity.
	Type of cage used (ToC)	+	Output is positively related to the type of cage used by the fish farmer. It is believed that farmers who use specialized cages have higher output than those that use unspecialized cages.
	Type of feed used (ToF)	+	Output is positively related to the type of feed used by the fish farmer. It is believed that farmers who use imported feeds have higher output than those that use local feeds.

Table 1 continued

Dependent variable	Explanatory Variables	Expected signs	Explanations of the relationship
Output (Q)	Price (P)	+	Expected high price of fish will be an incentive to increase output. When the farmers expect an increase in price of fish, they will be motivated to increase the output.

3.4.2 Data Collection Procedure

Data were collected through the use of tested, content-validated and structured interview schedules from respondents, between March and April, 2011. The instrument was considered most suitable for the research survey based on the facts that it provided uniform information which ensure comparability of data; also that it could easily be used to collect information from any respondent, whether literate or illiterate (Kumar, 2003).

3.4.2.1 Training of Research Assistants

Two research assistants were recruited and trained to ensure speedy and smooth collection of data. They were selected based on their educational background, proficiency in the local language and understanding of this kind of survey. The research assistants had good knowledge about the study area, could speak Ewe and/or Twi. They were taken through the process and mechanism of interviewing so that they could obtain the right responses from the respondents to achieve the objectives of the study. The research assistants were trained on operational definition of terms, relationship between respondents and research assistants, the general attitude to people and how to deal with difficult respondents. The research assistants were involved in the pilot survey to enable them to be abreast with what was to be expected ahead of the fieldwork to ensure consistency and accuracy in the recording of responses from the respondents.

3.4.2.2 Pilot Survey

The data collection process started with a pilot survey carried out in the Ahanta West district and Sekondi Takoradi metropolis in the Western Region of Ghana. These areas have similar characteristics as the actual study area. This area was different from the study area and results are not included in the main sample. This was done to ensure that the research instrument designed for the fieldwork was sharp, appropriate and comprehensive enough, as well as to safeguard the validity, unbiasedness and reliability of the data to be collected for the study.

In all, twenty (20) questionnaires were administered for the pilot exercise. This was done to check the appropriateness of the questions and responses (Anaman, 2003). The pilot survey revealed some inconsistencies in the responses which indicated that some of the questions were not framed or structured well to elicit the appropriate responses from the respondents, and also some of the questions were not asked but were necessary to ask. These shortcomings were noted and the necessary corrections were made. This facilitated the main fieldwork.

3.4.2.3 How Data was Collected

The actual data for the study were collected after the pilot survey. Reconnaissance was carried out to the survey area two weeks before the field work commenced. This was done to map out the exact locations of the various respondents within the given districts. Fieldwork took a maximum of eight (8) weeks in all using an average of eight (8) days per district. Twelve (12) days were used to mop up absentee respondents. One hundred and twenty four (124) questionnaires were administered. Of this, sixty (64) were administered to fish farmers and sixty (60) to input suppliers (10 feed mills, 10 hatcheries and 40 animal production input suppliers). The questionnaire was administered through the interview method with the help of two research assistants.

3.4.3 Data Analysis

Manual checking, data cleaning and editing of the field returns, as well as post-coding of open-ended questions were carried out to ensure coherence and consistency of the information gathered before the completed questionnaires were dispatched for data entry and processing. Edited data were then inputted into the computer using the SPSS version 16 (Statistical Product and Services Solutions). This was later transferred onto the Stata data software for further analysis. Respondents' characteristics were analyzed using descriptive statistics and presented in frequency tables. Analyzed data were presented using tables, however, interpretation was done statistically. Tests were conducted on the data to ensure consistency. Relationships between variables were determined by correlation analyses using Pearson's correlation. In this study, the response variable is output and the explanatory variables are age, sex, marital status and level of education of fish farmers. The Pearson correlation was used to determine whether there is a strong, moderate or weak relationship between output and the explanatory variables mentioned; and also whether there is a positive or negative relation. That is, whether output increase with an increase in the explanatory variables or vice versa.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The results of the study are presented and discussed in this chapter. The background information on the socio-demographic characteristics of the fish farmers were presented after the reliability test, followed by the activities on the farm, inputs that fish farmers used in production, cost of production, challenges faced by the fish farmers and input suppliers in their activities, and aquaculture. Presentation on the background information is done largely by the use of descriptive statistics in the form of frequency tables. The last section consists of inferential statistics.

4.2 Reliability Test

To determine the extent to which the instrument produced consistent results, a reliability statistics test was conducted. The result of the test gave a Cronbach's Alpha coefficients of 0.61 ($\alpha = .61$) for the questionnaires administered. Hence, the questionnaires proved to be reliable overall.

4.3 Background Information on the individuals/fish farmers

This section focuses on the age and gender distributions, marital status and educational status and number of years of experience of respondents. Furthermore, the types and number of cages used by respondents.

4.3.1 Distribution by sex

The most striking characteristic of fish farms (FF) visited was the sex of the farmers. The total farms visited were 64. Fifty five (55) farmers representing (86%) were males, whilst the rest, nine (9), were females. Table 2 shows that males dominate the aquaculture industry. This pattern pertains to most farming societies or communities in Ghana. This observation is not different from the work reported by FAO (2005) that females constituted about only five percent of fish farmers in Ghana.

Table 2: Gender Distribution of Fish Farmers

Sex	Frequency	Percent (%)
Male	55	85.90
Female	9	14.10
Total	64	100.00

Source: Field Survey, 2011

4.3.2 Distribution by Age

Table 3 shows a tabulation of the age of the farmers interviewed. The mean age for the household heads was about 46, with the minimum age being 26 years and the maximum age 78 years. The age category between 30 and 39 years had the highest number of twenty two (22) farmers interviewed. The age category between 20 and 29 formed the lowest category that was interviewed five (5) persons. About 14 farmers were within the age category above age 59 years.

Generally, majority of the farmers interviewed fell into the young adult and economically active age category of 20 to 59 years. This implies that, most farmers within these age ranges are in their active age and therefore, stood a better chance of developing aquaculture production in the study area, as supported by the work of Zaman *et al.* (2006). Moreover, this also shows likelihood for high productivity in fish farming as supported by work done by El-Naggar *et al*. (2008).

Table 3: Distribution of Fish Farmers by Age Categories

Age category	Frequency	Percent (%)
20-29	5	7.80
30-39	20	31.30
40-49	15	23.40
50-59	10	15.60
>59	14	21.90
Total	64	100.00

Source: Field Survey, 2011

4.3.3 Years of experience in fish farming

Respondents had an average of 3 years of experience in fish farming: 78.1 percent reported up to 2 years of experience, 14.1 percent reported 3–4 years and 7.8 percent reported 5 years and above.

4.3.4 Educational level of farmers

It is vital to consider farmers' level of schooling since it can influence their productivity. El-Naggar *et al*. (2008) stated that the ability of famers to adopt new technology/innovation will increase productivity. However, the ability of farmers to adopt and apply approved methods or technology will depend mostly on their ability to read information available or their educational level. This shows that, the industry have a vibrant working population and this to a large extent enhance productivity.

From Table 4, four (4) out of the 64 farmers interviewed did not have any formal education. About 12.5% had at least primary level education. However, as many as 23 (35.9%) reported they have completed either university education or polytechnic. It is clear that majority of the farmers representing more than 90 percent were educated or literate. This may be due to the fact that the regions that the study areas were selected from are noted for having well-developed educational institutions. These results could be a reflection of the situation and characteristics of fish farmers in the whole country (FAO, 2005); they appear better educated than those in other farming enterprises in Ghana.

Table 4: Distribution of Farmers by Level of Schooling

Level of schooling of FF (Fish farmers)	Frequency	Percent (%)
No schooling	4	6.20
Primary	8	12.50
JSS/JHS/Middle school	12	18.80
Sec./SHS/SSS/Tec./Voc.	6	9.40
Post Sec./ A Level	11	17.20
University/Polytechnic	23	35.90
Total	64	100.00

Source: Field Survey, 2011

Pearson correlation was used to find out the relationship between the dependent variable (Output) and the explanatory variables like age, sex, marital status and level of education of the farmers. From the Pearson correlation, there is a positive relationship ($p<0.01$) between productivity (output) and the experience of the fish farmer has in fish farming was establish. This means that productivity (output) is positively related to the number of years of experience. Hence, if a farmer gains one more year or an additional year of experience in fish farming, his/her productivity (output) will increase, and vice versa. Table 5 depicts this result.

Table 5: Relationship between Output and Number of Years of Experience in Fish Farming

		Total production per period
Number of years one has engaged in the fish farming	Pearson Correlation	.435**
	Sig. (2-tailed)	.000
	N	64

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.5 Marital Status of Respondents

Out of the 64 fish farmers interviewed, 52 (81.2%) were married, 6.2 percent were in unions (Table 6). According to El-Naggar *et al*. (2008) the good thing about married people practising aquaculture was the use of family labour in the fish farming operations leading to reduction in the use of hired labour, and thereby generally enhancing productivity. According to a report by FAO (2005), aquaculture provided a ready source of job for family members and neighbours.

Table 6: Distribution of Farmers by Marital Status

Marital status of FF	Frequency	Percent (%)
Never married / Not in union	0	0
In union	4	6.20
Married	52	81.20
Separated	6	9.40
Divorced	2	3.10
Widowed	0	0
Total	64	100.00

Source: Field Survey, 2011

4.3.6 Type and Number of Cages used by Respondents

The average number of cages owned by the fish farmers interviewed was about 10 cages; a minimum of one and maximum of 150 cages in the study area. It also revealed that the average number of cages employed by the fish farmers interviewed was about three; with a minimum of one cage for the small-scale farmer and maximum of 70, in the study area.

From the Pearson correlation, there is a positive relationship ($p<0.01$) between productivity (output) and the number of cages fish farmers used in their fish farming. This means that productivity (output) is positively related to the number of cages used. Hence, if a farmer constructs and uses an additional cage in fish farming, his/her productivity (output) will increase, and vice versa. Table 7 depicts this result.

Table 7: Relationship between Output and Number of Cages used by each Fish Farmer

		Total production per period
Number of Cages used by the fish farmers	Pearson Correlation	.531**
	Sig. (2-tailed)	.000
	N	64

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.7 Type of Cages used by the Fish Farmers in the Study Area

The types of locally made cages (some under construction) that some of the famers were using for their aquaculture business at the study areas visited are shown in Plates 1 – 7.

Plate 1: Complete four-sided locally made floating cage

Plate 2: Slightly improved locally made floating cage

Plate 3 : Small scale locally made floating cage

Plate 4: Cages in use on the Volta River

Plate 5: Frame construction stage of a locally made floating cage.

Plate 6: Large scale locally made cage under construction.

Plate 7: Partially completed locally made floating cage.

Plate 8: An interviewee and the interviewer (researcher)

Some of the farmers, especially on large scale-farms use specialised cages. This allows for high stocking density of fingerlings unlike the localised cages. The following are photographs of some of the specialized cages in use at the study areas visited, (Plates 9 – 10).

Plates 9: A specialised cage

Plates 10: Another type of specialised cage

Source: All Pictures are from Field Survey, 2011

Majority of the farms visited were located in the South Senchi area, Old Senchi (across the river), Akuse, Akwamufie, Atimpoku, Tuska, Akosombo, Adome, and Senchi Ferry, all situated along the Volta basin in the Eastern Region of Ghana. This is supported by work reported by FAO (2005), that most fish were farmed mainly from earthen ponds and in cage culture establishments mainly on the Volta Lake. Also, this is not different from Anon (2003) report which stated that most aquaculture in Ghana is being promoted in the Greater Accra, Volta and Eastern Regions, where this study was also conducted.

4.4 Introduction of Aquaculture as a Business

Most of the farmers interviewed (almost 45%) were encouraged to go into fish farming business by Non Governmental Organisations (NGOs). Others were into fish farming because it has been a long term family business, whilst yet others reported that they were motivated to go into fish farming business due to advice given to them by friends.

4.4.1 Number of years Involved in Business

Most of the farms visited have been in existence for a year or two, only few had been in existence for over four years. The relatively young nature of the farms is as a result of people responding to the call to go into fish farming as an alternate occupation that has a lot of potential for increasing the income of household; especially people living along water bodies in the country. Though aquaculture started in the 1950s in Ghana, most people in the study areas have only recently been engaged in it. This is supported by the Department of Fisheries (2004) report that showed an upward trend in total aquaculture production in Ghana.

4.4.2 Species of Fish Farmed

All the farmers interviewed were into the production of the Nile Tilapia (*Oreochromis niloticus)*. This finding supports the work conducted by the FAO (2005), which showed that tilapia formed about 80 percent of species farmed in aquaculture production in Ghana. Majority of the fish farmers interviewed reported the production cycle for the Nile tilapia to be six months, whilst a few reported five months and eight months as their production cycle. About 48 percent of the fish farmers interviewed harvested between a tonne and five tonnes of fish per production period, whilst about 11 percent harvested more than five tonnes per production period.

4.4.3 Sources of Fish Seed

About 84 percent of the fish farmers interviewed did not breed their own fingerlings; the rest bred their own fingerlings because most had been in existence for over five years. Aquaculture Research and Department Centre (ARDEC) is the largest fingerlings supplier to the majority of fish farmers in the study. ARDEC also produces and supplies the strain of tilapia needed for breeding the seed for stocking to other farms like Fish Reit, Maleka and Tropo farms to produce fingerlings for supply to other farms, and also for their food fish production farms. ARDEC is very consistent with the supply of good quality fingerlings. Plate 14 shows mature tilapia harvested from stock obtained from ARDEC.

Plate11: Harvested mature tilapia.

4.4.4 Type and Source of Fish Feed Used

It is very important to consider the type of feed used in the production of food fish since it will affect the total cost of production. Out of the 64 fish farmers interviewed, 60 (about 94 percent) used imported feeds as shown in Table 8, whilst only about three percent used locally made feed either prepared on the farm or purchased from a local feed miller like Aqua-Engines. However, imported fish feeds were the most dominant feeds used by fish farmers, probably due to their readily availability on the market and perceived superior quality over the local feeds. However, it is noteworthy that some farmers used a combination of both local and imported feeds on their farms (Table 8). The following are some reasons that informed their choice of imported over local feed:

- the imported feeds were of high quality, economical, certified standards and delivery is prompt;
- imported feed promote fast growth and can float so reduces wastage (nutrient leaching), and is readily available;
- there were inadequate facilities, technology and technical know-how for fish feed production locally;
- right from the onset, they were introduced to the use of imported feeds and have stuck to it.

The implication is that, there is high market potential for fish feed production in Ghana especially when the production of feeds for poultry is on decline. The production of fish feeds locally would bring the cost of producing a kilogram of fish down to the barest minimum, thereby encouraging increased output which will then trickle down amongst the stakeholders on the value chain. Profit margins would also increase and feed millers would revive their operations.

Table 8: Distribution of the Types of Fish Feed Used on the Farm

Types of fish feeds	Frequency	Percent (%)
Locally made fish feed	2	3.10
Imported compound fish feed	60	93.80
Both Locally made and Imported fish feeds	2	3.10
Total	64	100.00

Source: Field Survey, 2011

From the Pearson correlation (Table 9) there is a positive relationship ($p < 0.01$) between productivity (output) and the type of feed (e.g. sinking feed, floating feeds) used in feeding the fishes; and it is significant at all levels. This means that productivity (output) is positively related to the type of feed used. Hence, if a farmer uses more of nutritious floating feeds to feed fish on the farm, his/her productivity (output) will increase compared with other feeds like the sinking type, and vice versa. This is supported by a study conducted by Hayami and Vernon (1971).

Table 9: Relationship between Output and Type of feed used

		Total production per period
Type of feed used to feed the fish	Pearson Correlation	.608**
	Sig. (2-tailed)	.000
	N	64

**. Correlation is significant at the 0.01 level (2-tailed).

4.4.5 Market Outlets for Farmed Fish

Most Ghanaians are considered to be fish consumers and so there is ready market for fish produced. This is true for both marine and inland fishing, and fish farming is no exception (Aggrey-Fynn, 2001). Most of the farmers interviewed had no problem marketing their produce (harvested fish). In most cases it was either sold at the farm gate on the day of harvest or transported to nearby established fish markets (e.g. one at Asikuma in the Asuogyaman District of the Eastern Region). This implies that, there is availability of market for the distribution of farmed fish and this can be a motivation for farmers to produce more.

4.4.6 Technical Support for Fish Farming

About 81 percent of the fish farmers interviewed indicated that they had received some technical assistance from extension officers from Ministry of Food and Agriculture (MoFA) and technical officers from Aquaculture Research and Development Centre (ARDEC) a branch of Council for Scientific and Industrial Research (CSIR), Akosombo. The rest about 19% have employed aquaculturists on their farms on whom they depend for their technical support and a few others seek help from friends more experienced in fish farming. Two thirds of the farmers who received technical assistance were very satisfied with the kind of information or assistance they received, however, one third was not satisfied with the level of technical assistance they received from MoFA agents, officers from ARDEC and friends. With this kind of problem, the desire for farm expansions would be diminished as there is no motivation for that because the various stakeholders who are to provide the technical knowhow are deficient in the subject area.

Though majority of the fish farmers had attended some training programmes in aquaculture organised by organisations like ARDEC and have some level of satisfaction, they reported that they needed further training in the following areas:

- basic knowledge in fish farming and how to produce good broodstock;
- how to produce farm- based feed and fingerlings;
- handling of fingerlings and calculating feeding rates;
- feeding techniques and cage construction;
- knowledge on water quality and management;
- knowledge on fish health and how to maximize profit.

Specially trained extension agents with better understanding of aquaculture should be deployed to fish farming areas, so that, they can teach the fish farmers the best practices that would allow for sustainability of their farming activities.

4.4.7 Fish Health and Diseases

Health issues concerning fish production are very important and need to be considered seriously. About half of the fish farmers interviewed reported mortality during stocking, moving of cages and damage of net by wild fish as the most common problems faced during production as captured in Table 11. However, fish cataract, worm infection, fungi infection, skin damage and water pollution were mentioned as health related problems on a minor scale.

Farmers contended that in times of disease problems, they often seek advice from ARDEC and MoFA Extension Agents stationed in their districts.

Table 10: Distribution of Fish Health and environmental Problems

Common fish health problems	Frequency	Percent (%)
No health problem	15	23.40
Water pollution	2	3.10
Fungi infection and skin damage	6	9.40
Mortality during stocking, moving of cages and damage of net by wild fish	32	50.00
Fish cataract and worm infection	9	14.10
Total	64	100.00

Source: Field Survey, 2011

4.4.8 Effect of Aquaculture on the Environment

Even though water pollution has been identified as one of the emerging problems in fish farming, only 4.7 percent of the respondents conceded that their activities were causing some level of pollution on the environment, as stated by Koeleman (2010) who found elevated zinc, copper, cadmium and manganese levels in sediments under the sea and solid wastes generated by land-based fish farms which leached into water sources. Half of the respondents reported that their activities did not affect the environment. About 45 percent of the respondents reported that though their activities may bring some potential harm on the environment, these have not been identified in the short term. Some of the farmers that were interviewed have put some measures in place to check any negative effects of their activities on the environment. For instance, some farmers consider for use only feeds that are low in phosphorus; others use only floating feeds; some also treat wastes before they are drained into the lake; whilst some have planted trees along the operational area to be used as anchorage for the floating cages. However, other farmers drain the water into paddy fields to improve the nutrient levels of the fields for better rice yield.

4.4.9 Factors Militating Against Aquaculture Development in Ghana

In general, there are factors militating against the development of aquaculture in the world, and Ghana is no exception. The results of this study (Table 11) shows that the majority (51%) of the farmers interviewed were faced with the problem of high cost of feed and irregular supply of fish feed. All the fingerling producing farms conceded that demand for fish seed exceeded what they could supply. This finding was not different from the reports by Viswanathan (2001) and USAID (2010). There exists other problems like small cage sizes, difficulties in accessing credit, high mortalities, delays in restocking, upwelling and chemical pollution of the water body, theft and intrusion by other local fishermen. Another challenge that these farmers face has to do with inadequacy of technical know-how. Adeogun *et al.* (2007) found that the most commonly expressed problem facing aquaculture development in the Lagos state has been with the issue of technical know-how. According to FAO (2005), shortage of trained staff and less motivated practitioners were also factors that were identified as impeding the development of aquaculture in Ghana.

Table 11: Distribution of Major Problems Affecting Fish Farming Business

Major problems affecting fish farming business	Frequency	Percent (%)
High cost and irregular supply of fish feeds	33	51.60
Small cage size	10	15.60
Difficulties in accessing credit	6	9.60
High mortality at stocking	5	7.80
Delays in restocking of fingerlings	3	4.70
Upwelling and chemical pollution of water	3	4.70
Theft and intrusion by local fishermen	3	4.70
Inadequate knowledge in fish farming	1	1.60
Total	64	100.00

Source: Field Survey, 2011

With regard to the problems farmers reported on, they believed that the following remedies could help alleviate the difficulties they have to contend with in the course of their operations. About half (50%) of the respondents believed that producing high quality fish feed locally by feed millers could go a long way in reducing the cost of production to a greater degree thereby making food fish much cheaper than it is now. More so, they believed that intensifying sectoral support such as technical assistance for well trained extension agents purposely for fish farmers could be very beneficial to their work; this is supported by FAO (2005). Others were of the view that, the following could help in boosting production: credits should be made available at a low interest rate to fish farmers; waiver of import duties on fish farming inputs; stocking of matured fingerlings, and better security around the cages could go a long way to boost production. It is suggested that the leaders of the fish farmers association of Ghana should draw out policy that would guide the members and all other stakeholders in the value chain to have the best practices that would make the sector attractive for financial institutions, private investors to want to invest in the sector.

4.5 The Role of Agro-input Suppliers

Ghana has a large consumer front with high fish consumption. This could serve as an incentive for fish farming expansion, and that is what, all stakeholders in the sector have been aiming at, to sustain fish farming and make it attractive. This will make fish farming to become a venture which will generate employment, create wealth and contribute substantially to increase GDP in the years to come. Therefore, to expand aquaculture, we need to consider the roles of the various players including input suppliers in the production chain.

The role that inputs play in the overall promotion and sustainability of fish farming in Ghana should be closely examined. If all the major inputs such as fish feed, fishmeal, cages, hapas hormones used by fish farmers are erratic in supply then it would have a negative impact on production. Hence, it is important for that sector of the production chain to be closely looked at so that expansion in fish farming can be sustained. Unavailability and high cost of inputs have been some of the major problems inhibiting the growth of poultry production in Ghana; so, the issue of input must be taken seriously especially for the emerging fish farming industry. Since most of the inputs such as hormones and fish feeds are presently imported, the prices of these products are controlled internationally. This increases unpredictability in availability and pricing of such products. However, if a higher proportion of inputs are localized in their production, then the projected expansion can be managed with local resources which would result in producing fish that is of high quality and affordable to all.

The study showed that 10 percent out of the forty (40) input suppliers interviewed were dealing in agrochemicals only; 25 percent were into inputs for fish farming only, and another 10 percent were into veterinary drugs only. The majority of agro-input suppliers (55%) were dealing in complete fishmeal for domestic livestock e.g. poultry and pigs. Wetengere (2010) reported that fish farming inputs had high opportunity cost, also have many competing uses, but the worst of all it is also insufficient and seasonal in supply.

About 22.5 percent of the agro input suppliers interviewed reported that they supplied complete fish feeds to fish farmers, whilst 2.5 percent supplied specialised cages; also, 2.5 percent of the input suppliers supplied ropes, floaters, aerators and hooks. On the whole, about 72.5 percent representing the majority of the agro input suppliers interviewed did not supply any inputs specific to fish farmers but more to other farmers of terrestrial animals (poultry). This shows that generally, the agro input suppliers interviewed were not into the specialised sale of fish farming inputs. This is not different from work done by Onumah *et al.* (2010) which states that the growth of the fishery industry faces myriad challenges including lack of inputs and high production cost. Adding to this, is the work of FAO (2003), which indicated that in order for aquaculture to register further growth and meet its potential of bridging the gap between fish supply from capture fisheries and the demand for fish, the direction of aquaculture development in Africa will have to be refocused, with large emphasis placed on the role of input suppliers in the value chain process. This would enable the input supply problems faced in aquaculture production to be tackled more effectively.

4.5.1 Supply of Fish Feeds by Agro- Input Suppliers

The results of the study showed that about 7.5 percent of the agro input suppliers who were into the sale of fish farming inputs obtained their fish feeds locally from local producers. However, about 20 percent of the agro-input suppliers imported the fish feed; of these, about 15 percent did the importation themselves, whilst five percent obtained imported feed from other sources. The current import levels of feeds by these agro- input suppliers ranges from hundred (100) to ten thousand five hundred (10,500) tonnes. Imported feeds are mainly from Brazil, Israel, Peru, Nigeria, Spain and South Africa.

The results of the study also indicated that about 7.5 percent of the input suppliers imported starter feed, grower feed and finisher feeds, whilst 2.5 percent imported only starter feeds. About 7.5 percent of the agro input suppliers, who were into the sale of inputs for fish farming, imported only grower feeds and finisher feeds, whilst 2.5 percent were into the importation of maintenance feeds. Up to 15 percent of the complete feeds imported by the agro input suppliers were for tilapia only; 2.5 percent of the imports for both tilapia and catfish production and 2.5% were for tropical fishes like gold fish, angel and gourami. None of the feeds was imported for fishes like shrimps and trout, and this may be due to the fact that very few people are into such farming. About 20 percent of the imports made by agro input suppliers into the sale of complete fish feeds were purchased by large scale fish farmers, as well as some small and medium scale farmers. However, only 7.5 percent of this was sold to small and medium scale fish farmers the rest was consumed by the large scale fish farmers.

The study has shown that 11,775.02, 13,375.02 and 16,250.01 metric tonnes of starter, grower and finisher fish feeds respectively were imported into the country by agro- input suppliers dealing in fish feed imports and to a small extent goldfish in 2010 (Table 12).

Table 12: Categories and quantities of fish feeds imported by Agro Input Suppliers in 2010

Types of fish	Import levels of fish feed in tonnage		
	Starter	Grower	Finisher
Tilapia	11775	13375	16250
Gold fish	0.02	0.02	0.01
Catfish	0	0	0
Total	11,775.02	13,375.02	16,250.01

Source: Field Survey, 2011

As aquaculture production becomes more and more intensive, fish feeds, being one of the major inputs in fish production, will become a significant factor in increasing productivity and profitability of aquaculture. There is therefore the need to increase the supply of fish inputs of which complete fish feed is probably most prominent. Out of the eleven (11) interviewed agro input suppliers involved in the sale of inputs for fish farmers, 20 percent were willing to increase the quantity of inputs they currently supply by increasing their imports over the current level. However, 7.5 percent did not intend to increase imports because there were foreign suppliers producing complete fish feeds locally. Also importers who bring in complete fish feed just for aquarium and other ornamental fishes would not want to import more because demand is limited.

About 20 percent of the agro input suppliers who imported directly complete fish feed faced some challenges, including inadequate finance, high interest rates from creditors, and high import duties. However, about 7.5 percent of input suppliers did not face any challenges due to the fact that they did not import inputs, including complete feed themselves. Most importers were satisfied with the type of feed they imported and sold.

To ensure the quality of the complete fish feeds imported, the agro input suppliers into the sale of fish feed have put in place the following measures to ensure the quality of the complete fish feed is maintained:

- store the imported complete fish feeds on a wooden platform (pallets) to avoid damage. They also test the nutrient content and quality by taking samples to the Food Research Institute for analysis;
- the quality of the fish feed is monitored by continuous visual observation, and by storing complete fish feed in a conducive environment such as a cool dry place;
- most of the agro- input suppliers who import complete fish feeds provide good storage facilities to keep the feed fresh or

tend to import smaller quantities at a time to prevent long storage.

The result of this study indicated that, 17.5 percent of the agro input suppliers involved in the sale of complete fish feeds reported that “Nicolluzi” (a fish feed brand from Brazil) was the most common complete fish feeds demanded by fish farmers. Another 2.5 percent of agro input suppliers reported that most of their customers purchased “Coppens” (a fish feed brand from Peru) which is another type of complete fish feed. About 5 percent of the suppliers of complete fish feeds reported that “Ranaan feeds” (a fish feed brand from Israel) were the feed that were mostly demanded by their customers. The input suppliers reported that about 2.5 percent of fish farmers demanded for feeds produced locally.

In the case of Ghanaian fish farmers interviewed, the main constraints have been the general lack of inputs, as well as low patronage, inadequate access to credit and sourcing of products. According to Zaman *et al.* (2006), the main constraints in improving living standard of fish farmers in Bangladesh was found to be the lack of inputs and the persistent indebtedness to their traditional credit system.

To summarize, aside the many challenges listed above, 43 percent of agro- inputs suppliers who are into the supply of fish farming inputs are projecting an increase in demand because they are anticipating a future expansion in aquaculture. FAO (2007) reported, that aquaculture continues to grow more rapidly than all other animal producing sectors; and it is being estimated that by the year 2025, it will beat any form of animal farming by weight, except cattle. In another assessment conducted on growth rates since

1970, aquaculture per year has grown worldwide on average basis at a rate of 8.8 percent. Input suppliers who are into ornamental fishes were also anticipating an increase in the importation of ornamental fish products in the near future since most farmers are now showing some interest in such fishes. However, some five percent of input suppliers interviewed are anticipating a decrease in the demand for fish farming inputs due to low returns reported on investment in input for fish farming.

4.6 The Role of Feed Millers

USAID (2010) indicated that more widespread application of correct feed and feeding techniques amongst farmers has led to the development of markets for fish feed over the years. This has resulted in the shifting from the purchase of complete feed by small holder farmers to mill their own fish feed because feed cost is of concern when raw material prices increase. This calls for a holistic look at how best the necessary technologies can be harnessed to encourage local feed millers to produce locally, so that price of fish feed can be stabilized, if not reduced. This will also enhance the production capacities of local feed millers to a greater extent and create job opportunities within the value chain.

Fish will consume feeds that are unpalatable or cannot be digested by most land animals and this broadens the variety of ingredients that can be selected for fish feed production. This reduces the cost of feeding further since localized ingredients would be readily available and cheaper as compared to exotic ones.

Feed production in Ghana over the past few years has seen a downward trend. This is as a result of the near collapse of the broiler industry due to multiple factors but prominent amongst them is dumping of poultry products from other countries. Between 2000 and 2010, the recorded feed output from the Feed Millers Association of Ghana (GFMA) showed stagnation and downward trend. Recorded feed output went from 38,129.8 metric tonnes (MT) in 2000 to 4,867.74 metric tonnes in 2010 (Table 13), a decrease of over 783% (Personal data collected at the GFMA secretariat).

Table 13 below gives the recorded outputs by the association between 2000 and 2010.

Table 13: Recorded Feed production by GFMA from 2000-2010

Year	Number of companies	Output (MT)
2000	24	38,129.86
2001	23	39,924.41
2002	23	43,931.77
2003	20	35,566.93
2004	16	36,389.33
2005	11	36,959.80
2006	11	35,243.11
2007	9	36,650.00
2008	14	42,671.00
2009	7	11,619.74
2010	4	4,867.74

Source: Field Survey, 2011

4.6.1 Prospects of Fish Feed Production in Ghana

The advent of fish farming in Ghana is opening a new business frontier that can be harness by the feed millers whose fortune has declined over the years. The decline in production of feed for farmed animals can be reversed by producing fish feed which is in high demand and also with a sector that is expanding rapidly with a lot of future prospects. This can be a huge economic benefit to the feed millers.

From the 10 medium and large-scale feed mills interviewed for the study, the total sum of feeds produced for terrestrial animals amounted to 2,130 metric tonne per month in 2011.

The study results showed that about 70% of the feed millers interviewed did not have any formal technical know-how on how to produce fish feeds. According to Adeogun *et al.* (2007), the most commonly expressed problems facing aquaculture development in Lagos State was technical know-how. However, 30 percent of the feed millers interviewed reported that they had knowledge on nutritional requirements of farmed fish as well as have nutritionists to formulate fish feed using software packages. This is an indication why currently most feeds used on fish farms in the country are imported due to lack of local technical know-how in this area.

Following from the above results, about 70 percent of the feed millers interviewed did not have the facilities to produce fish feeds; 20 percent of the millers had specialized set up such as a grinder, mixer, pelleting machine, with a boiler. This kind of facility can only produce pellet feed; without an extruder with a binding agent, the feeds would sink very fast in water. About 10 percent of millers have an improvised system where they use a corn mill and a pelletizer to produce complete feeds for fish that is slow sinking. The fish feeds produced by these companies are either slow or rapid sinking for tilapia, and can also be used for catfish. Rapidly sinking feed increases the rate of wastage, as feeds that go beyond the cage area cannot be utilized by the fish; this promotes zooplankton and phytoplankton in the water system which would be of no benefit to the caged fish but rather attract wild fishes to the farming area which can result in damage to nets. Also, this can reduce water quality around the cage area which can adversely affect growth rate of fish within the pond system.

About 40 percent of the feed millers interviewed showed no interest in diversifying into fish feed production. However 60 percent did indicate that, looking at the rate of growth of fish farming, they will need pelletizers, dryers, extruders, binding agents and storage facilities to be able to commence production of complete fish feeds. Only six (6) metric tonnes of fish feed is produced per month by the respondents who are into the production of fish feed. This is an indication of the fact that the local millers are not exploiting the business potential of the huge demand for fish feeds by fish farmers and so there is a huge gap between local demands for fish feed and what is being supplied from local suppliers.

About 30 percent of the respondent also stated that, they were planning to acquire the facilities that would enable them go into full scale production of floating feeds to meet the high demand of fish feed in Ghana. About 70 percent were not interested in expanding their facilities to include fish feed producing machines.

Fish feed producers currently sell through distribution outlets and also do direct factory sales to small and medium-scale farms. Feed millers interviewed reported that, the most pressing challenge to their operations has to do with cost, quality and availability of feed ingredients. The Feed millers further stated that most of the raw materials (mineral premixes, fishmeal, soybean meal and fish oil) used for fish feed production were sourced locally (even though imported) from local dealers such as Chemico Ltd, UT Logistics, Inter-Grow, Frankatson and Gokals, to mention but few. The feed millers who are currently producing fish feed interviewed reported that they preferred non-local sources of raw materials because these were generally of high quality, readily available, cost effective and standardized, thereby making them convenient to work with.

To ensure quality control of fish feeds, feed millers interviewed reported that, they conducted laboratory tests, sent some samples for field trials, and also collated responses from their customers. This enables them to have varied feedbacks on the extent of acceptance and performance of the feeds produced from their mills.

Ten percent (10%) of the feed millers interviewed reported that they have been exporting some of their complete fish feed into neighbouring West African countries such as Nigeria, mostly for catfish producers, and the response has always been positive.

The feed millers interviewed further reported that, some of the pressing challenges to their business have to do with the following:

- high cost of raw materials;
- undue delays at the ports, during clearing of feed ingredients;

- stiff competition from imported fish feed;
- high interest rates on loans for the manufacturing sectors, within the economy of Ghana;
- irregular supply of raw materials.

Though these feed millers are faced with the above challenges, they tried to mitigate their impact on production through the following non exhaustive measures such as:

- raising funds through the banks;
- by lobbying the government;
- importing raw materials as a group.

Looking at the market potential for the emerging fish farming industry and its associated activities, it would be very important for the feed millers to take a centre stage in the production of fish feeds. According to estimates from the Fisheries Commission (2005), total fish production coming from fish farming was 3,257, 6,514, 7,203 and 10,500 metric tonnes for 2007, 2008, 2009 and 2010 respectively. This shows an incremental percentage of 100 percent, 90.4 percent and 68.6 percent from 2007 through to 2010. The Fisheries Commission further estimated that farmed fish production in Ghana would reach 35,000 metric tonnes by 2015. This estimation shows a year on year increase of 60 percent in farmed fish production from the base year (2010). From the current output of 10,500 metric tonnes of fish annually, estimated total fish feed requirement would be 21,000 metric tonnes, based on the reported weight at six months maturity of about 500 gm when fed with one kilogramme of feed with the average crude protein of 36% percent, maximum fibre content of 12 percent, maximum lipid content of 12 percent and maximum carbohydrates of 29 percent (El-Sayed, 1998: Agbebi *et al*, 2009: Chou & Shiau, 1996; Agbo, 2008). This means that an appreciable amount of fishmeal, fish oil, wheat bran, rice bran, vitamins, minerals, and binding agent (maize or cassava starch) would be required to produce this amount of feed locally. However, 98.4 percent of fish farmers and 100 percent of hatcheries (fingerling producers) interviewed responded that, the preferred feed for their farms are the imported brands (Raanan, Niculuzzi, Coppens, Aquafed and Pira 36).

4.6.2 Samples of Type of Feeds used by Farmers

Plate 12: Starter Feed (RAANAN, PG 40)

Plate 13: Supper Starter Feed (SS 4, CP 55%)

Plate 14: Grower Feed (3 mm, CP 35%)

Plate 15: Grower Feed (2mm, CP 30%)

Plate 16: Locally Produced Pelletized Feed (CP 30%)

Plate 17: Finisher Feed (6 mm, CP 30%)

Only 1.6 percent of the respondents indicated that they prepared their own feed on the farm obtaining most of the raw materials locally. This means that, the entire aquaculture industry in Ghana is heavily dependent on imported feeds, thereby depriving the country of needed jobs for our feed mills, input suppliers, crop farmers (rice and maize and soybean), nutritionists and foreign exchange, just to mention a few.

Furthermore, the ten feed mills selected for this study indicated that, feed production for terrestrial animals from their mills amounted to 2,130 metric tonnes per month. This means annual production estimates from the monthly production figures would sum up to about 25,560 metric tonnes. This means that in some few years to come, the import of fish feeds would outstrip the production of terrestrial feeds from the commercial feed millers in Ghana.

These demand for fishfeed which is currently been satisfied by importation, opens up a huge business opportunity for the feed millers, whose fortune in terms of terrestrial feed production has dwindled over the years, to take up this opportunity to go into the production of floating fish feeds to supply to the aquaculture industry. One of the major challenges confronting fish farmers when asked has to do with the erratic supply of fish feeds by agro- input suppliers. This, to a large extent, is hampering their work and sometimes forced them to under feed fish when there is shortage of imported fish feed on the local market. This situation, however, delays maturity time and reduces attainable weight at the time of harvest. This would further translate into low output and reduced income to fish farmers.

4.6.3 Economics of Local Fish Feed and Fish Production

Fish feed requirements from 2011 through to 2015 would move from 21,000 metric tonnes (MT) to over 70,000 metric tonnes (Table 14). This will cost the nation a lot, in terms of foreign exchange and jobs, if all the feed required by fish farmers had to be imported without any local participation in supply.

Table 14: Feed requirements based on estimated fish production

Year	Output (MT)	Feed Requirement (MT)
2010	10,500	21,000
2011	15,400	30,800
2012	20,300	40,600
2013	25,200	50,400
2014	30,100	60,200
2015	35,000	70,000

Source: Field Survey, 2011

Estimation made from Fisheries Commission report (2006)

4.6.4 Comparative Cost Analysis of Producing Locally Versus Importation of fish feeds

From the Table 15, the initial cost of producing a standard one metric tonne of floating fish feed with a crude protein level of 36 percent at the time of this research amounted to GH₵ 966.50. Adding to the cost of ingredients a 10% manufacturing cost and 10% overhead cost, would sum up to GH₵ 193.00. Adding 10% for distribution and 10% for retail margins would bring the total selling price at retail to GH₵ 1,159.80 per metric tonne. At the current dollar exchange rate of 1.53 (June 2011), the selling price would be $758 per metric tonne. Comparing this to imported fish feed at the current average retail price of GH₵ 41.00 per 20 kg, one metric tonne at retail would cost GH₵ 2,020.00 ($1,339.86). Comparatively, if produced locally, fish feed would then be cheaper than to import.

- Cost of producing and selling locally per MT $ 758.00
- Cost of importing and selling per MT $ 1,339.86
- Price differential $ 581.86 per MT

Based on this calculation, producing fish at the current price of imported fish feeds brings the cost of producing a kilogramme of tilapia fed on 2 kilograms of feed to $ 2.68. Feed cost constitutes 60% of the total cost of producing one kilogramme of tilapia (Saddiqui *et al.*, 1991). This means that the cost of producing one kilogramme of tilapia holding all other things constant would be $ 4.46. However, 2 kilogramme of locally produced feed at the current price estimates will be $1.52, meaning the same kilogramme of tilapia can be produced at $ 2.53. The savings farmers would make per kilogramme of tilapia produced, all other things being equal, are $ 1.93.

Extrapolating this for the 2011 output of tilapia produced, would be $ 20,265 in savings. Based on the above analysis the cost of producing 1kilo of tilapia has gone up by 100% when the current production cost of $4.46 is compared with FAO (2004) reported value of $ 2.00. However, other countries such as Philippines, China, Indonesia and Bangladesh have largely remained the same in terms of cost of producing one kilo of tilapia at $0.99, $1.30, $ 0.43 and $ 0.16, respectively (FAO, 2004). The likely reason could be the high cost of imported fish feed used in Ghana, while these other countries use integrated farming systems where leftovers and faecal matter from poultry and piggery farms are used extensively as alternative source of feeding.

This cost analysis indicates that by producing fish feed in Ghana; cost of feed would reduce by about 43% which would translate in terms of savings, basing the calculations on 2010 output in terms of farmed fish, at $ 12,219,060 annually. The production component that has to do with feeding would be reduced by 26% and this will bring the retail price of tilapia down markedly thereby increasing consumption which can then further drive up production..

Also, most of the raw materials (rice bran, wheat bran, soy meal and fishmeal) used in the formulation of fish feed can be obtained locally as Table 15 shows. Materials like rice bran are not commonly used in most poultry and livestock feeds formulations in Ghana; however, it can be used extensively in the formulation of fish feed or as a substitute for wheat bran.

Currently due to decreasing fortunes of the poultry industry, all the ancillary services have been affected and feed milling companies are no exception. Most of the feed milling companies are operating well below capacity. Fish farming that requires fish feed becomes a new frontier that can revive the feed milling industry to a greater extent if they take a lead in the production of fish feed to support the fish farming industry in Ghana and the West African sub region. It would also create jobs for the service providers, input suppliers, distributors, animal nutritionists and all other stakeholders in the agricultural sub-sector.

The cost component of producing fish feed locally will also insulate the industry from dumping of farmed fish products into the country as our production cost would be in line with the production cost of other producing nations. These costs of fish feeds estimates are based on current prices of feed ingredients on the local market and this is depicted by Table 15.

Table 15: Sample Composition and cost of commercial floating fish feeds (36% crude protein)

Ingredients	C.P.	Inclusion	Cost (in GHc)
Fishmeal	27.5	50.00	650.00
Soya bean meal	6.6	15.00	192.00
Wheat bran	1.92	12.00	37.50
Vitamin mineral		0.25	9.00
Fish oil		12.00	48.00
Amino acids		0.20	18.00
Binding agents	0.194	10.55	12.00
Total	36.21	100.00	966.50

Source: Field Survey, 2011

4.6.5 Cost of Production

From the Pearson correlation, there is a negative relationship between productivity (output) and the cost of production; and it is significant at all levels ($p<0.01$) as shown on Table 16. This means that productivity (output) is negatively related to the cost involved in fish farming, of which cost of feed alone covers 60 percent (Rana *et al.* 2009). Hence, if a farmer incurs an additional cost in the production of Tilapia, his/her productivity (output) will fall or decrease, and vice versa. The more farmers incur more cost, the lesser their productivity (output). This is due to the fact that when cost of production is high, farmers will not engage in the fish farming business, hence output falls. This is supported by a study conducted by FAOSTAT, (2004) which states that high cost of input has a direct effect on output. Table 16 depicts this result.

Table 16: Relationship between Output and Cost of production per cycle

		Total production per period
Cost of production per production cycle	Pearson Correlation	-.891**
	Sig. (2-tailed)	.000
	N	64

**. Correlation is significant at the 0.01 level (2-tailed).

4.7 The Role of Fingerling Producers

Though broodstock for fish seed is still being obtained from rivers and reservoirs in the remote areas, there are private commercial farms producing fingerlings of tilapia for sale while individual farmers who produce in excess of their requirements also sell to their colleagues. Fisheries Commission report 2006,stated that, fingerlings continue to be produced from concrete tanks and hapas in addition to earthen ponds, as was the practice previously. However, the technology for fingerling production had improved tremendously between 1990 and 2004. This was as a result of the entry into the sector by specialists and also internationally funded programmes to breed the desired strain of Nile tilapia by the Water Research Institute of the CSIR-Akosombo. Also, a report by USAID (2010) indicated that, although fingerling production had increased since 2007, it was still far from meeting the requirements of fish farmers who required fingerlings to stock their ponds and cages.

Viswanathan (2001) reporting on aquaculture in Uganda indicated that fish seed, fish feed and equipment for harvesting were of primary importance. In that, fish ponds cannot be established without sufficient fingerlings of reasonably good quality. It was demonstrated further that, shortage of fish fry production centres, had a negative impact on the growth and development of aquaculture. Hence, there was the need to establish fry production centres to promote aquaculture development.

Though aquaculture started in the 1950s in Ghana, most people actively engaged in it quite recently. This is supported by the Department of Fisheries Report (2004), which traced total aquaculture production in Ghana from 1950 to 2000. Most of the fish seed (fingerlings) producers visited have been in existence for over a year; for instance, one fingerling production centre was established in 1979 making it the oldest producer amongst the hatcheries visited, with the most recent established hatcheries being in 2010. It is noteworthy to state that many of the fish seed producers visited were established in 2009 indicating response to the call for people to go into fish farming. Though the oldest fish seed production firm was established in the late 1970s, it was recognised by international bodies as a breeding centre to produce the desired strain of Nile tilapia in the late 1980s. Even till now, some of the fish seed producing centres have not officially attained that status. Those fish seed production centres that have officially been recognised by international bodies as breeding centres to produce the strain of Nile tilapia were given certification by institutions such as the Ministry of Food and Agriculture and CSIR – ARDEC in Akosombo.

Ninety percent of the fish seed production centres visited were in the production of Nile Tilapia seed (*Oreochromis niloticus)*. However, ten percent of the fish seed production centres also produced catfish seeds, as well as *Heterotis niloticus seeds,* in addition to the Nile Tilapia.

One of the most important inputs in fish farming is fish seed for stocking ponds and cages. This should be in the right quantities and the right size to enable food fish producers to attain the right size at maturity. To attain the best results, fingerlings must be obtained from certified hatcheries with better quality standards of practice. From ten selected hatcheries interviewed, production levels per annum were as follows: Total Nile tilapia fry produced by these hatcheries amounted to 192,807,000; total catfish fry produced amounted to 200,000; and the total amount of *Heterotis* fry produced were 50,000 (Table 17). About 50 percent of the outputs from the hatcheries were used by the farms themselves to stock their cages. Ten percent (10%) are sold to large-scale farms such as Darko farms, Crystal Lake, Germeni Farms and

Goldfieds –Tarkwa. The rest (40 percent) of the outputs from the hatcheries were sold to small and medium-scale fish farms.

Table 17: Quantities of fish seeds produced by the various hatcheries visited

Types of fish	Level of production
Nile Tilapia	192,807,000
Catfish	200,000
Heterotis	50,000
Total	193,057,000

Source: Field Survey, 2011

4.7.1 Fish Seed Demand and Supply

In terms of the supply of fingerlings to farmers, about 70 percent of the hatcheries interviewed indicated that they were unable to meet customers demand. Only 30 percent reported that they were able to meet the demand from customers. Viswanathan (2001) also reported similar findings in Uganda hence suggested the establishment of more fry production centres to increase production meet demand. This would facilitate the expansion drive in aquaculture in the country. The 70 percent of hatcheries that were unable to meet the demand from their customers listed the following production problems as reasons:

- they produce mainly for their farms only;
- a lot of people who are now engaged in cage culture of Tilapia thereby increasing the demand for fingerlings;
- inadequate land to engage in large scale production, and
- inadequate supply of broodstock .

Even though the CSIR-WRI is a nucleus producing institution for the Akosombo strain of Nile tilapia; and so produce the broodstock of fast growing strains which are sold to the hatcheries to produce the seed for the farmers, it is not able to meet the demand of all the hatcheries in the country.

All the hatcheries interviewed reported that demand for fry from customers comes from all parts of the country, especially Greater Accra, Central, Western, and Eastern Regions. Some demands also come from the neighbouring countries within the sub-region, such as Togo, Benin and Burkina -Faso.

4.7.2 Major Challenges Facing the Hatcheries

The fish seed producers interviewed reported pressing needs of their business that was making it impossible for them to produce to meet the market demand; the major challenges to their business have to do with the following:

- inadequate and expensive broodstock from WRI;
- poor quality of hapas and high cost of feeds;
- inadequate methyltestosterone (hormones for sex reversal);
- high cost of cage maintenance and construction;
- scarcity of local materials for cage construction;

- cumbersome process for acquiring financial assistance from financial institutions.

Ofori & Prein (1996) stated that production is very low due to failures in adequate siting, construction and management. Adding to this work is that conducted by the Fisheries Commission in 2006, which also indicated that tilapia fish seed are obtained from less desirable sources which are of very poor quality. Tilapia in production ponds which are not caught during harvesting because of their stunted growth are also used as fingerlings. Fish caught as fingerlings from rivers and reservoirs are either mature or of poor genetic quality and health, or are undesirable species. Hence there is the need to address these challenges that the hatcheries are facing in other to position them as vibrant stakeholder in a wider expansion of the aquaculture industry in Ghana.

All the hatcheries visited reported that they sourced their broodstock from ARDEC, the Ministry of Food and Agriculture and from the wild. However, ARDEC itself also collaborated with other international institutions like the World Fish Centre located in Penang, in Malaysia. This enabled them to obtain the necessary technology which went a long way to facilitate production of better strains of tilapia broodstock for hatcheries in the country.

The results of the study show that about 90 percent of the feed used by these hatcheries were imported (Table 18). Only 10 percent of the hatcheries visited prepared their own feed on the farm. They either import these fish feed themselves and/or purchase them from a local agro input dealer.

Table 18: Sources of fish feed used in the hatcheries Visited

Types of fish feed	Frequency	Percentages
Imported fish feed	9	90.00
Locally made fish feed	1	10.00
Total	10	100.00

Source: Field Survey, 2011

All the hatcheries visited reported that the common diseases and fouling agents that affect the fingerlings and the broodstock were growth of Trichodiria, bodily injuries, and cataracts. With all these problems, all the hatcheries visited had the requisite skills to deal with the above listed problems. Aside the skills they had, they needed further technical skills with regard to the following areas:

- upgrading of hatchery equipment;
- rehabilitation of ponds;
- education / training in best practices in hatchery management;
- production of farm- based feed and calculation of feeding rates for fish.

According to Ofori & Prein (1996) most fish farmers and extension personnel have little knowledge in the appropriate technologies. Hence, education, training and follow-up are necessary to create this knowledge among farmers and to promote more success stories.

4.8 Number of Persons Employed

From the Pearson correlation, there is a positive relationship between productivity (output) and the number of labourers employed on each farm; and it was significant at all levels ($p<0.01$) (Table 19). This means that productivity (output) is positively related to the number of persons employed and used. Hence, if a farmer employs and uses an additional labourer on the farm, his/her productivity (output) will increase, and vice versa. The more farmers use hired labour, the more they increase output. This is supported by a study conducted by Hayami and Vernon (1971).

Table 19: Relationship between Output and Number of Labour Employed

		Total production per period
Number of labourers employed by the fish farmers	Pearson Correlation	.532**
	Sig. (2-tailed)	.000
	N	64

**. Correlation is significant at the 0.01 level (2-tailed).

4.9 Summary of the Results and Discussion

This study revealed a male - dominated enterprise which pertains in most farming societies or communities in Ghana. Thus, fish farming activities were almost entirely male dominated.

FAO (2005) observed that females constituted about only five percent (very few) of fish farmers in Ghana. There was the tendency for productivity in fish farming to be high since majority of the fish farmers fall within the age range (20-59) years, and this is also supported by the works done by El-Naggar *et al*. (2008). It is clear that majority of the farmers (representing over 90 percent) were educated or literate. The uneducated or illiterate respondents were very few. This is a positive index for high productivity and may be due to the fact that the regions that the study areas were selected from are noted for having well-developed educational institutions. These results could be a reflection of the situation and characteristics of fish farmers in the whole country (FAO, 2005).

With regard to the marital status of the farmers interviewed, majority of them reported that they were married and only few were not married. According to El-Naggar *et al*. (2008) the good thing about having many married people practising aquaculture was the availability of more family labour in the fish farming operations; leading to a reduction in the use of hired labour thereby enhancing productivity. According to a report by FAO in 2005, aquaculture provides labour for family members and neighbours.

The chapter presented and discussed the results of the study. The STATA programme and SPSS statistical packages were used for the analysis. The results of the study assisted in drawing the following conclusions: Through the Pearson Correlation, analyses revealed that number of labour employed on a farm, number of cages used for fish farming, years of experience in fish farming and cost of production are positively related to output and do have significant effect on productivity (output).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

This chapter seeks to present a brief summary on the content of the research on the role of input suppliers in the development and sustainability of aquaculture production in Ghana. Major conclusions that were derived from the empirical results will be outlined. The other sections present recommendations.

5.2 Summary

Aquaculture in the sub-Sahara Africa is likely to grow by 8.3 percent from its current 1.2 percent over the next 20 years, with leading producers like Egypt. However, it is worth mentioning that Ghana has taken a leading role but analysts are alarmed that these growth trends will raise the demand for inputs used in fish production, especially fishmeal and fish oil, and can threaten the sustainability of fish farming. Another issue is sustainability and the impact of aquaculture on the environment. Today, poultry and other domestic animals have gone through a lot of transformation and this has increased their acceptance of a wide variety of feeds from plant sources. Major environmental impact has been associated mainly with high output of intensive systems of fish farmed in raceways, and in cages, in rivers and stream.

The problem of cost of production has arisen due to high protein needs of tilapia and other fish species currently being farmed and so there is the need for the cost of production to be taken into consideration as policies are being drafted for the sustainability of the sector. This can help to prevent some of the pitfalls that have befallen the poultry industry in Ghana which has led to dumping of poultry products on the local market, almost killing broiler production. Currently, some of the leading countries in tilapia production have adopted methods that have made it possible to produce at cheaper cost and this has enhanced their work greatly.

The study looked at the agricultural sector in Ghana as a whole encompassing aquaculture production in Ghana. The study considered when aquaculture started in Ghana and the challenges it has faced over the period till now. The study also looked at the major players in the production cycle. It was observed that the availability and cost of fish feed and other key inputs are likely to have a profound negative effect on the sustainability of aquaculture production in Ghana. When the various stakeholders within the production cycle perform their roles as expected, then Ghana is assured of smooth aquaculture production.

The study investigated the availability of inputs for aquaculture in Ghana, with emphasis on the following areas: Ashaiman Municipal, Tema Metropolitan Assembly, Accra Metropolitan Assembly, Ga-East Municipal, Asuogyaman district Assembly and Lower Manya district. Other objectives were to find out how socio-economic characteristics of fish farmers in the lower parts of the Volta basin the main study area, influenced their production (i.e. areas before and after the Akosombo and Kpong Hydro Electric Dams); assess the availability of inputs fish farmers use in their production; identify the challenges fish farmers face with supply of inputs; assess the potential of local feed mills for producing fish feeds in Ghana, and to come out with some recommendations. To achieve the goals of this study, a review of available literature was done on the topic to arrive at suitable model and to come out with variables that were likely to be relevant to the purposes of the study.

The study used Pearson Correlation to find out the relationships between the dependent variable (Output) and the various explanatory variables in the study area (like age and sex of farmers, number of cages used in production, number of people employed, cost of production, etc). A survey was conducted within seven selected Metropolitan, Municipal and District Assemblies (MMDAs), in the Greater-Accra and Eastern Regions to collect the required data. In all, one hundred and twenty four (124) respondents, made up of 64 fish farmers, 10 feed mills, 40 input suppliers, and 10 fingerling producers were purposely selected and interviewed.

Through the Pearson Correlation analyses, it was observed that the number of people employed on a farm, number of cages used in fish farming, years of experience in fish farming, and cost of production all had significant effect ($p<0.01$) on productivity (output).

5.3 Conclusions

From the perspective of the objectives of the study the following conclusions were made:

- The study revealed that the age, sex, level of education and marital status of fish farmers had a positive effect on production
- Fish farmers do not have access to all the inputs required for production and this has resulted in high production cost.

- Input supply is erratic, expensive and unavailable sometimes.
- Feed millers do not have the required capacity to produce floating fish feed locally

5.4 Recommendations

On the basis of the findings of the study, the following recommendations are being made to the Ministry of Food and Agriculture, and other stakeholders like feed millers and agro–input suppliers, as they map up strategies to enhance aquaculture in the country.

- Stakeholders such as Agro-Input Suppliers should be encouraged to stock more of fish farming inputs and extend their activities closer to fish farming areas
- It is recommended that local feed millers should be equipped with the necessary technical know-how and financial resource to boost their capacity to produce fish feed locally
- More certified hatcheries should be set up to produce high quality and affordable fingerlings to meet the stocking demands of fish farmers
- The WRI should be supported with the needed resources (human capacity and equipment) to research into and breed high performing strains of tilapia adapted to our local environment.
- The Water Resource Commission in conjunction with the Fisheries Commission should regulate the sittings of ponds and cages along the Volta River to prevent pollution.

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APPENDICES

APPENDIX A

Interview Schedule

Research Topic: The role of input suppliers in the development and sustainability of aquaculture production in Ghana: the case study of (North Tongu, Asuogyaman and Lower Manya Krobo Municipal Assembly)

Dear participant, I am a graduate student of the School of Agriculture, University of Cape Coast. I am conducting this research as in partial fulfilment of the requirements for the award of a Master of Philosophy Degree in Animal Science. I assure you that the responses you give will be treated with strict confidentiality. All information provided in this interview schedule will be added to those of other respondents for a general analysis so there will be no way of identifying sources of specific responses after analysis. I would be grateful if you would agree to answer the Questions below as frankly and objectively as you can.

Section A- Socio-Economic and Demographic Characteristics

1. Age: ………………………………
2. Sex:
   1 = Male ☐
   2 = Female ☐
3. Level of education
   0 = Non ☐
   1 = Primary ☐
   2 = JSS/JHS/Middle school ☐
   3 = Sec/SHS/SSS/Tec/Voc ☐

4 = Post sec/A level

5 = University/Polytechnic

6 = Other (specify)............................

4. Marital status

1 = Never married/not in union

2 = In union

3 = Married

4 = Separated

5 = Divorced

6 = Widowed

5. Religious affiliation

1 = Orthodox Christianity

2 = Pentecostal Christianity

3 = Islam

4 = Traditionalist

5 = Other specify …………………

SECTION B- Production Data

6. Name of the farm/firm? ....

7. Location of the farm /firm: …………………………………….............

8. How did you get into aquaculture production (fish farming)

1 = Family business

2 = Through a friend

3 = Personal project

4 = Other (specify) ....

9. When was the farm/firm established? ……… (Month and year)

10. Number of years engaged in fish farming.................................

11. What types of fish do you produce?

A...

B...

C...

12. How long is a production period (cycle) for each farmed fish

A..

B..

C..

13. What is the total production per period? Give estimates

Item	**Types of fish**		
	A	**B**	**C**
1 = 1-5 tonnes			
2 = 6-10 tonnes			
3 = 11-15 tonnes			
4 = 16 -20 tonnes			
5 = others (specify			

14. Do you breed your own fingerlings?

Item	**Types of fish**		
	A	B	C
0 = No →**go to Q15**			
1= Yes →**go to Q16**			

15. If No, where do you procure your fingerlings from?

Item	Types of fish		
	A	B	C
1= Friend			
2 = Certified breeder (specify)...........			
3 = Other (specify)			

16. How consistent is the supply of fish seed (fingerlings)?

Item	Types of fish		
	A	B	C
0 = Not consistent			
1 = Consistent			
2 = Very consistent			

SECTION C - Feed

17. What is the source of the fish feed used?

    1 = Locally made fish feed →**go to Q18** ☐

    2 = Imported feed →**go to Q21** ☐

    3 = Both 1&2 ☐

18. If locally made feed, do you prepare your own feed on the farm?

    0 = No →**go to Q19** ☐

    1 = Yes →**go to Q20** ☐

19. If No, from which local feed produce do you obtain your feed......................

20. If Yes, what type of feed?

1 = Slow sinking

2 = Rapidly sinking

3 = Floating feed

4 = Other (specify) ....

21. If imported feed, how do you get it?

1 = Importation by yourself

2 = From local input suppliers

3 = Other (specify) ....

22. What are the reasons for your choice of feed? (either local or exotic)

....

....

23. Do you have any difficulty in marketing finished products?

0 = No →**go to Q24**

1 = Yes →**go to Q25**

24. If No, how do you market the farmed fish? ....

25. If Yes, what is the difficulty involved? ....

26. Who are your main customers? Please state

1 = Other fish farmers

2 = Local consumers (food joints etc)

3 = Fishmongers

4 = Select as many ....

5 = Others (specify) ....

27. How do you sell your products?

1 = Farm gate

2 = Outlet in major towns/cities

3 = Both 1 & 2

4 = Other (specify) ....

SECTION D- Data on Technical Assistance

28. Do you receive any technical assistance?

0 = No →**go to Q31**

1 = yes →**go to Q29**

29. From where do you receive technical assistance for production?

1 = Relatives

2 = Friends

3= Extension officers (specify)

4 = Other (specify) ....

30. How satisfied are you with the level of technical support you receive?

0 = Not satisfied

1 = Satisfied

3 = Very satisfied

31. In which areas do you require technical support?

....

32. Have you participated/attended any training programme in aquaculture?

0 = No →**go to Q33**

1 = Yes →**go to Q34**

33. If No, how do you keep up- to- date with developments in the industry? Please state ....

34. If yes, please where?

1 = Locally (in the country)

2 = Outside the country

3 = Both 1&2

35. Who were the organizers of this training programme? Please state

a. ....

b. ....

c. ....

36. How useful did you find the training programme?

....

37. Do you train other farmers or potential farmers?

0 = No →**go to Q38**

1 = Yes →**go to Q39**

38. If No, why not? ....

39. If yes, what are major items of your training programme?

....

SECTION E- Fish Health

40. What are some of the common fish health problems faced during production? Please state...

41. Where do you go for help when health challenges arise? Please state

....

42. What harm do you suspect your farming activity may be causing to the environment? Please state ....

43. Have you put in place control measures to minimise the effect of your activities on the environment?

0 = No →**go to Q44** ☐

1 = Yes →**go to Q45** ☐

44. If No, why? ....

45. If yes, what are some remedial measures put in place? ....

46. What are the most challenging problems affecting your fish farming business? Please list them in order of severity.

....

....

47. How best do you believe the listed problems can be solved? Please state

....

....

AGRO INPUT SUPPLIERS (INTERVIEW GUIDE)

1) Name of company: ....……………….............
2) Location:...
3) What products do you deal in?
   1. Agrochemicals ☐
   2. Vet drugs ☐
   3. Inputs for fish farming ☐
   4. Complete feeds for terrestrial animals ☐

5. Others specify...

4) What inputs do you supply to fish famers?

1. Hapas
2. Specialise cage
3. Nets
4. Complete Fish feeds
5. Fish medicines
6. Others specify ....

5) Do you obtain complete fish feed locally?

0= No →**go to Q7**

1= Yes →**go to Q6**

6) If yes, where?

1 = from an importer

2 = from a local producer

3 = both 1 & 2

4 = other (specify) ....

If No, does your firm do the importation?

0= No →**go to Q9**

1= Yes →**go to Q8**

7) If yes, what firm's current import levels of complete feeds for fish? Please state.......................

8) What are the main sources of complete fish feed (Countries/ Company) imports? ....

9) What classes of complete fish feed do you import?

1= starter

2= grower

3= finisher

4 = if multiple response, please state?................

10) What types of fish feed do you import and for?

i. Tilapia

ii. Cat fish

iii. Shrimps

iv. Trout

v. State as many as possible ....

11) What is the firms current level of import in terms of tonnage both for class and type of fish?

Class of feed	Tonnage	Type of fish	Tonnage
starter		Tilapia	
grower		Cat fish	
Finisher		Shrimps	

12) Do you intend to expand or increase imports?

0 = No →**go to Q14**

1 = Yes →**go to Q15**

13) If No, please state why? ....

14) If Yes, please state how you intend to do that? ....

15) Who are your key customers?

i. Small and Medium scale farmers

ii. Large scale farmers

iii. If multiple, please state …………………………

16) Do you have any challenges when importing complete fish feeds?

0 = No →**go to Q19** ☐

1= Yes →**go to Q18** ☐

17) If Yes, please state the challenges that you face ....

18) What measures do you put in place to ensure that the quality of complete fish feed you import is maintained? ....

19) What is the level of satisfaction with the different types of complete fish feed you import and sell? ....

20) Which complete fish feeds are most commonly demanded by farmers? ....

21) What are the other major challenges to your business?

1 = low patronage ☐

2 = access to credit facilities ☐

3 = sourcing of products ☐

4 = State as many as possible.................................

5 = others please specify..

22) What is the future projection for fish input supply? Please state...

FEED MILLERS INTERVIEW GUIDE

1) Name of firm: ....

2) Location: ....

3) What is the current production level of feeds for terrestrial animals in terms of tonnage..

4) Do you have the technology to produce commercial fish feed?

0 = No →**go to Q6** ☐

1 = Yes →**go to Q5** ☐

5) If Yes, what facilities do you have to produce commercial fish feed? ....

6) If No do you intend to produce commercial fish feeds in the near future? ....

7) What types of commercial fish feed do you produce? Select the following?

1= Slow sinking ☐

2 = Rapidly sinking ☐

3= Floating feeds ☐

4= State multiple responses if possible ....

5= Other (specify)..

8) What types of fish do you produce for?

I. Tilapia ☐

II. Cat fish ☐

III. Shrimps ☐

IV. Trout ☐

V. State multiple responses if possible..................

VI. Other (specify)..

9) Please state the current production capacity for commercial fish feeds per day for?

1 = Tilapia (Tons)...

2 = Cat fish (Tons)..

3 = Shrimps (Tons)..

4 = Trout (Tons)..

10) Do you intend to expand or increase production for commercial fish feeds?

0 = No →**go to Q11** ☐

1 = Yes →**go to Q12** ☐

11) If No, please state why? ....

12) If Yes, please state how you intend to do that? ....

13) Who are your key customers for commercial fish feeds?

i. Small and Medium scale farms ☐

ii. Large- scale farms ☐

iii. Export ☐

iv. If multiple, please state ………………………..

14) How do you market your complete fish feeds?

i. Direct factory sales ☐

ii. Distribution outlets ☐

iii. Others (specify) ....

15) Do you have any challenges sourcing raw materials for commercial fish feed production?

0 = No ☐

1= Yes →**go to Q16** ☐

16) If Yes, please state major challenges ....

17) Do you obtain your raw materials for commercial fish feed production locally?

0 = No →**go to Q18** ☐

1= Yes →**go to Q19** ☐

18) If No, please where do you source them?...

19) If yes, state the main sources/ suppliers? ....

20) Why do you prefer non-local sources of raw materials? ....

21) Do you export commercial fish feed and where to? ....

22) What are the other major challenges to your business? Please state

....

23) How do you plan to address these challenges? ....

24) How do you monitor fish feed quality?

i. From customers ☐

ii. By laboratory analysis ☐

iii. Both i & ii ☐

iv. Others specify ....

BREEDER INTERVIEW GUIDE

1) Name of the farm/firm: ………………………………………....

2) Location of the farm/firm: …………………..............................

3) When was the farm/firm established: …............(Month and year)

4) When did the farm/firm attain a breeder status: …………..(year)

5) Which institution gave that certification? ....

6) What types of fingerlings are produced?

1 = catfish ☐

2 = tilapia ☐

3 = both 1 & 2 ☐

4 = Other (specify) ....

7) What is the number of fingerlings produced per annum? Please give specifics for each for each type of fish you produce..

8) Who are your key customers? Please state...............................

9) Are you able to meet the market demand for fingerlings?

0= No →**go to Q10** ☐

1=Yes →**go to Q11** ☐

10) If No, please state why? ....

11) If Yes, how much are you able to supply: ....

12) From how far do customers come to buy stock? (Specify town and/or city) ....

13) What are the challenges plaguing your business with regards to the following:

Cost and availability of broodstock ....

Cost and availability of hapas...

Cost and availability drugs ....

Cost and availability of materials for cage construction ....

Financing..

Marketing...

Availability of water source ....

14) Where from the starting stock sourced from and how often is the

stock replaced?..

15) What is the source of feeding for the brood stock? ....

16) What are the common diseases affecting your breeding stock?

a. Fingerling (list)...

b. Brood stock (list)..

17) What technical support does the farm have for breeding work? ....

18) What additional technical support do you require? ....