UNIVERSITY OF CAPE COAST

# ASSESSMENT OF OPERATIONS OF TILAPIA FARMERS IN THE ASUOGYAMAN DISTRICT OF GHANA

JUDITH AKUFFO

2014

UNIVERSITY OF CAPE COAST

# ASSESSMENT OF OPERATIONS OF TILAPIA FARMERS IN THE ASUOGYAMAN DISTRICT OF GHANA

BY

JUDITH AKUFFO

Dissertation submitted to the Department of Management Studies of the School of Business, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Business Administration in Entrepreneurship and Small Business Development.

OCTOBER 2014

# DECLARATION

## Candidate's Declaration

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

Candidate's Signature: ……………………….. Date: ……………….

Name: Judith Akuffo

## Supervisor's Declaration

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

Supervisor's Signature: ……………………….. Date: ……………………

Name: Dr. Owusu Boampong

## ABSTRACT

Tilapia farming is expanding across the world because this type of fishes can be cultured under very basic conditions and so is ideal for rural subsistence farming, yet is amenable to more sophisticated, market-oriented culture programmes. This therefore informed the decision to look into the operation of tilapia farmers. The study focused on assessing the operations of tilapia farmers in the Asuogyaman District of Ghana. The study adopted a descriptive approach. The study relied on the census technique to source views from sixty farmers in the district. All the sixty questionnaires were retrieved.

The study made use of frequencies in its data analysis. The study revealed that the source of fingerlings for most of the farmers was the pond. Majority of the farmers indicated that they were not aware of any government assistance in raising capital. However, credit/loans were their means of raising capital. With regards of farming systems, most of the farmers indicated that they use the intensive farming system. It was therefore recommended stakeholders involved in the farming should on regular basis ensure sustenance and further investments into the production of seed/fingerlings.

## ACKNOWLEDGEMENTS

I am grateful to my supervisor Dr. Owusu Boampong for his insightful comments, suggestions, direction and recommendations in helping to shape the work to its final stage. I am most grateful to him for supervising this work.

To the other lecturers of University of Cape Coast, I say many thanks for your contributions towards the completion of this programme. Finally, I thank all my colleagues, family and friends for their support and encouragement to complete this thesis.

# DEDICATION

To my husband, Frederick W.K. Akuffo.

# TABLE OF CONTENTS

## LIST OF TABLES

# CHAPTER ONE

# INTRODUCTION

## Background to the Study

Popma and Masser (1999) opine that tilapia fish was one of the first fish species cultured more than 3,000 years ago and remains the most widely cultured fish in Africa. Artificial introductions of this species in many Asian and some Pacific Island countries is a post-1950 phenomenon as a potential panacea to the growing animal protein deficiency in Asia (Lin, 1977). Tilapia farming is witnessing a global expansion because of the rapid growth rate and hardy characteristics of this freshwater fish, its high reproductive and growth rates, and minimal management requirements, making it ideal for rural subsistence farming, yet is amenable to more sophisticated, market-oriented culture programmes (Nandlal & Pickering, 2004).

As at 2002, the aquaculture production of tilapia was about 1.5 million tonnes, the great bulk of which took place in Asia and accounted for nearly 80 percent of the total world production. Buy by the end of 2004, farmed tilapias across the world exceeded 2 million metric tonnes (El-Sayed, 2006). It is important to note that tilapia culture in Africa and South America also increased (De Silva, Subasinghe, Bartley & Lowther, 2004). In Egypt for instance, there are a few large-scale production operations, notable among them being the government supported farm at Maryut. This farm, originally built with international aid monies, provides fingerlings, training, production ponds, and includes a retail seafood outlet.

Further growth of the industry is predicted based on the population size in Egypt and its hosting of the major research location in the region. Most countries of western and central Africa have strong domestic markets and few, if any, tilapia product exports in international trade. Virtually all of these countries have significant wild harvests that are supplemented by farmed products (Fitzsimmons & Watanabe, 2010).

The production of tilapia fry and fingerlings is done largely with the use of either plastic lined tanks, or earthen ponds, or net enclosures called "hapa" in ponds (Balarin & Haller 1982). Selection of production system is relative to the life stage that will be collected. Mixed size fry are typically collected from earthen ponds. Fertilized eggs and sac fry are typically collected from brooders held in hapas and tanks. Production in earthen ponds is relatively extensive while production in hapas and tanks is more intensive, though daily production is generally higher (Peterman, 2011).

Fish farming started in Ghana in the 1950s with the stages of aquaculture development in Ghana divided into three: The pre-1980s saw the construction of most of the ponds by the government for training, demonstration and for research. The second phase was in the 1980s which saw a widespread response to the government's initiative towards self-sustainability in fisheries where many ponds were constructed by both individuals and communities (Prein, Ofori & Lightfoot, 1996; Quagrainie, Amisah & Ngugi, 2009). According to Prein et al (1996), much of the effort in the first and second phases yielded very little results and created disillusion among those who ventured into it. Quagrainie et al (2009) suggest that the most recent phase began about a decade ago, and is characterized by a gradual shift from subsistence to commercial farming and from the pond system to the cage system. This contributes over 80% of total aquaculture production in Ghana (Ashitey & Flake, 2009).

Much of the Tilapia fish on the market are thus from cages and not ponds. Since 2000, the general annual growth rate of Tilapia fish farming is about 16 percent. This is evident in the numerous farms both small and large along the lower section of the Volta Lake but not in the quantity of fish produced annually (Asmah, 2008).

**Statement of the Problem**

The operation of Tilapia farmers in Ghana started in the 1950s. Despite the half-century years of operations in the industry, evidence from earlier research reveals that the production potential of small scale fish farming in Ghana has been very low over the past decade (Prein et.al., 1996). This study therefore seeks to investigate the operations of Tilapia farmers in the Asuoygaman District, with wild capture on the decline from 459,000 metric tonnes in 2000 to 357,000 metric tonnes in 2008 (Ashitey & Flake, 2008), Prein et.al. (1996) believe that aquaculture can be assigned the significant role in meeting the shortfall.

This has however not been met due to challenges such as insufficient availability of affordable fish feeds, lack of financial resources to bring about profitability of aquaculture operations, lack of effective extension systems for technology transfer, and absence of an in-country research agenda that is responsive to the needs of the aquaculture sector (Rurangwa, Agyakwah, Boon & Bolman, 2015). This work is to examine the operations of tilapia farming in the Asuogyaman District of Ghana and the challenges faced by the farmers and contribute to filling the knowledge gap in this area.

## Objectives of the Study

The main objective of this research is to examine the operations and challenges facing tilapia farmers in the Asuogyaman District. The specific objectives include;

1. Identification of the sources of tilapia seed for the tilapia farmers
2. Examination of the system of farming used by the farmers
3. Examination of the sources of capital for tilapia farming operations
4. Identification of the challenges faced by the tilapia farmers
5. The examination of the demographics of tilapia farmers in the district

## Research Questions

The researches questions that the researcher seeks to address are as follows;

1. What are the sources of tilapia seed for tilapia farming?
2. What are the sources of capital for tilapia farming operation?
3. What are the systems of farming used by tilapia farmers?
4. What are the challenges faced by the tilapia farmers?
5. What are the demographic characteristics of tilapia farmers?

## Significance of the Study

Indisputably, the use of tilapia as sources of protein has been on the increase, causing tilapia farmers to increase their supply to meet this demand. However, farmers mostly find it difficult to evaluate their operations to see the need in meeting the high demand and if they are giving consumers value for money. This is partly attributable to a lack of established practices to evaluate the operations of the farmers over a period or the fact that most of the farmers see no reason why they should evaluate their operations. The principal significance of this study, therefore, is to provide the farmers with some suggestions on how their operations can be improved. This study will support the farmers and the fisheries department to evaluate their operations and make recommendations to improve fish farming itself and also support in identifying other types of fishes that have been left in the dark whiles identifying the real gaps for further support.

It is again expected that this work will generate a justifiable basis for tilapia farmers to continue to spend financial resources on tilapia farming and be able to see improvements in their lives. This work is to verify if the resources they invest will give them value for money. This ensures that good investment practice standards are in place and working to meet consumer's needs. Moreover, this work seeks to identify and suggest best practices that can be put in place before, during and after harvesting to ensure successful business operations. Finally, to support the tilapia farmers in the Asuogyaman District, this study outlines some recommendations for consideration. If the farmers of tilapia are able to implement these recommendations made, the implication is to see improvement in how they operate the farms and leading to increase in individual performance and therefore the collective farms in the Distract.

## Delimitations

Since it was not practical to involve all the tilapia farmers in the selected District, some tilapia farmers located in two towns in the District were selected for the study. The researcher consulted the Ministry of Fisheries and Aquaculture Development to have a fair idea of fish farming practices before randomly selecting the Kpong and Asuogyaman Fishing Communities for the study. The Asuogyaman District was preferred due to the cluster of tilapia farmers in that community. The limit of the research was to assess the operations of tilapia farmers and see the benefits their operations have brought to them.

## Organization of the Study

The study is organised into five chapters. The first chapter is an introduction; covering the background, statement of problem, objective of the study, research questions, significance of the study, delimitation of the study, and organization of the study. In Chapter Two, a broad review of both theoretical and previous researches of the main subject is done. The methodology and data collection process and sampling techniques and data analysis are considered in Chapter Three. Chapter Four looks at the analysis, presentation and discussion of results. The report ends with the summary, conclusions and recommendation in Chapter Five.

# CHAPTER TWO

# REVIEW OF RELATED LITERATURE

## Introduction

The chapter reviews the relevant literature on the types of tilapia; aquaculture, stakeholders and aquaculture potential in Ghana; fish farming in Ghana; the national aquaculture policy; factors to consider in establishing fish farm; fish seeds and fingerlings production; fish farming extension service in Ghana; management of fish farms; common fish diseases in fish farms; capital for tilapia farming operations; some systems of farming used by the fish farmers; and some challenges faced by tilapia farmers.

## Aquaculture

The Food and Agriculture Organization (FAO) defines aquaculture as the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants (FAO, 1990). Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. The various stages of aquaculture operations include a hatchery operation which produces fertilised eggs, larvae or fingerlings; a nursery operation which nurses small larvae to fingerlings or juveniles; and a grow-out operation which farms fingerlings or juveniles to marketable sizes.

For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licenses, are the harvest of fisheries (Welcomme & Barg, 1997). As global fish production continues to outpace world population growth, aquaculture remains one of the fastest-growing food producing sectors (Srivastava & Pandey, 2015).

In 2012, aquaculture set another all-time production high and now provides almost half of all fish for human food. This share is projected to rise to 62 percent by 2030 as catches from wild capture fisheries level off and demand from an emerging global middle class substantially increases. (FAO, 2014). Unlike terrestrial farming systems, where the bulk of global production is based on a limited number of animal and plant species, the aquaculture sector comprises over 200 different species which reflects the diversity of the sector, particularly the wide variety of candidate species cultivated and different production systems used (Thompson & Amoroso, 2010).

In association with this diversity, and because of its relatively recent development, there is still a great need for practical scientific knowledge, economic and profitability studies, and knowledge of potential areas for site selection, development and expansion. In this respect reliable analytical tools for use in decision-making are key need in planning expansion (Nath, Bolte, Ross, & Aguilar-Manjarrez 2000).

**Tilapia Fish Farming**

Tilapia has good characteristics for farming, and are now so domesticated that they have earned the title "the aquatic chicken" (Maclean, 1984). They are fastgrowing, able to survive in poor water conditions, eat a wide range of food types, and breed easily with no need for special hatchery technology (Darko, 2012). Tilapias are one of the best researched species for aquaculture, and there is a wealth of experience in their husbandry (El-Sayed, 1999). Tilapia is tough and tolerates a wide range of environmental conditions: little environmental modification is needed, so aquaculture systems can be low-tech. (Pullin & Lowe-McConnell, 1982; Welcomme, 1988; Beveridge & McAndrew, 1998).

Earthen ponds of appropriate design in non-flood-prone areas will be sufficient for tilapia farming. Concrete tanks or raceways can be used, but are more expensive to build and usually cannot be justified in rural areas. Cages in lakes, dams or rivers can also be used. Nevertheless, tilapia has some bad characteristics. Uncontrolled breeding in ponds can lead to overcrowding and stunted growth. Tilapia can be a pest that eats other fish species. Once tilapia are present in a pond, they are difficult to get rid of except by poisoning or by draining the place and leaving it to dry until the bottom has baked hard in the sun. They need to live in warm water and do not grow well if the water temperature is lower than 22°C (Pickering & Forbes, 2009).

The trick to efficient, successful and profitable tilapia farming is to stock with large batches of fingerlings of similar size and age. Only then can all fish in a pond be harvested at the same time, after which the pond must be completely dried out to kill any leftover, unwanted fish. A sign of inefficient farming is ponds filled with fish all of different sizes and ages. It is easy to farm tilapia badly, but to farm them well and produce large batches of similar-sized fish, management skills and a good supply of quality fingerlings are needed (Nandlal & Pickering, 2004).

**Fish Farming in Ghana**

Ghana started stocking fish in small reservoirs and dugouts between the 1950s and the early 1970s (Prein & Ofori, 1996). During this period the number of fish farmers rose to about 1000 with over 2000 earthen fish ponds with a surface area of about 350 hectares. Collectively, these ponds were managed within 1300 farms (Asmah, 2008). The majority of farmers were small-scale farmers that practised extensive farming systems and semi-intensive farming systems. Within the various systems some practiced polyculture while others practised monoculture and mono-sex culture. In these culture systems, farmers reared different types of fish species, with tilapias and Clarias sp. being the most common. The maintenance of these fish is highly dependent on manufactured feeds and farm made types using local ingredients (Frimpong & Adwani, 2015).

Normally, these ponds are maintained on schedule maintenance and drainage (Mboge, 2010). Naturally, their water sources include rivers, streams, underground and rainfall. However, the fertility of these ponds is maintained mainly through the use of organic manure and inorganic, in rare cases (Frimpong & Adwani, 2015). Similarly, in extensive system practice, some farmers apply a shovel full of poultry manure every day. Other small-scale farmers apply together both poultry droppings and pig wastes as their organic fertilizers while few chose the inorganic fertilizers, NPK and urea (FAO, 2009).

Usually farmers that practise semi-intensive systems give oil palm kernel cake to their fish as supplement (Okai, 1995). Within the systems, some fish farmers in the Eastern Region, Tema and Greater Accra practise polyculture of Sarotherodon galilaeus, Oreochromis niloticus, Tilapia zilli, Tilapia discolour Tilapia busumana, Heterotis niloticus, Clarias gariepinus and Ophiocephalus spp. These fish are normally fed with wheat bran (c. 800/25-30 kg bag) and spent grain, brewery waste (c. 700/truck load); at 2 bags of wheat bran supply to 4 ponds every week (Mboge, 2010)).

Furthermore, the farmers also practise rice-cum-fish culture through the integration of the two after broadcasting the rice fields with appropriate seeds and stock three weeks later with about 8 to 10 cm tilapia fingerlings at a density of about 700 per hectare (Mboge, 2010). Conveniently, the water depths in the rice fields are maintained between the range of 15 and 45 cm. Subsequently, fish in these rice fields are fed with rice bran at the same rate as those in the ponds and, both rice and fish are harvested together, about 120 days after seeding. Similarly, other farmers at the irrigation schemes in Central Region stock their rice fields at 500 fingerlings in 1.6 acres (780 fingerlings/ha) and give rice bran at a rate of 15-20 kg per day for every pond. Unlike other farmers, some of them harvest their fish only once every year.

Farmers in the Western Region stock catfish in reservoir and use to feed them with a mixture of chopped paw-paw (Casica papaya), cocoyam (Colocasia esculenta) leaves and wheat bran, twice daily. Sometimes, fish farmers use feeds that are made of wheat bran mixed with cassava leaves. In addition, some used food leftovers, papaya leaves and even palm kernel waste (FAO, 1990a).However, commercial fish farmers in Volta Region produce their own fish seeds through the incubation of fertilized eggs in recirculating troughs which are also structured as tanks. Later, the fry are recovered from these troughs and reared in concrete tanks to produce fingerlings up to 10 grams before stocking (FAO, 2000, 2009). Normally, their parent tilapias or brood stock are confined in hapas in earthen ponds (Mboge, 2010).

Fish farming in Ghana is based largely on earthen ponds where rainfall, ground water and stream are the main sources of water while cage culture systems are found in commercial farms in the Volta lakes and irrigation dams in Akuse (Asmah, 2008). Naturally, most of the Ghanaian fish farmers depend on seepage of water from the pond bottom to fill the ponds (Akpaglo, 2013). Although series of attempts are made to control the flow, the most effective is the use of chicken and pig wastes. The use of this manure is attributed to physical blockage of soil pores, with secondary biological clogging due to slime-forming microorganisms (Little & Satapornvanit, 1996). Technically, farmers use plastic seals and layers of clay compacted on the bottom of the ponds but these are washed away during draining operations (Oribhabor & Ansa, 2006). .

During the maintenance of these ponds, the farmers clean the bottom and do the levelling; uproot the weeds and repair the dikes together with their inlets and outlets as well as cutting grasses on dikes. Normally, such ponds are drained only once every 3 years. Some of the labour force come from the family members as well as hired labourers (Vincke & Awity, 1990).

**Stakeholders and Aquaculture Potential in Ghana**

The Fisheries Commission is the lead agency of the Ministry of Fisheries and Aquaculture Development (MoFAD) vested with the administrative control of aquaculture in Ghana. The Commission is responsible for aquaculture planning and development in Ghana. Other responsibilities of the Commission include the implementation of fisheries policies and programmes, monitoring, control, surveillance, evaluation, as well as facilitating the increment of fish production from marine, inland waters and aquaculture (Fisheries Act, 2002, Act 625).

The Water Research Institute (WRI) under the Council for Scientific and Industrial Research (CSIR) is mandated by law to carry out aquaculture research. (CSIR Act 1996, Act 521). Other groups like the Institute of Renewable Natural Resources of the Kwame Nkrumah University of Science and Technology and Institute of Aquatic Biology are collaborating with the Fisheries Commission to train more technicians and farmers as well as provide extension services. Presently, the Department of Oceanography and Fisheries of the University of Ghana also trains students and research in Aquaculture.

Another stakeholder is the Ashiaman Aquaculture Demonstration Centre offers training programme for students, farmers and its staff members. In addition, the Center has a hatchery that produces fingerlings for fish farmers (Kasam, 2014). Its institutional collaborators are the Department of Biological Sciences, ARDEC, Directorate of Fisheries and the Faculty of Renewable Natural Resources, KNUST. Nunoo et al. (2014) reported that interests in fish farming continue to grow with an overall annual average growth rate of about 16% since 2000. Nunoo and colleagues attributed this to governments' motivation through opportunities of trainings, free extension services, capacity building of farming agents and provision of fingerlings for sale (Nunoo et al., 2014).

The existing farms, 1,300 in number were however very small with a mean farm size of 0.36 ha and a median 0.06 ha of which commercial farms accounted for less than 3%. Through GIS study, it has been stated that, 2% (3,692 km2) and 0.2% (313.8 km2) of the country's available land is most suitable for subsistence and commercial farming, respectively. In addition, there are another 97.4% of land for subsistence farming and 84% of land for commercial purpose while potential areas for cage culture are in the southern and middle part of the country (Gilbert, 2013).

Furthermore, there are irrigation schemes and dams for aquaculture agriculture in Upper Region, Upper West Region. Other projects include World Bank funded Pilot aquaculture centre in Kona-Tano Odumasi, fingerling production in Ashaiman Fisheries Station, water supply from irrigation dam at a rice project in Dawhenya and ARDEC Akosombo WRI/CSIR in Eastern Region (Owusu et al., 1999).Besides, potential areas for cage culture are in the Greater Accra, Western , Eastern and Ashanti Regions. The specific areas are Lake Bosomtwi, Atwima, Kwamwoma district, Weija reservoir, Dawhenya irrigation reservoir. In addition, the most suitable areas for culture-based fisheries are Northern, Upper East and Upper West. The advantage of these areas is the availability of their artificial water while rainfalls are very low (Anane-Taabeah, 2012).

Fish species of culture importance in Ghana include Oreochromis niloticus, Lates niloticus Heterobranchus longifilis and Chrysichthys nigrodigitatus, (Alhassan et al, 2015)-). In addition, small-scale farmers produce various species of tilapia such as Tilapia zillii, Tilapia discolor, Tilapia busumana, Sarotherodon galilaeus and Hemichromis fasciatus, Heterotis niloticus and the catfishes: Clarias gariepinus and Heterobranchus bidorsalis. Normally, women buyers demand to buy the harvested fish from farm gates because of their low costs (Hiheglo, 2008).

**National Aquaculture Policy for Fish Farming in Ghana**

The preparation of strategic framework for aquaculture development was completed with the involvement of all stakeholders (FAO, 2009). The Fisheries Act of 2000 (Act 625) is the main legislative instrument that governs the practice of aquaculture in Ghana. The relevant sections are stated as follows:

Section 60 is on licenses for aquaculture and recreational fishing. This section stipulates that a license is required for an aquaculture project > 1 ha, an application for which must be made to the Fisheries Commission and accompanied by an environmental impact assessment.

Section 93, i.e. the requirement for a Fisheries Impact Assessment: Subsection (1) makes it compulsory for anyone undertaking any activity other than fishing, and which is likely to have a substantial impact on the fishery resources or other aquatic resources of Ghana, to inform the Fisheries Commission prior to the commencement of the planned activity. Subsection (2) empowers the Commission to prepare or commission reports and make recommendations that must be taken into account in the planning of the activity and in the development of means of preventing or minimizing any adverse impacts. Subsection (3) adds that this requirement is additional to any other requirements of the Environmental Protection Agency.

Section 139 stipulates that the Minister may, on the recommendations of the Commission and by law, establish regulations relating to aquaculture. This option has yet not been used. The Act is not explicit on legal rights, protection against other resource users and ownership and tenure. It does not contain anything on fish health, quality assurance or product safety. In exercise of the powers conferred on the Minister responsible for the environment under section 28 of the Environmental Protection Agency Act 1994 (Act 490) i.e.L.I.1652, and on the advice of the Environmental Protection Agency Board, regulations were made for the conduct and submission of environmental reports and impact statements. Schedule 2, regulation 3 of the Environmental Assessment Regulation, 1999, prescribes land-based aquaculture as one of the undertakings for which an environmental impact assessment (EIA) is mandatory.

In the same legislative instrument, schedule 5, regulation 30(2) contains the provisions to regulate the activities associated with fish cage culture. It characterizes water trapped for domestic purposes, water within controlled and/ or protected areas and that water which supports wildlife and fishery activities as environmentally sensitive areas the use of which is governed by EIAs. The Food and Drug Law, 1992, prohibits the sale of unwholesome, poisonous or adulterated and unnatural substances and lays down penalties for breaching the law (FAO, 2000, 2009).

In the development plans, the Government aim to promote small-scale pond farming through the integration of aquaculture into agriculture. Furthermore, culture-based fisheries are introduced within communities living close to irrigation dams for their livelihood opportunities (Owusu et al. 1999). In addition, government proposes to convert 5% of all irrigated areas into small-scale fish farms. Also, there are plans for further research in aquaculture agriculture which will be facilitated through the reinforcement of institutional collaboration (Owusu et al. 1999). The institutions include Department of Fisheries, Institute of Renewable Natural Resources, the Crop Research Institute, University of Development studies, the Irrigation Development Authority and various NGOs. In addition, Water Research Institute collaborates with ICLARM, GTZ, the World Bank and FAO (Owusu et al. 1999).

**Site Selection for Fish Farm Establishment**

Site selection for a fish farm, includes a lot of factors for consideration. Examples of these factors are: topography, availability of quality water and condition of the water table, suitable soil types for pond construction, level of seepage, ideal pond position, surrounding vegetation, access road, land size and ownership as well as the meteorological and hydrological information about the area.

In selecting a site, one should consider the volume of water available, level of the land in relation to the water possibilities of flooding, vehicular access, electricity supplies, and proximity to potential markets (Woods, 1994). Other meteorological and hydrological information about the area are temperature, rainfall, evaporation, sunshine, speed and direction of winds. In land-based aquaculture where earthen ponds are normally used, ease of filling and drainage by gravity are basic consideration. So, it would be advantageous to select land with slope not steeper than 2 percent (Pillay, 1990).

Secondly, it is advisable to make discrete enquiries about ownership of the land or swamp and if the owner is prepared to sell for a reasonable sum (Woods, 1994). However, a good irrigated agricultural land may be the best for fish ponds. Asia is an example, where farmers utilized rice fields for fish farming (Pillay, 1990). In other areas, before designing a fish farm, a survey is carried out on the site using few trial holes dug to establish the type of terrain as well as taking advantage of the feature of the land (Woods, 1994). This is important because a place with high ground water level may create problems in the farm operation, as drainage will become difficult and expensive. Woods (1994) concluded that selection of suitable site will depend on the culture system to be adopted.

**Fish Seeds and Fingerlings Production**

Fish seed is either collected from the wild or produce by inducing the fish to spawn under farm conditions. The best known fish that spawn easily in a pond are tilapias. Carp form an example half-way between the tilapia and the trout, because they spawn in a farm pond and the eggs and fry can be reared in the pond (Swift, 1993). In Europe, one of the modern methods for seed production is the introduction of early-spawning females to photoperiods in order to facilitate their ovulation. Similarly, sex-reversal females, when subjected to the same condition, will result to all-female eggs (Mussion, 1994).

Other techniques include the use of hormones from the pituitary gland; which automatically control the maturation of the fish gonads. In this way, fish become ripe without having to undergo spawning migration (Swift, 1993). Normally, sexually matured fish are given injections of either whole fish pituitary gland or of pituitary hormones to facilitate spawning. Furthermore, cryopreservation technique has been developed in order to preserve viable fish sperm at very low temperatures for long period (Swift, 1993).

**Suitable Soils for Fish Pond Structures**

Soils are the joint products of rocks, climate and vegetation (Quayson, 1999). Soils are considered due to their suitability for dike construction. Suitable soils for pond construction include sandy clay to clayey loam, clay, clayey silt and silt clay loam. This is because of their additional advantages: retain nutrients for organic production in ponds; resistant to erosion and other damages (Pillay, 1990). These soils are determined by sample collection through the use of anger on regular pit (1.0-2.0 m deep, 0.8 m wide and 1.5 m long) while touch and feel are used to determine the texture (Pillay, 1990).

**Pond Construction for Fish Farming**

The Institute of Science in Society, I-SIS (2005), described most ponds as rectangular shaped, 0.4 to 0.6 ha in area and 2 to 3 meters deep whiles dykes are usually 6 to 10 meters wide with extension of 0.5 to 1.0 meter above the pond surface. According to Swift (1993), ideal position for a pond is one where it can receive water supply under gravity and discharge the used water under gravity. It is also believed that fish pond located under a tree will encourage a lot of shed leaves (drop into the pond) that can result to pollution and need constant removal (Lee, 2006).

Generally, the excavated material is used to form the dyke whereby impermeable soil is preferred for a central core of about 50 cm thick in case of permeable soil. The slope of the inside of the dyke should be 1:2 or decrease to 1:4 in large ponds; where wave action is greater. On the other hand, the slope outside the pond is 1:1 or 1:1.5 (Swift, 1993). On completion, the pond bottom is compacted and drainage ditches are dug into it. The main ditch is about 50 cm wide and the side slope is about 1:1.5 (Swift, 1993). In front of the pond outfall is constructed as a collection basin sunk below the level of the pond bottom, lined with concrete, and form a firm base for the collection of fish.

Generally, pond inlets are structures which enable water supply to be turned on and off at the same time prevent the entrance of unwanted organisms into the pond. The outlets of the pond are formed by a structure known as monk (Swift, 1993). Pillay (1990) further suggested that ponds could be constructed and operated without disturbing the acid soils, allowing a non-acidic layer of sediment on the bottom. Secondly, at the designing stage, one should also consider that a fish pond with an average depth of 1.5m required 15000 m3 of water per every hectare. It is also recommended that, before filling the ponds with water, further preparation is done through clearing, cleaning and applying fertilizers such as quick lime, tea-seed cake and livestock manure (I-SIS, 2005).

## Infrastructural Services for Fish Farmers

These are facilities such as hatcheries and irrigation schemes which serve as source of fish seed for fish farmers. Hatchery production is used to stabilize the supply of improved seeds for better growth and fish production. This involve the rearing of brood stock, spawning or stripping and fertilization of ova, incubation of fertilized eggs and rearing of larvae; which are later transferred to nursery enclosures (Pillay, 1990). Equipment in a hatchery, include tanks and scoop nets for catching brood stock as well as jars, troughs or other containers, net cages or hapas‘ (mesh cloth tanks) for incubation of fertilized eggs; food dispensers; larval rearing tanks and aeration systems (Pillay, 1990).

In addition, trough-type incubators that are used in trout and salmon hatcheries have egg baskets fitted in trays with perforations which are of the same shape and sizes to retain the eggs; but allow the hatchlings to fall through to the bottom of the trough. On average, the sizes of such troughs is 3m x 0.5m x 0.25m (Simpson, 2002). Generally, 20-30 degree centigrade is maintained for warm water fish species while the dissolved oxygen level can be slightly lower than the range from 3 to 4 mg per litre of the water (Mallya, 2007). Normally, hatcheries with small fries use around 300 gallons of water per minute while larger fish use a maximum of 700 gallons in every hour. Usually, these are stocked at low density in order to achieve quality fish (Avery & Steeby, 2004)).

Also, irrigation systems are potential sites for fish grow-out or nurseries. Some of the examples are: large irrigation reservoirs, extension network of irrigation canals and irrigated fields (Li, 2002). Li (2002) further stated that, high densities of fish in irrigation systems enhance the crop yields, alleviate the pressure of both terrestrial and aquatic pest to lower the population of vectors of diseases of man and domestic animals.

**Fishing Farming Extension Service in Ghana**

In Ghana, the Directorate of Fisheries and the Ministry of Agriculture provide free extension services and other technical services to fish farmers which include the production of fingerlings for sale at government-operated fish hatcheries. In addition, non-governmental organizations and universities have also provided some technical assistance to fish farmers in effort towards the development of aquaculture in Ghana (Quagrainie et al. 2009). However, the Fisheries Directorate, are represented at the farmer contact level by Agricultural Extension Agents (AEA). This is because fisheries extension capacity for aquaculture activities was very weak because this area was not part of the curriculum of the agricultural colleges (Kwadjosse, 2009).

**Management of Fish Enclosures for Fish Rearing**

Pond is one of the enclosures where management is concerned with the water supply and to maintain the environmental conditions required for the optimum growth and minimum mortality of the pond's fish population (Swift, 1993). After each harvest the pond is drained and the bottom is allowed to dry out. Excess mud and detritus are removed while the soil is ploughed and then treated with lime and manure as required. Normally, the water flow is controlled in order to adjust the temperature and oxygen content of the water (Swift, 1993).

Repeated draining and filling of a pond may result to desiccation of the entire embankment, causing cracks and entry of water into the structure. Eventually, the crackfaces become saturated and the moisture penetrates into the interior by capillary action (Pillay, 1990). Gradually, greater amount of water flows through the cracks, resulting into the development of gully or tunnel erosion (Szilvassy, 1984). Secondly, siltation may become a problem but this will depend on the annual volume of sediment entering the pond. Where the water turbidity is undesirably high, separate sedimentation tanks are required to reduce it (Pillay, 1990).

Generally, ponds filled from natural bodies of water create entry of extraneous fish and other eggs or larvae of organisms even whereas inlet protection made of small-meshed screens are provided (Pillay, 1990). Swift (1993) further explained that, concrete-lined ponds are used in systems where the entire food supply for the fish is placed in the pond by the farmer. Such ponds are meant for the intensive production of high-priced fish (example trout) in intensive systems.

Normally, pond management becomes easier and most economical with shallow type (3 to 6 feet & 1 to 10 acres) ponds with drainage systems.

Pond draining is necessary in order to harvest all of the fish; after which the pond bottom is allowed to dry for the eradication of any fry or fingerlings that may interfere with the next production cycle (Rakocy & McGinty, 1989). Usually, ponds are drained two or three times yearly, and the mud is added onto the dykes, thereby raising and repairing the dykes as well as restoring the depth of the pond (I-SIS, 2005). Ponds are also sealed by pudding which is a process where fine particles are used to clog the most permeable parts (Pillay, 1990). Furthermore, Nilson and Wetengere (1994) recommended cleaning of pond slopes, three times every year while harvesting twice per year and pond construction and maintenance, in the months after the rainy season.

Furthermore, planting some water plants around the pond edges will help to manage and absorb some of the nutrients in the fish pond in order to control the presence of algae (Lee, 2006). It is also suggested that, plastic lining can be used in a pond in other to separate the ground as well as control the debris and soil nutrients (Lee, 2006). However, fish tank is also another enclosure which is maintained through regular cleaning of the filtration system as well as the interior of the tank (Stevens, 2007). Usually, a partial water change of about 20% is needed during fish tank and aquarium maintenance. This is a continuous replacement after each cleaning of an aquarium.

During the process, algae scrubber is used to remove a little amount of algae off the front viewing panel of the aquarium and as well scrape any algae off both the front and sides of the tank (FishLore, 2007). Consequently, the filter media is given a special care and rinse with discarded tank water. This is because beneficial bacteria load needed for the aquarium nitrogen cycle are concentrated at the filter media (after draining) and rinsing it in tap water with chlorine can kill some of these bacteria. Therefore, the tank is refilled with de-chlorinated water as the same temperature as the remaining water (FishLore, 2007).

Stevens (2007) further registered that, cleaning the filter of fish tank is usually a monthly task while the entire tank is clean at least once a week or once every fortnight. Normally, salt water aquarium is cleaned once a week whereby the algal built up on the front and side of the glass are scrubbed out completely. Subsequently, the water is replaced but freshly mixed salt water can be fairly toxic to fish. Thus, a day is allowed to prepare the mixture in order to dissolve properly; prior to the need. At this moment salinity is determine using the hydrometer (FishLore, 2007).

**Seepage in Fish Ponds**

Verdegem and Bosma (2009) opine that seepage in fish ponds depend on soil conditions, area of pond surface and dike construction. Example, loss through seepage and evaporation in an arid climate is estimated at 1-2 cm per day or more. Therefore, the minimum quantity required for filling and topping under such situation is estimated between 35000m$^3$ and 60000m$^3$ per hectare per year. In Europe, the range of such losses is reported to be about 0.4-0.8 cm per day (Chaudhari, 2003). Technically, seepages are reduced through compaction of soils during pond construction. This is supported with other elements that cause natural sealing or colmatation include decaying debris, pond wastes and algal growth. Naturally, seepage water losses can be reduced by proper site selection and adequate pond construction (Tucker & Hargreaves, 2009).

**Water Quality in Fish Farms**

This section will discuss water quality measures for the maintenance of healthy water for fish farming. Basically, these include turbidity, acidity and alkalinity, dissolved oxygen and salinity. High turbidity of water by suspended solids affects both productivity and fish life. It reduces light penetration into the water and as a result primary production decreases (Bash et al., 2001). The suspended solids also clog the filter-feeding apparatus and as well injure gills of fish. This occurs when the water contains about 4% by volume of solids (Chaudhari, 2003).

However, these solids are reduced through the use of settling tanks with different types of filters and repeated application of gypsum (200 kg per 1000 m3, followed by additional application of 50g per 1000m3). The best conditions for a fish pond are a stable pH with a level between neutral and alkaline (Osman et al., 2010). Pillay, (1990), clearly stated that the most suitable pH of water for aquaculture farms lie in the range of 6.7 to 8.6 while below or above inhibit growth and production. Normally, water of low pH is commonly found in freshwater areas with soils that are low in calcium and rich in humic acids (Pillay, 1990).

Occasionally, acidic water (pH range of 5.0-5.5) is harmful to eggs and fry of most fish. Therefore, it is advisable to take pH measurement on daily bases as productive water is prone to reach higher pH values of 9-10 due to the uptake of carbon dioxide during (photosynthesis) the day. Beyond that level, even pH level of 11 may be lethal to fish. Photosynthesis, respiration, exchanges at the air-water interface, and supply of water to the pond controlled the amount of oxygen dissolved in water Erez et al. 1990). The source of dissolved oxygen in water is partly from the air and mainly photosynthetic activities (Delincé, 1992).

In Israel, Milstein et al. (1989) reported that the impacts on water quality of reservoirs use for fish farming is primarily the result of algal activities, followed by decomposition processes, and, finally, wind action. In the epilimnion, algae produce oxygen, while in the hypolimnion, they consume oxygen. Furthermore, in the metalimnion, consumption and production are balanced (Chang & Ouyang, 1988). Generally, the principal source of oxygen consumption in ponds is heterotrophic respiration (include all animals) while the autotrophs react during the night (Pace & Prairie, 2005).

Therefore, in the early afternoon, at the peak of production, oxygen saturation can reach 250%, and this is towards release of oxygen into the air (Marks & Pytel, 2011). Typically, the level of dissolved oxygen varies from 14.6 mg/ litre at 0 degrees centigrade to 7.6 mg/litre at 30 degrees centigrade. Thus, over the temperature range of 0 to 30 degrees centigrade the amount of oxygen contained in the water is halved. The required oxygen varies with species, example salmon require 9 mg/litre; carp 6 mg/litre, but can withstand levels as low as 3 mg/litre. Tilapia can also withstand low levels of oxygen below 6 mg/litre (Swift, 1993).

However, salinity is the sum of all solid substances in solution in 1 kg of water (measured with salinometer), when all carbonate ions have been converted to oxide ions, all bromide and iodide ions are replaced by chloride ions, and all organic matter oxidized (Spotte, 1979). Similarly, in temperate freshwater, calcium and magnesium are the most abundant ions while in African waters, sodium and magnesium are often dominant (Delince, 1992). Furthermore, Weninger (1985) stated that the water in tropical humid areas are commonly dominated by calcium and bicarbonate ions and become alkaline.

**Common Fish Diseases in Fish Farms**

Viral, fungal, bacterial and parasitic diseases are all water-borne that can be carried from pond to pond either by the introduction of new fish or by the farmer and his equipment (Swift, 1993). Farmers in such conditions like the European, small-scale producers in restricted water areas are more vulnerable to diseases and encounter higher cost than larger growers (Halls, 1994). Furthermore, high fish densities suffered more risks of infections by parasites like fish lice, fungi (Saprolegnia species), intestinal worms (nematodes or trematodes), bacteria (Yersinia spp., Pseudomonas spp.), and protozoa (such as Dinoflagellates) (Attipoe & Agyakwah, 2008).

Most of these diseases are distributed worldwide. Example, Furunculosis affect both cold and warm water of many fish species worldwide (Faisal et al., 2013). Similarly, Bacterial gill disease also affect all ages of fish. Normally, such contagious diseases are highly fatal and very destructive in an endemic area (Swift, 1993). This has caused heavy losses in many infected fish farms. Some of the predisposing factors include the types and conditions of the fish species. Fry types or fingerlings are highly susceptible to viral diseases (Moeller, 2007).Normally, such diseases are not curable and very difficult to eradicate.

Similarly, fungal diseases (Saprolegniasis) cause a lot of irritation which eventually disturb the feeding habit of the infected fish. Consequently, the pond becomes loaded with uneaten feeds that may lead to pollution. The feeds load also increase the nutrient level of the ponds which indirectly affect the water quality through the encouragement of algal growth. Eventually, poisons develop from the algae; which also reduce the oxygen level in the pond water (Swift, 1993). Generally, large-scale intensive farming suffers severe problems with fish diseases.

However, vaccines have been used successfully against bacterial diseases. Some are administered by oral, injections, high pressure spray or by immersion. Recent technology allows fish to swim in vaccine solution for about 2 hours, and the protection last for about 5 to 7 months (Swift, 1993). Preventive measures include the avoidance of infected sources and quarantine stock before the introduction into the ponds (Aly, 2013).

**Record Keeping in Fish Farms**

Record keeping is the most important tool used to keep information about the fish farm. Some of this information include inventory of farm facilities such as ponds, tanks, pens, cages and others. Usually, records are divided into different schedules: personnel records, dates of project activities and records of other farm operations (SM, 2008). Behrendt (1994) also stated that farmers keep pond books which enable them to accurately predict the number of fish stocked in each pond. Without reliable farm records, not much progress can be made on the farm (Pillay, 1990).

Stamp (1978), stated that computers are used for planning, budgeting, keeping records and accounting at shrimp farming in the USA. Already, Jaffa (1994) discovered the use of computers in farm offices, in Scotland, for keeping track of large amount of information on a daily basis; which are automatically updated after every entry in order to examine the current performance of a farm. Technically, the system is built to suit farmers who have no experience in computer operation. Ingram (1994) further stated that, a cumulative record of normal situation at farm levels as well as water and stock analysis will strengthen a claim on a disaster relief.

**Fish Culture Systems Practice**

These are techniques used to culture fish in different types of enclosures: ponds, tanks and cages. As mentioned before, different farm practices are carried out using these enclosures. The importance is to enable the manipulation of the rearing environmental conditions. Pond culture is the most popular method of growing tilapia. Naturally, the fish are able to utilize available nutrients. On the other hand, the management of tilapia ponds ranges from extensive systems, which uses only organic or inorganic fertilizers; to intensive systems, using high protein feeds, with aeration and water exchange (Rakocy & McGinty, 1989).

Fry rearing is also done in tanks and troughs with much control over ambient conditions. Trout and other sport fish are often raised from eggs to fry or fingerlings, in long shallow concrete tanks, filled with fresh stream water as well as supplied with commercial fish food in pellets (Brown, 2006). However, cage culture is a system where cages are placed in open water resources to contain and protect fish until they can be harvested (Flimlin et al., 2008). Generally, many types of water can be used in cage system: rivers, lakes and filled quarries. A few advantages of fish farming with cages are that many types of waters can be used (rivers, lakes, filled quarries, etc.), many types of fish can be raised, and fish farming can co-exist with sport fishing and other water uses (Azevedo-Santos et al., 2011).

Normally, wooden cages of 8m square are stocked with Salmons from their original hatchery and remain in fresh water for about nine months (Mbugua, 2007). This is a condition where artificial feeds are given to the fish.. At the same time some farmers allowed their loch to lie fallow for two months between generations. Subsequently, the on growing is taken to sea cages, a system known as cage to cage culture (Torrissen et al., 2013). Similarly, the cage culture facility in Ghana has 8 cages, each with a diameter of 15m, and depth of 4m. Each cage is stocked with

50,000 fingerlings of O. niloticus at 30 grams which are cultured for six months. In addition, fingerlings of 10 grams in weight are stocked in cages for culture (Salm et al., 2011).

**Fish Culture Practices**

Normally, these are culture practices that accommodate single or special combination of fish species for a particular purpose. Examples are monoculture and polyculture, likewise, sexes are also considered as mono-sex or mixed-sex culture. In monoculture only one species of fish (catfish or trout) is reared in the pond. Purposively, this is used in expected high levels of production with a support of supplementary feeds. Specifically, there is a monoculture practice which involves two species of fish, commonly practised for the control of overpopulation of tilapia in ponds (Swift, 1993).

Similarly, in male mono-sex culture, all-male fingerlings are obtained by three methods: hybridization, sex-reversal and manual sexing. Only the single sexes are reared in tanks with high quality water (Rakocy & McGinty, 1989). The stocking rate for male mono-sex culture varies from 4,000 to 20,000 per acre while a stocking rate of 8,000 per acre is frequently used. Normally, a culture period of 200 days or more are needed to produce fish weighing close to 500 grams (Rakocy & McGinty, 1989). In mixed-sex culture, tilapias are usually stocked at low rates to reduce competition for food and promote rapid growth.

Fry of one month old (1 gram) are stocked at 2,000 to 6,000 per acre into grow-out ponds for 4 to 5 months culture period. Usually, supplemental feeds with

25 to 35 percent protein are given. At harvest, their average weight is approximately 220 grams or 0.5 pounds (Rakocy & McGinty, 1989). However, in polyculture practice several species of aquatic animals are stocked simultaneously to take advantage of the different food niches available in the pond environment (Wurts, 2001). Rakocy and McGinty (1989), further explained that polyculture is the type where tilapias are commonly cultured together with other species to utilize the available natural foods in ponds and as well as to control tilapia recruitment. This is a control that involves the use of predatory fish, such as largemouth bass (Micropterus salmoides).

Similarly, small sized predators are also stocked when tilapia begin their breeding season, because this would prevent the elimination of the original tilapia stock and the recommended predator/prey ratio is one largemouth bass to 15 tilapias (Rakocy & McGinty, 1989). Kapetsky et al (1991) reported that Snakeheads (Channidae) are used in polyculture as fish predators and as well considered as valuable food fish. Usually, younger snakeheads feed on plankton, aquatic insects and molluscs while the adults feed on bigger fish example, carps or frogs.

In rare cases, small mammals like rats are also preyed (Attipoe & Agyakwah, 2008). Similar combination in China and India usually involve carps with other species and, include at least one scavenging species that feeds on the faecal matter of other species. This is done in order to reduce wastes load in the ponds. Technically, this type of culture, improves the water quality through the creation of a better balance among the microbial communities in the pond (Martínez et al., 2012).

**Feeding in Fish Farming Systems**

Normally, feeding rates are affected by factors such as time of the day, season, water temperature, dissolved oxygen levels, and other water quality variables. Therefore it is not advisable to feed fish (grown in ponds) early in the morning when the dissolved oxygen level becomes very low. This is with exception to recirculating aquaculture systems where oxygen supply is continuous (Craig & Helfrich, 2002). The efficiency of the feeding rates by fish is monitored through the consideration of factors such as feed application rates, number of feeds per day and the duration of each feeding. The suggested approach for this is to relate diameter of the type of pellet to the appropriate fish size and estimate the average number of pellets to satisfy (satiation) the particular fish for its daily ration.

Automatically these calculations are used to examine effect of number of daily meals, the duration of each meal and the feed application rates. The outcome of this provide a guideline to be able to divide daily meals into different numbers of feedings (feeding frequency) at a given feeding rate; example, 1 kg fish at 1% body weight per day needs 31pellets per day (Talbot, 1994b). The feeding frequency is another factor which is highly dependent on labour availability, farm size, and the fish species and sizes of fish grown.

It is also believed that, growth and feed conversion increase with feeding frequency (Craig & Helfrich, 2002). Generally, such feeds are quality feeds with the required ingredients to become more acceptable, palatable and digestible.

However, a combination of such improved diets and low stocking densities will reduce the risk of water quality (Halls, 1994).

## Fertilizer Application in Fish Ponds

Sewage effluents and properly treated animal wastes are used as fertilizers to increase growth of food organisms in aquaculture farms (Pillay, 1990). Other types are artificial fertilizer mixtures, such as potash, phosphorus, nitrogen and micro-elements which are also use to fertilize ponds in order to increase their photosynthetic production. Normally, the type of phosphorus use at high level is liquid polyphosphate (13-38-0); which is applied at a rate of 20 pounds per acre (2.4 gallons/acre) (Rakocy & McGinty, 1989). It is also stated that organic fertilizers (manure) such as pig, chicken and duck wastes increase fish production more than cow and sheep manure (Rakocy & McGinty, 1989). The rates to apply such manure from chicken, cattle and pigs is 20,000 kg per hectare, to be placed on the bottom of the pond in small heaps in order to allow free oxygen circulation (Swift, 1993).

## Liming in Fish Ponds

Liming is a method use to neutralize low pH (acidity) as well as high calcium bicarbonate ($Ca(HCO_3)_2$). Examples of lime are: quicklime (calcium oxide, Cao), slaked lime or agricultural lime (Calcium hydroxide, $Ca(OH)_2$) and limestone (Calcium carbonate $CaCO_3$) (Pillay, 1990). Lime is added when the pH of the water is low, when the alkalinity is low, when the pond bottom is muddy, when the organic content of the pond is too high and when there is a threat of disease in the pond (Swift, 1993).

Liming is also used to activate the mud bottom and prevent the water becoming too acidic (Behrendt, 1994). The lime requirement for low pH is in the proportion of 1:1; while, 5:2 is recommended for high chemical content (Pillay, 1990). For example, for normal routine maintenance; calcium oxide is directly applied into the water at the rate of 200 kg /ha while 200 to 400 kg/ha is used on the pond floor (Swift, 1993). This application is increased to 1000 kg/ha (on pond bottom) for the eradication of fish parasites and 1000 kg/ha when combating conditions of low pH in the pond (Swift, 1993). Usually, drained ponds are treated with quicklime at 2,000 kg per hectare; before the bottom dries out (Behrendt, 1994).

### Weed Control Measures in Fish Farms

Weeds are of different types: succulent and, fibrous and woody. The succulent types include duck weed (Lemna sp., Spirodela sp., and Wolffia sp.), Azolla spp., pond weeds (Potamogeton spp.), Hydrilla verticillata, Najas spp., Chara spp., Myriophyllum sp. and Eleocharis spp. The fibrous and woody weeds are the water hyacinth (Eichhornia sp.), Pistia sp. and Sagittaria spp. (Cagauan, 1994). According to Behrendt (1994), in the United Kingdom, ―Canada weeds‖ (Elodea Canadensis) or ―water pest can choke pond, lake or river within a short period.

In this country, farmers control weeds through the use of large black polythene sheets place under the water surface. Eventually, the weeds are killed in about three to four weeks after which their roots are eliminated three months later (Behrendt, 1994). Similarly, in Sweden, a large wooden raft is used to smother under water weeds while the raft is constructed with closely-boarded; at the same time excluding light from the environment. Eventually, all weeds beneath it died off (Behrendt, 1994). It is recommended that selected weed killers are effectively used to control such weeds (Behrendt, 1994). Other methods include the drying of ponds together with the weeds. In addition, the most wasteful method is to cut them during the summer. Specially, bushes on the banks of the ponds are cut in order to discourage reed beds. Furthermore, the grass carps are also used as a control measure (Behrendt, 1994).

**Sustainability of Fish Farming**

Wurts (2000) suggested that it is more practical and efficient to recycle nutrient (converting nitrogen back to protein) through different polyculture systems than controlling or treating the effluents. Secondly, the culture of channel catfish with paddlefish and some species of freshwater mussels could be another option. Wurts (2001), noticed that on a dry weight bases, plankton can account for almost half of the standing biomass in a culture pond (900 to 1000 kg/ha).Technically, for sustainability in such a pond with plankton rich water, the kind of plankton harvest uses filter feeders which are placed in a series arrangement (Wurts, 2001).

In order to compartmentalize various sizes of particles, different planktivores are introduced in the order of largest planktons feeders first followed by smallest particle feeders. Secondly, in a systematic method, the pond water can be pumped repeatedly, from one enclosure into the next; through a series of floating or land-based chambers which remove the plankton sequentially. However, it is a strong believed that careful selection and segregation of filter feeders would recycle waste nutrients indirectly through the planktivores (Wurts, 2001).

The assurance of the availability of feeds through integrated livestock-cum-fish farming, is also contributing in sustainability because the animal manure fertilizes the ponds and encourages the growth of plankton that feed the fish (Pillay, 1992). In addition, most dyke crops, such as elephant grass are fed directly to the fish (grass carp) or else to the livestock (I-SIS, 2005). The bottom feeding activities of fish like the common carps (Cyprinus carpio) result to turbid condition which reduces the light penetration for the control of photosynthetic activity in water quality (Cagauan, 1994).

**Effluent Control and Waste Treatment in Fish Farms**

Normally, the cage culture systems, encounter low dissolved oxygen levels as well as the release of hydrogen sulphide and methane. In order to control these, the University of Stirling et al. (1990), reported that Atlantic salmon cage farms in Scotland undergo fallowing for periods ranging from 4 to 51 weeks; to allow the dilution of nutrient wastes and to recover the sediments. Although, many ways such as sand filtration, micro straining and air flotation had been tried for the treatment of effluents from fish ponds, but simple sedimentation has proved to be more cost-efficient in commercial farms (Pillay, 1992).

Subsequently, the accumulated detritus at the pond bottom are removed after harvest; for the preparation of the next cropping (Pillay, 1992). Boyd (1985) gave an example that, well-managed channel catfish ponds were found with no accumulation of nitrogen and organic matter in their sediments; due to the control over feed wastages.

## Capital for Tilapia Farming Operations

A commonly accepted fact is that aquaculture support always needs to be applied with great knowledge of local conditions so as to not have negative environmental and social consequences (Hishamunda & Ridler, 2006; Brummett & Williams, 2000; Coche, Haight & Vincke, 1994). If prevailing regional economic conditions, social systems, natural resource constraints and indigenous knowledge bases are not taken into account sufficiently, impacts of any support mechanism applied are likely to be negligible in the long-term.

In a case study in Bangladesh, Ahmed (2009) showed that fish production efficiency, and hence the chance of self-sustainability, were increased through extension services and farmer trainings: Both methods are relatively low-cost and can help reducing risks in fish farming as well as improve profitability. If self-sustainability cannot be achieved, investments evidently need to be made to ensure the continuous (and costly) availability of quality technical assistance to achieve long-term success of fish farming.

Amisah (2010) found in his study about small-scale fish farming that the way to financially help fish farmers is loan-availability. Loan may help fish farmers to recuperate from shocks, as well as a starting capital for fish farming business. Quagrainie, Ngugi and Amisah (2010) found in their study about small-scale fish farmers in Kenya that the level of credit use in fish farming is very low even though the GoK encourages aquaculture development by offering credit facilities through the government agricultural finance institution, Agriculture Finance Corporation.

**Systems of Farming used by Fish Farmers**

Basically, these are the farming systems that are practiced throughout the World. The five main types are intensive, semi-intensive, extensive, integrated and recycling but this piece of work will only dwell on the first three systems. In intensive fish farming systems, fresh water, sufficient oxygen and food are provided through integration of massive water purification system in the fish farm as well as the combination of hydroponic horticulture and water treatment. Normally, there is tight monitoring of water quality (oxygen, ammonia, nitrite, etc.) and a high level of expertise of the fish farmer (Avnimelech & Kochva, 1994).

Similarly, commercial fish farmers in Ghana undertake intensive fish farming practices and feed their fish with balanced diets which are locally prepared (Frimpong & Kalbersonn, 2014). Generally, fish are fed with higher level of protein (up to 60%) which is a consequence of the higher food conversion efficiency: FCR—kg of feed per kg of animal produced (of aquatic animals). For example salmons have FCR‘s in the 1.1 kg of feed per kg of salmon range.  Relatively, in indoor, intensive fish farming systems, fish may be fed as many as 5 times per day in order to maximize growth at optimum temperatures (Craig & Helfrich, 2002).

One of the intensive systems is known as recycle aquaculture systems (RAS) where control over all the production parameters are being used for high value species. The water is recycled such that very little quantity is used per unit of production (Helfrich & Libey, 1991). Economically, RAS is for high products: brood stock for eggs production, fingerlings for net pen aquaculture operations, sturgeon production, research animals and some special niche markets like live fish (Lane et al., 2014).

The other farming system is the integrated recycling system (IRS) where large plastic fish tanks are placed in a greenhouse while a hydroponic bed is placed closer, above or between them (Franco, 1991). The tank water is slowly circulated into the hydroponic beds where the tilapia waste feeds a commercial plant crops. At the same time, the tanks are properly fertilized in order to encourage algal growth which is feed upon by the raise fish (example tilapia). Automatically, cultured microorganisms in the hydroponic beds convert ammonia into nitrates while the plants are fertilized by the nitrates and phosphates (Diver, 2000).

On the other hand, wastes are strained out by the hydroponic media, which doubles as an aerated pebble-bed filter. This system is advantageous of adapting to almost all temperate climates and may also adapt to tropical climates, since it is based in a greenhouse (Enete et al., 2011). Usually, the discharged water is salted in order to maintain the fishes' electrolyte balance. Scientifically, some veterinary authorities suggested that, ultraviolet ozone disinfectant system (widely used for ornamental fish), may play a vital role in keeping tilapia healthy with recycled water (Brown, 2006).

**Semi-intensive Fish Farming Systems**

In Tanzania, semi-intensive fish farming is defined as a practice where feeds are given 2-3 times a week or even once a week while fertilizer is applied at least once per week. Normally, the feeds are supplements added to the available natural nutrients in the ponds. The feeds include maize, rice bran, vegetable leaves, kitchen wastes, local brew leftovers, and manure (cattle, goats and chicken) (Nilson & Wetengere, 1994).

Similar systems are irrigation ditches or farm ponds that have the potential to retain water, possibly with an above-ground irrigation system while others use buried pipes with headers. In the smaller systems fish are often fed with commercial fish food, and their wastes products are used to fertilize the fields. Naturally, grown water plants and algae are use as fish food in larger ponds whereby water quality is closely monitored (Abdel-Raouf et al., 2012).

**Extensive fish farming systems**

In this system, food is supplied by natural sources: zooplankton feeding on pelagic algae or benthic animals. Biologically, almost all available food sources in the pond are tap by fish species which occupy different places in the pond ecosystem: tilapia (filter algae feeder), carp or catfish (benthic feeder), various carps (zooplankton feeder) and grass carp as submerged weeds feeder (Holomuzki, 2010). Ranching is a similar type practice in Asia, USA and Scandinavia. These are areas where young salmon are released into the river to return to the sea to complete their growth phase. This is a system where the fish are reared on the farm to a certain age and are then released without control or additional food (supplement) into large bodies of natural water, lakes and oceans, where they complete their life cycle and grow to maturity (Swift, 1993).

**Challenges faced by Tilapia Farmers**

Constraints of fish farming are considered as any factor or subsystem that works as a bottleneck to restrict the fish farmers from achieving their potentials (BD, 2010). Initially, some of the constraints were poor site selection, bad pond designing and construction, inefficient pond management, shortages of fingerlings, lack of fertilizers, feeds, lack of harvesting strategies, marketing and processing (Prein & Ofori, 1996). Owusu et al. (1999) highlighted the major constraints of Ghanaian fish farmers as: Inadequate extension service, lack of fish seeds, inadequate manufactured feeds, lack of capital for expansion and lack of biotechnical information.

Furthermore, according to findings by Vincke & Awity (1990), the constraints faced by Ghanaian fish farmers include lack of credit for pond construction, lack of technical information, high cost of equipment, lack of fingerlings of Clarias gariepinus and Heterobranchus bidosalis, poaching by villagers and lack of nets for harvesting.(Adedokun, 2006). As regard to the pond harvesting, farmers faced additional costs on hiring beach seine nets and those who use machines (bulldozer) for pond construction pay at a daily rate of 30,000 cedis per day (Ansah & Frimpong, 2015). Ansah and Frimpong (2015) also reported that majority of fish farmers depend on the water seepages to fill their ponds which become a challenge for the drying of these ponds.

On the contrary, few farmers have ponds that do not hold water due to serious seepages. Furthermore, in certain areas of Ghana; during the rainy season, the ponds and rice fields are sometimes flooded for periods of 2 to 3 days and even up to about a month (Kapetsky et al., 1991). Other challenges are that tilapia fish seeds are often obtained from less desirable sources such as fish production ponds of other farmers that have not been drained for several years and other common sources are reservoirs and rivers (Mensah et al., 2003).

Normally, these fingerlings are of very poor quality because most of them are stunted due to their long stay in the ponds while chosen as seeds for culture. Biologically, fish caught as fingerlings from rivers and reservoirs are either mature or of poor genetic quality and health or are undesirable species (USDA, 2009). It is also reported that the flow of information between some of the farmers and the researchers becomes difficult because these farmers cannot remember the stocking densities, feeding rates and the days of certain operations on the farm (FAO, 1990a)

# CHAPTER THREE

# RESEARCH METHODS

## Introduction

The purpose of the study was to examine the operations of Tilapia farmers in Asuogyaman District of Ghana. This chapter looks at the variables for the study and methods used to collect and analyze the data. It explains the research design, the study area, population, sampling and sample size. The chapter also describes the fieldwork process and statistical tools adopted for analyzing the data.

## Study Area

The study focused on Small-Scale Tilapia Farmers in the Asuogyaman District of Ghana and the various activities and their roles in tilapia production were reviewed. The Asuogyaman District Assembly is one of the twenty-one (21) districts in the Eastern Region of Ghana. It covers a total estimated surface area of 1,507 square kilometers and constitutes 5.7% of the total area of Eastern Region and making the 10th largest district in the Region with its capital at Atimpoku. The Asuogyaman District Assembly is one of the fifteen districts in the Eastern Region, located approximately between latitudes 6º 34º N and 6º 10º N and longitudes 0º 1º W and 0º14E. It is about 120m above Mean Sea Level (MSL).

Asuogyaman is a traditional district situated between the Volta and Eastern Regions and they share borders to the east with Kpando, South Dayi, Ho Municipal and the North Tongu Districts of the Volta Region. The study area was chosen due to the concentration of fishing and fish farming communities along the Volta Lake. Fishing in the Volta Lake constitutes an important segment of agriculture in some communities along the 141km shoreline, including parts of the Kpong headwaters.

These communities include Dzidzokope, Atimpoku, Abume, Akosombo, Surveyline, Adomi and Dodi Asantekrom. The following fish types are very important and preferred in the fishery due to their occurrence in large commercial quantity in the Volta Lake: Tilapia, Chryrtrissa (One Mouth thousand), Synodontis (Gear Box), Bagrus. About 1000 tons of fish are produced in the District annually and marketed in various forms: fresh, smoked, fried, and dried

**Research Design**

The research design that will be used is the descriptive survey. Ekure (1997) posits that descriptive survey involves collection of data in order to accurately and objectively describe existing phenomenon. He further describes the design as the one which is directed towards determining the nature of a situation as it exists at the time of investigation. The rationale for the use of the descriptive study design is to accurately and objectively describe the operation and challenges of Tilapia Farming in the Asuogyaman District. According to Best and Khan, (1999) this design strives for an in depth knowledge of the existing phenomena and allows for generalisation based on accurate description of activities and it also appropriate for describing conditions and attitudes.

However, the design is not without flaws. It is often characterized by difficulty in ensuring that questions to be answered or statements to be responded to are clear and not misleading (Frankel & Wallen, 2000). They further espoused that the design may produce unworthy results because the researcher may be tempted to delve into the private matters that people may not be completely truthful about. Nonetheless, the design is considered appropriate for description and documentation of the phenomena under investigation. Financing of production and marketing of produce is a modern societal issue of concern for producers, government and NGO's alike and this makes descriptive research approach ideal for the study.

**Population of the Study**

The target population for the study comprised all the Tilapia Farmers in the Asuogyaman District in the Eastern Region of Ghana. The study population was all the Small – Scale Tilapia Farmers in the District which according to the database of the Tilapia Farmers Association of the District is made up of a total of 85 farmers as at March 2015. This area is selected because of the numerous and dominance of small scale tilapia businesses in the area as compared to any other parts of the country. It gives the researcher a cost sensitivity and availability of information.

**Sample and Sampling Procedures**

Simple random sampling was used for the selection of sampled respondents from the farms. The sample frame of the study consisted of all the 85 farmers.

According to Krejcie and Morgan (1970), for a population of 85, the suggested minimum number that should be used as sample size could be 60.

## Sources of Data

Both primary and secondary data were utilized for the study. Data on tilapia fish farming, types of tilapia, aquaculture, fisheries and food supply, aquaculture in Africa, fish farming in Ghana, stakeholders and aquaculture potential in Ghana, human resource for aquaculture in Ghana, aquaculture extension service in Ghana, national aquaculture policy for fish farming in Ghana. The instrument that was used to collect the primary data for the study was a set of questionnaires.

## Data Collection Instruments

The questionnaire was the sole data collection instrument used in collecting the data. A questionnaire is an instrument with predetermined items to be answered by the respondents by writing. A questionnaire is administered to respondents that can read and understand the individual items in the instrument. It has a high respond rate, easy to administer, create opportunity to observe non-verbal behaviour and also has the capacity for correcting misunderstanding by respondents when administered personally (Ary, Jacobs, Razavieh & Sorensen, 2006).

However it is more time consuming, inconvenient and less effective than other methods when sensitive issues are needed. This instrument is believed to help the researcher in collecting reliable and reasonable data within a relatively simple and cheap short space of time. First and of all, the researcher met the Association

Executives to brief them on the reason for the research and tasked the Executives to gather the members of the Association for a meetig to speak about the research, seek their consent and establish rapport with them. The questionnaires were then given to the Association President for on-ward distribution to the farmers.

**Data Processing and Analysis**

The data collected was edited, cleaned and processed using the Statistical Product for Service Solutions (SPSS, Version 17) which is extensive and comprehensive software to aid in analysis. More so, primary data from questionnaires from the field work and respondents was listed and assigned codes before analyzing them for the report. The questionnaires were numbered and sorted first before performing quality control checks on the data. This involved looking at the sheets for the completeness and consistency. The data was further analyzed using simple frequency tables and percentages.

**Ethical Issues**

This study is for academic purposes and therefore demands quality in the processes as in commissioned or contract research. As such, introductory letters were shown to respondents about the importance of the research being conducted. Informed consent, and voluntary participation was sought and all respondents were assured of confidentiality.

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## Introduction

This chapter presents information on the analysis and discussion of the results of the survey and is divided into two sections. The first section touches on the socio-economic background of the respondents. The issues considered include: sex, age, marital status, educational status, ethnicity, income at the end of production, number of years in the Tilapia farming, and the medium through which they entered into Tilapia farming. The second section tackles the issues that were presented as objectives such as; source of Tilapia feed/fingerlings for the Tilapia farmers, source of capital for Tilapia farming operations, the system of farming used by the Tilapia farmers and some challenges faced by the Tilapia farmers.

## Characteristics of the Respondents

It was necessary to consider the socio-economic characteristics of the respondents in the study. The socio-economic characteristics helped in ascertaining the type of farmers who were involved in the day-to-day activities of the Tilapia farmers. The socio-economic characteristics of the respondents focused on the sex, age, marital status, educational status, ethnicity, income at the end of production, number of years in the Tilapia farming, and the medium through which they entered into Tilapia farming.

### Gender Distribution of Respondents

According to the study, all (100%) the farmers that responded to the issues presented in the questionnaire were males. The overall picture indicates that males are mostly involved in Tilapia farming in the Asuogyman District.

### Age Distribution of Respondents

Another socio-economic characteristic of the respondents that was examined by this study was the age distribution of respondents. The survey indicated that the maximum age of the respondents was 49 years and the minimum age was 24 years. The average age of the respondents was 37 years. That is, most of the respondents were aged around 37 years. This shows that, the Tilapia farmers in the Asuogyaman District were fairly young with the appropriate energy to rear the Tilapia fish to meet the demand of their target market.

### Marital Status of Respondents

The next socio-economic characteristic that was considered under this survey was the marital status of the respondents. The survey revealed that majority (51.7%) of the respondents were married, 36.7 percent of the total respondents indicated that they were single, 10.0 percent of the total respondents also said they have divorced their wives and the rest (1.7%) of the total respondents also indicated they were widowed. The broader picture that this study presents is that more than half of the Tilapia farmers in the District are married.

**Table 1: Marital Status of Respondents**

| Status | Frequency | Percent |
|---|---|---|
| Married | 31 | 51.7 |
| Single | 22 | 36.7 |
| Divorced | 6 | 10.0 |
| Widowed | 1 | 1.7 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**Educational Status of Respondents**

The forth socio-economic characteristic that was examined under this survey was the educational status of respondents. The study revealed that majority (81.7%) of the total respondents had Senior High School certificate, 10.0 percent of the total respondents alluded to the fact that they have been to school to the primary level, and the rest (8.3%) of the total respondents also indicated that their educational status was Junior High School. None of the respondents indicated that they do not have formal education. The overall picture, therefore, is that all the farmers have had at least basic education which happens to be the basic requirement for education in Ghana. The result is shown in table 2 below;

**Table 2: Educational Status of Respondents**

| Status | Frequency | Percent |
|---|---|---|
| Non Formal Education | 0 | 0.0 |
| Primary | 6 | 10.0 |
| JHS/Middle School | 5 | 8.3 |
| SHS | 49 | 81.7 |
| Degree | 0 | 0.0 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**Ethnic Background of the Respondents**

Ethnicity of the respondents was another socio-economic characteristic that was examined under this survey. The study revealed that most (38.3%) of the respondents indicated that they were Ewes, 28.3 percent of the total respondents made it known that they were Akans, 18.3 percent of the total respondents also indicated that they were Guans, 11.7 percent also of the total respondents alluded that they were Akweapems and the rest (3.3%) said they were Fante. The result, therefore, shows that most of the Tilapia farmers in the Asuogyaman District are Ewes. The result is presented in Table 3 below.

**Table 3: Ethnic background of respondents**

| Ethnicity | Frequency | Percent |
|---|---|---|
| Ewe | 23 | 38.3 |
| Akan | 17 | 28.3 |
| Akweapem | 7 | 11.7 |
| Fante | 2 | 3.3 |
| Guan | 11 | 18.3 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**Income Earned by Respondents at the End of Production**

The income earned at the end of each production period by the respondents was another socio-economic characteristic that was also examined under this survey. The study revealed that majority of the total respondents earned between GHs 1,001.00 and 2,000.00 at the end of each farming period, 20.0 percent of the total respondents earned between GHs 2,001.00 and 3,000.00 at the end of each farming period, 3.7 percent also of the total respondents said they earned between GHs 3,001.00 and 4,000.00 and the rest mentioned that they earned less than GHs 1,000.00 at the end of each farming period. The result is shown in Table 4 below.

**Table 4: Income Earned by Respondents**

| Income | Frequency | Percent |
|---|---|---|
| Less than GHs 1000.00 | 1 | 1.7 |
| Between GHs 1,001.00 and 2,000.00 | 45 | 75.0 |
| Between GHs 2,001.00 and 3,000.00 | 12 | 20.0 |
| Between GHs 3,001.00 and 4,000.00 | 2 | 3.4 |
| GHs 4,001.00 and more | 0 | 0.0 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**Number of Years of Farming by Respondents**

The years of farming of the respondents were yet another socio-economic characteristic that was considered under this survey. The result of the survey showed that majority (53.3%) of the total respondents said they have been in the farming of Tilapia in the Asuogyaman District for more than 10 years, 36.7 percent of the total respondents also indicated that they have been in the farming of Tilapia between 5 and 10 years and the least (10.0%) of the total respondents also indicated that they have been in the Tilapia farming business for less than 5 years. The result is presented in Table 5 below.

**Table 5: Number of years of farming by respondents**

| Years | Frequency | Percent |
|---|---|---|
| More than 10 years ago | 32 | 53.3 |
| Between 5 and 10 years | 22 | 36.7 |
| Less than 5 years ago | 6 | 10.0 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**Entry Route into Tilapia Farming**

The last but not least socio-economic characteristic that was examined as far as this survey is the medium through which the Tilapia farmers in the Asuogyaman District entered into the Tilapia farming business. The result revealed that majority (80.0%) of the total respondents indicated that they were introduced into the Tilapia farming business in the Asuogyaman District by their friends and the rest (20.0%) of the total respondents also alluded that they were introduced to the Tilapia farming business by their relatives. The result is presented in Table 6.

**Table 6: Entry Route into Tilapia Farming**

| Medium | Frequency | Percent |
|---|---|---|
| Friend | 48 | 80.0 |
| Relative | 12 | 20.0 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**The Source of Tilapia Seed/Fingerlings for Tilapia Farmers**

Objective one of the study sought to know the source of Tilapia seed/fingerlings for the Tilapia farmers in the Asuogyaman District. When the farmers were asked to indicate whether or not they have any knowledge about the Tilapia seed/fingerlings majority (91.7%) of the said they have knowledge about Tilapia seed/fingerlings and the rest (8.3%) also gave their response in the negative, that they have no knowledge about the Tilapia seed/fingerlings. They were again asked in a follow up question to indicate how they acquired the knowledge. Majority (96.7%) of the total respondents indicated that they acquired their knowledge of Tilapia seed/fingerlings from their fellow farmers and the rest (1.7%) of the total respondents indicated that they had acquired their knowledge on Tilapia seed/fingerlings from the Agricultural Extension Officers and the Fisheries Directorate respectively.

**Table 7: Source of Tilapia Seed/Fingerlings Knowledge Acquisition**

| Source of Acquisition | Frequency | Percent |
|---|---|---|
| Fellow Farmers | 58 | 96.7 |
| Agricultural Extension Officers | 1 | 1.7 |
| Fisheries Directorate | 1 | 1.7 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

When the respondents were again asked to present information on how they get the Tilapia seed/fingerlings, majority (61.7%) of the total respondents indicated that their source of the Tilapia seed/fingerlings was the pond source, 31.7 percent of the total respondents also indicated that their source of the Tilapia seed/ fingerlings was from their fellow farmers and the rest (3.3%) of the total respondents alluded that their source of the Tilapia seed/fingerlings was the Fisheries Directorate and the Hatchery Operators respectively. The overall picture present here is that more than half of the respondents have pond as their source of Tilapia seed/fingerlings. This result is, however, consistent with Swift assertion that the best known fish that spawn easily in a pond are tilapias. Carp form an example half-way between the tilapia and the trout, because they spawn in a farm pond and the eggs and fry can be reared in the pond (Swift, 1993).

**Table 8: Sources of Tilapia Seed/Fingerlings**

| Sources | Frequency | Percent |
|---|---|---|
| Fisheries Directorate | 2 | 3.3 |
| Pond Source | 37 | 61.7 |
| Fellow Farmers | 19 | 31.7 |
| Hatchery Operators | 2 | 3.3 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

**The Source of Capital for Tilapia Farming Operation**

The second objective of the study was to examine the source of capital for Tilapia farming operation in the Asuogyaman District. The respondents were asked to indicate whether or not they were aware of any government policy regarding assistance in rising capital for Tilapia farmers. Majority (97.3%) of the total respondents gave their response in the negative direction that they are not aware of any government policy regarding assistance in rising capital for Tilapia farmers and the rest (2.7%) indicated that they were aware of government policy regarding assistance in rising capital for Tilapia farmers.

Again in a follow up question to ascertain whether or not they have received any of the assistance, all the (100.0%) indicated that they have not received any of the assistance given by government to assist Tilapia farmers to raise capital for Tilapia farming. This is however inconsistent with Quagrainie, Ngugi and Amisah finding in their study about small-scale fish farmers in Kenya that the Government of Kenya encourages aquaculture development by offering credit facilities through the government agricultural finance institution, Agriculture Finance Corporation. (Quagrainie, Ngugi & Amisah, 2010).

Furthermore, the respondents were asked to indicate their source of capital for starting the Tilapia farming business. Majority (51.7%) indicated that their source of capital for starting the tilapia farming business was their personal funds, 36.7 percent of the total respondents indicated that the source of the capital they used to start the Tilapia farming was from credit/loan, 8.3 percent of the total respondents also indicated that the of their capital to commence the Tilapia farming was from their family and the rest (3.3%) of indicated that the source of their capital for commencing the Tilapia farming business was from their friends.

This finding is however consistent with Quagrainie, Ngugi and Amisah (2010) findings in their study about small-scale fish farmers in Kenya that the level of credit use in fish farming is very low and inconsistent with Amisah (2010), finding in his study about small-scale fish farming that the way to financially help fish farmers is loan-availability. This is presented in Table 9.

**Table 9: Respondents' Source of Capital for Starting the Tilapia Farming**

| Source of capital | Frequency | Percent |
|---|---|---|
| Self-financed | 31 | 51.7 |
| Family Source | 5 | 8.3 |
| Credit/Loan Source | 22 | 36.7 |
| Friend Source | 2 | 3.3 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

Moreover, the respondents who indicated that their source of capital for starting the Tilapia farming business was through the acquisition of credit/loan were asked to indicate the financial institution from which they acquired the credit/loan. Majority (68.2%) of the total respondents indicated that they received the credit/loan for the commence of their Tilapia farming business from the Agricultural Financial Institution, 22.7 percent of the total respondents also indicated that they received their credit/loan for the commencement of their Tilapia farming business was from the Government Financial Institution and the rest (9.1%) of the total respondents said they got their credit/loan for the commencement of their Tilapia farming business from the Microfinance Institutions.

From the result present in Table 10, the respondents did not receive any of their credit/loan from any of the Private Financial Institution and the Cooperative Society. This result is however, consistent with Quagrainie, Ngugi and Amisah finding in their study about small-scale fish farmers in Kenya that the GoK encourages aquaculture development by offering credit facilities through the government agricultural finance institution, Agriculture Finance Corporation. (Quagrainie, Ngugi & Amisah, 2010).

**Table 10: Financial institutions that respondents acquired credit/loan**

| Financial Institution | Frequency | Percent |
|---|---|---|
| Private Financial Institution | 0 | 0.0 |
| Government Financial Institution | 5 | 22.7 |
| Agricultural Finance Cooperation | 15 | 68.2 |
| Cooperative Society | 0 | 0.0 |
| Microfinance Institution | 2 | 9.1 |
| Total | 22 | 100.0 |

Source: Field survey, Akuffo (2014)

**The System of Farming used by the Tilapia Farmers**

The third objective of this study sought to delve into the system of farming used by the Tilapia farmers in the Asuogyaman District. The respondents were asked to indicate whether or not they were aware of any kind of farming system used in Tilapia farming. Majority (95.7%) gave their response in the positive direction which indicated that they were aware of the any of the kinds of the systems of farming used in the Tilapia farming business and the rest (4.3%) of the total respondents also indicated that they were not aware of any king of farming system used in Tilapia farming.

In a follow up question still on the system of farming, the respondents were asked to indicate the type of farming system they use in their Tilapia farming business and the Asuogyaman District. Majority (91.7%) of the total respondents indicated that they use the Intensive fish farming system in their operations in the District, 6.7 percent of the respondents also indicated that they use the Extensive fish farming system in their operations and the (1.7%) of the total respondents also said they use the Semi-intensive fish farming system in their operations in the Asuogyaman District.

The overall picture that the result presents is that almost all the farmers in the Asuogyaman District use the Intensive system of fish farming in their operations and this finding is consistent with finding of FAO (2000) that commercial fish farmers in Ghana undertake intensive fish farming practices and feed their fish with balanced diets which are locally prepared.

**Table 11: Farming System Used by Respondents**

| Farming System | Frequency | Percent |
|---|---|---|
| Extensive fish farming system | 4 | 6.7 |
| Semi-intensive fish farming system | 1 | 1.7 |
| Intensive fish farming system | 55 | 91.7 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

Again, the respondents were asked to indicate why they prefer the system of fish farming they use. Majority (73.3%) of the total respondents indicated that they prefer the Intensive system of fish farming because it has sufficient oxygen, 20.0 percent of the total respondents also alluded that they prefer the Intensive system of fish farming because it maintains fresh water for the Tilapia, 3.3 percent of the total respondents also said they prefer the Intensive system of fish farming because it is reliable and good respectively. This finding makes it clear that more than half of the respondents use the Intensive system of fish farming.

This is, however, consistent with the information sourced from Wikipedia, that in intensive fish farming systems, fresh water, sufficient oxygen and food are provided through integration of massive water purification system in the fish farm as well as the combination of hydroponic horticulture and water treatment. Normally, there is tight monitoring of water quality (oxygen, ammonia, nitrite, etc.) and a high level of expertise of the fish farmer (Ansah & Frimpong, 2015). This is presented in Table 12.

**Table 12: Reason for the Choice of Farming by Respondents**

| Reason | Frequency | Percent |
|---|---|---|
| It has sufficient oxygen | 44 | 73.3 |
| It is reliable | 2 | 3.3 |
| It is good | 2 | 3.3 |
| It maintains fresh water | 12 | 20.0 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

## Challenges Faced by Tilapia Farmers

Based on the stated objectives, the final issue that was of much interest to the researcher was the challenges faced by Tilapia farmers in the Asuogyaman District of the Eastern Region of Ghana. The respondents were asked to mention some of the challenges they face in the Tilapia farming business. Majority (81.7%) of the total respondents indicated inadequate capital as the challenge they face in the Tilapia farming business in the District.

8.3 percent of the total respondents also said shortage of fingerlings is the challenge they face in their operation as Tilapia farmers, 6.7 percent also indicated their challenge as Tilapia farmers to be lack of education by the Agricultural Extension Officers, and the rest (3.3%) of the respondents indicated that high cost of equipment is the challenge they face in their operation as Tilapia farmers in the District.

This finding is consistent with the work of Vincke and Awity who selected 24 farms where a research was conducted on Description and Assessment of Fish Farms in Ghana. In the findings, the constraints were: lack of credit for pond construction, lack of technical information, high cost of equipment, lack of fingerlings of Clarias gariepinus and Heterobranchus bidosalis, poaching by villagers and lack of nets for harvesting (FAO, 1990a). This is presented in the Table 13.

**Table 13: Challenges Faced by Respondents**

| Challenge | Frequency | Percent |
|---|---|---|
| Inadequate capital | 49 | 81.7 |
| High cost of equipment | 2 | 3.3 |
| Lack of education by Extension Officers | 4 | 6.7 |
| Shortage of fingerlings | 5 | 8.3 |
| Total | 60 | 100.0 |

Source: Field survey, Akuffo (2014)

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Introduction

This chapter presents the summary as well as the conclusions drawn from the results. It also makes recommendations based on the findings of the research.

## Summary of Findings

The study sought to examine the training the operation of Tilapia farmers in the Asuoygaman District in the Eastern Region of Ghana. The design for this study was descriptive survey to examine the operation of Tilapia farmers. To achieve these objectives, the probability sampling procedures was used in this study. The census method of the simple was used to select the farmers who were the respondents for the study. A sample of 60 was drawn from a population of 85 farmers. The main instrument for the study was the questionnaire. The analysis of the data was primarily done using the SPSS (Version 17.0) software. The results were presented in frequency tables.

The following are the findings from the study based on the objectives of the study: On the issue of the gender distribution of the respondents, majority (100.0%) of the Tilapia farmers in the Asuoygaman District in general were males. The second socio-economic characteristic of the respondents was their age distribution. The survey revealed that the maximum age of the respondents was 49 years and the minimum age was 24 years. The average age of the respondents was 37 years. That is, most of the respondents were aged around 37 years.

With regards to the marital status of the respondents as the third socio-economic characteristic, the survey revealed that the majority of the respondents were married, a sizable number of the total respondents indicated that they were single, some were divorced, and quite an insignificant number of them indicated that they were widowed.

The forth socio-economic characteristic of the respondents was their educational status. The study revealed that most of the total respondents had Senior High School certificate, some alluded to the fact that they have been to school to the primary level, and the rest also indicated that their educational status was Junior High School. With respect to the ethnicity of the respondents, the study revealed that the numbers were at par between Ewes and Akans, whiles the Guans and Akweapems were not that many and the rest being Fantes.

Again, regarding the income earned at the end of each production period by the Tilapia farmers as part of the socio-economic, the study revealed that most of the total respondents earned between GHS1,001.00 and GHS2,000.00 at the end of each farming period, a good number of them earned between GHs 2,001.00 and 3,000.00 at the end of each farming period, and very few earned above GHs 3,001.00 at the end of each farming period.

Another socio-economic characteristic that was ascertained under this survey was the numbers of years of respondents in the Tilapia farming business.

The result of the survey revealed that most of the farmers have been in the farming of Tilapia in the Asuogyaman District for more than 10 years, with the average number of years been five years and a few under five years. The results also revealed that most of these farmers were introduced into the Tilapia farming business in the Asuogyaman District by their friends and others by their relatives.

The first issue of interest as presented in the objectives of this study was the source of Tilapia seed/fingerlings for the Tilapia farmers in the Asuogyaman District. The survey revealed that majority of the farmers said they have knowledge about Tilapia seed/fingerlings and the rest also gave their response in the negative, that they have no knowledge about the Tilapia seed/fingerlings. On the issue of the respondents indicating how they acquired the knowledge, a very significant proportion of the respondents indicated that they acquired their knowledge of Tilapia seed/fingerlings from their fellow farmers and the rest. A limited number of them indicated that they had acquired their knowledge on Tilapia seed/fingerlings from the Agricultural Extension Officers and the Fisheries Directorate respectively.

The study also discovered that about half of the farmers acquired their fingerlings from pond source while others indicated that their source of fingerlings was from their fellow farmers. There were others who alluded that their source of the Tilapia seed/fingerlings was the Fisheries Directorate and the Hatchery Operators respectively.

The second objective sought to delve into the source of capital for the Tilapia farmers. On the issue of the respondents awareness of government policy to give assistance, majority of the total respondents gave their response in the negative direction that they are not aware of any government policy regarding assistance in rising capital for Tilapia farmers and the rest indicated that they were aware of government policy regarding assistance in rising capital for Tilapia farmers.

The survey again revealed that, all the respondents who indicated that they were of the government policy said they have not received any of the assistance given by government to assist Tilapia farmers to raise capital for Tilapia farming. Furthermore, majority indicated that their source of capital for starting the tilapia farming business was their personal funds, 36.7 percent of the total respondents indicated that the source of the capital they used to start the Tilapia farming was from credit/loan, while the others also indicated that the of their capital to commence the Tilapia farming was from their family or friends.

Again, majority of the total respondents indicated that they received the credit/loan for the commence of their Tilapia farming business from the Agricultural Financial Institution, 22.7 percent indicated that they received their credit/loan for the commencement of their Tilapia farming business was from the Government Financial Institution and the rest of the total respondents said they got their credit/loan for the commencement of their Tilapia farming business from the Microfinance Institutions.

On the issue of the system of farming which has to do with the third objective under this survey. Majority gave their response in the positive direction which indicated that they were aware of the any of the kinds of the systems of farming used in the Tilapia farming business and the rest of the total respondents also indicated that they were not aware of any king of farming system used in Tilapia farming.

To mention the specific farming system used by the respondents, almost all the respondents indicated that they use the Intensive fish farming system in their operations, with a minimal number of them using the Extensive fish farming system and Semi-intensive fish farming system in their operations in the Asuogyaman District. In addition, many of the total respondents indicated that they prefer the Intensive system of fish farming because it has sufficient oxygen and others believed the Intensive system of fish farming maintains fresh water for the Tilapia and because it is reliable.

On the final issue raised in the objectives which as to do with the challenges faced by the farmers, almost all the farmers indicated inadequate capital as the challenge they face in the Tilapia farming business in the District, with a few of them indicating that the shortage of fingerlings is the challenge they face in their operation as Tilapia farmers. Others stated that their challenge as Tilapia farmers was the lack of education by the Agricultural Extension Officers the high cost of equipment is the challenge they face in their operation as Tilapia farmers in the District.

## Conclusion

The conclusions of this study were drawn on the basis of the stated objectives of the study and the strength of the findings from the study. From the findings of the study, the source of seed/fingerlings for the Tilapia farmers in the Asuogyaman District was from fellow farmers who also claimed to have acquired their knowledge of Tilapia seed/fingerlings from their fellow farmers.Therefore one may conclude that, the Tilapia farmers in the Asuoygaman District have enough knowledge regarding their operation and their source for the seed/fingerlings is largely acquired from the ponds in the farms.

More so, with respect to the source of capital for starting the Tilapia farming business in the Asuogyaman District, majority of the farmers use their own capital for starting the tilapia farming business. Once again, the study revealed that most of the farmers rely on Intensive fish farming system in their operations in the District. Therefore, one may conclude that almost all the Tilapia farmers in the Asuoygaman District make good use of the Intensive fish farming system since it has sufficient oxygen that is mostly needed by the Tilapia to grow very well because majority of the total respondents indicated that they prefer the Intensive system of fish farming because it has sufficient oxygen.

Finally the result revealed that the Tilapia farmers in the Asuoygaman District identified a number of challenges they face in their operation. These challenges include; Shortage of fingerlings, High cost of equipment, Lack of education by Extension Officers and Inadequate capital. But out of all thses challenges faced by the farmers, majority of the total respondents indicated inadequate capital as the challenge they face in the Tilapia farming business in the District. One can, therefore, conclude that the major challenge faced by Tilapia farmers in the District is the issue of raising capital to start and remain in the business.

**Recommendations**

Based on the findings and conclusions, the following recommendations are suggested for action.

1. The Tilapia farmers in the District are vigorously pursuing self-production of seed/fingerlings by their fellow farmers. However, there is need to increase the source of acquiring the seed/fingerlings, therefore, the stakeholders involved should on regular basis ensure sustenance and further investment into the production of the seed/fingerlings can never be overemphasized.

2. The Fisheries Directorate through the Agricultural Extension Officers should involve themselves in the day-to-day activities of the Tilapia farmers in the District so that they will ensure rapid assistance to address the challenges they are facing as Tilapia farmers in the District.

3. Additionally, there is the need for Fisheries Directorate and the Association to introduce some kind scheme to address their financial challenges or form a cooperative society that the farmers will have to contribute some amount of money into and provide them with loan at a minimal interest rate or better

still interest free so that the famers will be encouraged to remain in operation.

4. Finally, Fisheries Directorate through the Agricultural Extension Officers should put measures in place to give farmers the opportunity to be trained and represent fairly at the various training and development programmes and avoid being selective in the selection of farmers that attend training and development programmes.

## REFERENCES

Abdel-Raouf, N., Al-Homaidan, A. A., & Ibraheem, I. B. M. (2012). Microalgae and wastewater treatment. *Saudi Journal of Biological Sciences*, *19*(3), 257-275.

Adedokun, O. A., Adereti, F. O., & Opele, A. I. (2006). Factors influencing the adoption of fisheries innovations by artisanal fishermen in coastal areas of Ogun State. Nigerian *Journal of Applied Science Research*, *2*(11), 966-971.

Adeyemo, O. K., Olaniyan, A. O., Ishola, O. O., & Adedeji, O. B. Seasonal water parameters of active and resting nursery ponds on Wildlife and Fisheries Management Department's farm University of Ibadan. *Nigerian Veterinary Journal*, *23*(1), 22-26.

Ahmed, N. (2009). The Sustainable Livelihoods Approach to the Development of Fish Farming in Rural Bangladesh. *Journal of International Farm Management*, *4* (4), 1-18.

Akpaglo, P. K. (2013). The Potential Of heterotis Niloticus (African Bony-Tongue) as Aquaculture Candidate in Ghana (Doctoral dissertation).

Alal, M. (2012). Fish Landing Sites to Improve Fish Production in Kenya. Retrieved from http://www.africanews.com/site/list_message/44179

ALCOM (1994). Aquaculture into the 21st Century in Southern Africa: Report prepared by the Working Group on the Future of ALCOM. ALCOM Report No. 15. Harare, Zimbabwe

Alhassan, E. H., Ofori-Danson, P. K., & Nunoo, F. K. E. (2015). Fish Abundance and Diversity During the Pre-and Post-Impoundment Periods of the Black Volta at Bui, Ghana.

Aly, S. M. (2013). *A review of fish diseases in the Egyptian aquaculture sector*: Working report.

Anane-Taabeah, G. (2012). Harnessing the opportunities and overcoming constraints to widespread adoption of cage aquaculture in Ghana.

Ansah, Y. B., & Frimpong, E. A. (2015). Impact of the adoption of BMPs on social welfare: A case study of commercial floating feeds for pond culture of tilapia in Ghana. *Cogent Food & Agriculture*, *1*(1), 1048579.

Ary, D., Jacobs, L. C., Razavieh, A., & Sorensen, C. (2006). *Introduction to research in education* (7th ed.). US: Thompson/Wadsworth.

Ashitey, E., & Flake, L. (2009) Fishery product report; Ghana, No. GH9004). Global Agricultural Information Network (GAIN).

Asmah R., Muir J.F. & Little D.C., (2008). Development potential and financial viability of fish farming in Ghana: Geographical Information Systems (GIS) Ghana, Tilapia market potential Ghana, Aquaculture development policy Ghana, Overview of fish farming in Ghana, Potential for cage farm development in Ghana. STORRE: Stirling Online Research Repository. University of Stirling. Retrieved from http://hdl.handle.net/1893/461

Asmah, G. (2008). Aquaculture: Driving Ghana‘s fish import cuts. In: Fish importation cut in Ghana through aquaculture.

Attipoe, F. Y. K., & Agyakwah, S. K. (2008). Status of catfish farming and research in Ghana. In Proceedings of a Workshop on the Development of a Genetic Improvement Program for African Catfish Clarias gariepinus (p. 23).

Avery, J. L., & Steeby, J. A. (2004). 7 Hatchery management. Developments in aquaculture and fisheries science, 34, 145-165.

Avnimelech, Y; Kochva, M; et al. (1994). "Development of controlled intensive aquaculture systems with a limited water exchange and adjusted carbon to nitrogen ratio." Israeli Journal of Aquaculture Bamidgeh. 46 (3): 119–131.

Azevedo-Santos, V., Rigolin-Sá, O. & Pelicice, F.M. (2011). "Growing, losing or introducing? Cage aquaculture as a vector for the introduction of non-native fish in Furnas Reservoir, Minas Gerais, Brazil". Neotropical Ichthyology. 9 (4): 915–919

Balarin, J.D., & Haller, R.D. (1982). The intensive culture of tilapia in tanks, raceways and cages.In J.F. Muir & R.J. Roberts (eds.), pp. 265- 355.

Barg, U. (1992). Guidelines for the promotion of environmental management of coastal aquaculture development. Fisheries Technical Paper, 328.

Barg, U., Bartley D., Kapetsky, J., Pedini, M., Satia, B., Wijkstrom, U., & Willmann, R. (1999). Integrated resource management for sustainable inland fish production. FAO Aquaculture Newsletter, 23: 4.

Bash, J., Berman, C. H., & Bolton, S. (2001). Effects of turbidity and suspended solids on salmonids. University of Washington Water Center.

Beveridge, M.C.M., & McAndrew, B.J. (1998). Tilapias: Their biology and exploitation. London: Chapman and Hall.

Brown, J. H. (2006). Shellfish culture in West Africa; economic and sustainable opportunities for artisanal fishing communities. Background paper for FAO/DFID SFLP Policy brief series, FAO.

Brummett, R.E., & Williams, M.J. (2000). The evolution of aquaculture in African rural and economic development. Ecological Economics, 33 (2).

Brummett, R.E., Gockowski, J., Pouomogne, V. & Muir, J. (2011). Targeting agricultural research and extension for food security and poverty alleviation: A case study of fish farming in Central Cameroon. Food Policy, 36 (6), 805-814.

Chaudhari, L. P. (2003). Sustainable use of natural resources for integrated aquaculture and agriculture: An Indian overview. Bombay, India: Institute for sustainable Development and Research, 187-195.

Coche, A.G., Haight, B.A., & Vincke, M.M.J. (1994). Aquaculture development and research in sub-Saharan Africa. Rome: Food and Agriculture Organization of the United Nations.

Craig, S., & Helfrich L. A. (2002). Understanding Fish Nutrition, Feeds and Feedings. In: Knowledge for the Common Wealth. Regional College of Veterinary Medicine and Department of Fisheries and Wildlife Services. Virginia-Maryland. Publication Number 420-256.

Delincè, G. (1992). The ecology of the fish pond ecosystem: with special reference to Africa. Kluwer Academic Publishers, 1992. Volume 72 of Developments in hydrobiology

Dey, M., Kambewa, P., Prein, M., Jamu, D., Paraguas, F.J., Pemsl, D.E. & Briones, R.M., (2006). Impact of Development and Dissemination of Integrated Aquaculture- Agriculture (IAA) Technologies in Malawi. NAGA, World Fish Center Quaterly, 29 (1-2), 28-35.

Diver, S. (2000). Aquaponics-Integration of hydroponics with aquaculture. Attra.

Edwards, P. (1999) Aquaculture and poverty: Past, present and future prospects of Impact. Fifth Fisheries Development Donor Consultation, Rome, Italy, 22 24.

Enete, A. A., Madu, I. I., Mojekwu, J. C., Onyekuru, A. N., Onwubuya, E. A., & Eze, F. (2011). Indigenous Agricural Adaptation to Climate Change: Study of Southeast Nigeria.

Faisal, M., Schulz, C. A., Loch, T. P., Kim, R. K., Hnath, J., Whelan, G., ... & Leonard, N. (2013). Current status of fish health and disease issues in the Laurentian Great Lakes: 2005–2010. Great Lakes fisheries policy and management: A binational perspective, 2nd Ed, Taylor WW, Lynch AJ, Leonard NJ, editors. Michigan State University Press, East Lansing, Michigan, 259-302.

FAO (1990). The definition of aquaculture and collection of statistics, FAO Aquacult. Min.,7.

FAO (1990b). Description and Assessment of fish farms in Ghana. In: field working paper 10 (Vincke, M.M.J and Awity L.K.A.). Rome, 1990.

FAO (1996). Food for All Summit, 13-17 November 1996, Rome.

FAO (2002). The State of World Fisheries. FAO, (Ed.) 148pp.

FAO (2003). The role of aquaculture in improving food and nutrition: Committee on World Food Security. 12-16 May 2003, Rome, Italy.

FAO (2004). Aquaculture extension in sub-Saharan Africa. FAO Fisheries Circular. No. 1002. Rome, FAO. 55p.

FAO (2006). Cultured aquatic species information programme: Oreochromi niloticus. 10 Rome: Fisheries and Aquaculture Department, FAO.

FAO (2006). National Aquaculture Sector Overview, Ghana http://www.fao.org/fishery/country sector/naso ghana/en

FAO (2009). National Aquaculture Sector Overview. Ghana. In: Fisheries and Aquaculture. Fisheries and Aquaculture Department.

FAO (2014). The State of World Fisheries and Aquaculture: Opportunities and Challenges. Food and Agriculture Organisation of the United Nations. FAO, Rome

Fitzsimmons, K., & Watanabe, W. O. (2010). Tilapia (Family: Cichlidae). In Finfish Aquaculture Diversification. (pp. 374-396). CABI Publishing.

Flimlin, G., Buttner, J., & Webster, D. (2008). Aquaculture systems for the Northeast. University of Maryland, Northeastern Regional Aquaculture Center, College Park, MD. NRAC Publication, (104-2008).

Franco, L. (1991). Nile tilapia (Oreochromis niloticus) production in tropical microcosms fertilized with rabbit excreta.

Frimpong, S. K., & Kalbersonn, N. J. L. (2014). Assessing the Contribution of Microfinance Institutions to Poverty Reduction in Ghana: A Case Study of the Christian Rural Aid Network (CRAN) Hohoe, Ghana. International Journal of ICT and Management, ISSN 2026, 6839, 116-124.

Gilbert, A. (2013). Modelling Sustainable Harvesting Strategies of a Fish Pond-a case study (Doctoral dissertation, Department of Mathematics, Kwame Nkrumah University of Science and Technology, Kumasi).

Haylor, G., & Bland, S. (2001). Integrating aquaculture into rural development in coastal and inland areas. Proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25 February 2000, pp. 73.

Hecht, T. (2006). Regional review on aquaculture development. 4. Sub-Saharan Africa – 2005. FAO Fisheries Circular. No. 1017/4. Rome.

Helfrich, L. A., & Libey, G. (1991). Fish farming in recirculating aquaculture systems (RAS). Virginia State Cooperative Service.

Hiheglo, P. K. (2008). Aquaculture in Ghana: prospects, challenges, antidotes and future perspectives.

Hishamunda, N. & Ridler, N.B. (2006). Farming fish for profits: A small step towards food security in sub-Saharan Africa. Food Policy, 31 (5).

Holomuzki, J. R., Feminella, J. W., & Power, M. E. (2010). Biotic interactions in freshwater benthic habitats. Journal of the North American Benthological Society, 29(1), 220-244

Kapetsky, J. M., Wijkstrom, U. N., MacPherson, N. J., Vincke, M. M. J., Ataman, E., & Caponera, F. (1991). Where are the best opportunities for fish farming in Ghana? The Ghana Geographical Information System as a decision-making tool for fish farming development. Based on the work of JM

Kapetsky, UN Wijkstrom, N. MacPherson, MMJ Vincke, E. Ataman, F. Caponera.

Kapetsky, J.M., (1994). A Strategic Assessment of warm-water fish farming potential in Africa.

Kasam, L. (2014). Aquaculture and food security, poverty alleviation and nutrition in Ghana: Case study prepared for the Aquaculture for Food Security, Poverty Alleviation and Nutrition Project. WorldFish, Penang, Malaysia. Project Report: 2014-48

Krejcie, Robert V., Morgan, Daryle W., (1970). "Determing Sample Size for Research Activities", Educational and Psychological Measurement.

Kwadjosse, T. (2009). The law of the sea: impacts on the conservation and management of fisheries resources of developing coastal states—the Ghana case study. Division for Ocean Affairs and the Law of the Sea. Office of Legal Affairs, the United Nations, New York, 2003.

Lane, A., Hough, C., & Bostock, J. (2014). The long-term economic and ecologic impact of larger sustainable aquaculture.

Li, Q. (2002). An investigation of integrated management of irrigation systems for agriculture and aquaculture (Doctoral dissertation, University of Newcastle upon Tyne).

Little, D., & Satapornvanit, K. (1996, September). Poultry and fish production–a framework for their integration in Asia. In Second Food and Agriculture Organization of the United Nations Electronic Conference on Tropical Feeds.

Mallya Y. J. (2007) The effects of dissolved oxygen on fish growth in aquaculture. UNU-Fisheries Training Programme: 16–17

Marks, R., & Pytel, M. (2011). Bubbles, Dissolved Oxygen saturation and coastal abrasion in the southern Baltic Sea. Journal of Coastal Research, (64), 417.

Martínez Cruz, P., Ibáñez, A. L., Monroy Hermosillo, O. A., & Ramírez Saad, H. C. (2012). Use of probiotics in aquaculture. ISRN microbiology, 2012.

Mboge, A. B. (2010). Opportunities and Constraints of fish farming in Ghana (a case study of Ashanti Region).

Mbugua, H. M. (2007). A Comparative Economic Evaluation of Farming of three Important Aquaculture Species in Kenya.

Mensah, M. A., Koranteng, K.A., Yeboah. D. & Bortey, A. (2003). Study of the impact of international trade in fishery products on food security – the case of Ghana.

Moehl, J. (1999). Aquaculture in Africa: Perspectives from the FAO Regional Office for Accra. FAO Aquaculture Newsletter, No. 22 21-22. FAO.

Muir, J. (1999). Aquaculture and Poverty: Full Baskets or Empty Promises? Perspectives from DFID Aquaculture Research Programme. Paper presented at the Fifth Fisheries Development Donor Consultation, 22-24 February, FAO, Rome.

Muir, J. (2005) Managing to harvest? Perspectives on the potential of aquaculture. Philosophical Transactions Royal Society London Biological Science, 360, 1453.

Nath, S., Bolte, J. P., Ross, G. L. & Aguilar-Manjarrez, J. (2000). Applications of geographical information systems (GIS) for spatial decision support in Aquaculture. Aquacultural Engineering, 23, (1-3).

Naylor, L.R., Goldbury, J.R., Primavera, H., Jurgenne, K.N., Beveridge, C.M.M., Clayason, F & Max, T. (2000). Effect of Aquaculture on World Fish Supplies.

Nilson, H., & Wetengere, K. (1994). Adoption and Viability Criteria for Semi-intensive Fish Farming. Alcom Field Document No. 28.

Nunoo, F. K. E., Asamoah, E. K., & Osei-Asare, Y. B. (2014). Economics of aquaculture production: a case study of pond and pen culture in southern Ghana. Aquaculture Research, 45(4), 675-688.

Okai, D. B. (1995). Improving swine feeding in the northern region of Ghana by ensuring the optimum use of alternative feed resources. Proceedings of Ghana Society of Animal Production (GSAP). 8th Ann. Gen. Conf. Tamale. 87 – 92.

Oribhabor, B. J., & E. J. Ansa. "Organic waste reclamation, recycling and re-use in integrated fish farming in the Niger Delta." Journal of Applied Sciences and Environmental Management 10.3 (2006): 47-53.

Osman, M. A. M., Mohamed, A. M., Ali, M. H. H., & Al-Afify, A. D. G. (2010). Assessment of agriculture drainage water quality to be used for fish farm irrigation. Nature and Science, 8(8), 60-74.

Owusu, B. S., Kuwornu, L., & Lomo, A. (1999). Integrated Irrigation: Aquaculture Development and Research in Ghana. Annex 5.

P. K. Srivastava and A. K. Pandey, Role Of Immunostimulants In Immune Responses Of Fish And Shellfish, Biochem. Cell. Arch. Vol. 15, No. 1, pp. 47-73, 2015.

Pace, M. L., & Prairie, Y. T. (2005). Respiration in lakes. Respiration in aquatic ecosystems, 103-121.

Pedini, M., & Shehadeh, Z. (1997). Aquaculture in Sub-Saharan Africa: Situation and Outlook. The FAO Aquaculture Newsletter, No.15. 3-6pp.

Peterman M.A.: Evaluation of production characteristics of four strains of Nile tilapia Oreochromis niloticus and a Red variety under two sets of intensive culture conditions, Master thesis Auburn University, Alabama, 2011.

Pillay, T.V.R. & Kutty, M.N. (2005). Aquaculture: Principles and Practices. 2nd (edn), 625pp Oxford: Blackwell Publishing Ltd.

Prein M. & Ofori, J.K. (1996) Past Initiatives for Promoting Aquaculture in Ghana. M Prein, J.K. Ofori and C Lightfoot (Eds). Research for the Future Development of Aquaculture in Ghana, ICLARM Conference Proceedings. 1-3. 96. Manila, Phillipines, ICLARM.

Prein, M., Ofori, J., Lightfoot, C. (1996) Research for future development of aquaculture in Ghana. (Summary Papers of the ICLARM/IAB workshop

Accra, No. ICLARM contribution No. 956). Accra: lnstitute of Aquatic Biology/Council for Scientific and Industrial Research.

Pullin, R.S.V., & Lowe-McConnel, R.H. (1982). The biology and culture of tilapias, ICLRAM Conference Proceeding 7. Manila: ICLRAM.

Quagrainie et al. (2009) Aquaculture information sources for small-scale fish farmers: The case of ghana. Aquaculture Research, 40, 1516-1522.

Quagrainie, K.K., Ngugi, C.C. & Amisah, S. (2010). Analysis of the use of credit facilities by small-scale fish farmers in Kenya. Aquaculture International, 18 (3), 393-402.

Ridler, N., & Hishamunda, N. (2001). Promotion of Sustainable Commercial Aquaculture in Sub-Saharan Africa. Policy Framework Volume 1. Rome: Food and Agricultural Organization.

Salm, R. V., Smith, S. E., & Llewellyn, G. (2001). Mitigating the impact of coral bleaching through marine protected area design. Coral bleaching: Causes, consequences and response. University of Rhode Island: USA, 81-88.

Shang, Y.C. (1985). Aquaculture economics: An overview. 10 (3):299-305.

Simpson, G. (2012). Opportunities for small scale suppliers within the tilapia value chain in Ghana: A case study of fish farming in Achavanya. Erasmus University.

Stickney, R., (2005). Aquaculture: An Introductory Text. Wallingford, Oxfordshire, UK: CABI Publishing.

Swift, D.R., 1993. Aquaculture training manual. Fishing News books. Oxford, England. Second edition. pp. 46-114.

Tacon, A.G. (2001). Increasing the Contribution of Aquaculture for Food Security and Poverty Alleviation. In Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C. and McGladdery, C.E.a.A.J.R.e., (Eds.) 63-72. Bangkok, Thailand and Rome, Italy: NACA and FAO.

Torrissen, O., Jones, S., Asche, F., Guttormsen, A., Skilbrei, O. T., Nilsen, F., ... & Jackson, D. (2013). Salmon lice–impact on wild salmonids and salmon aquaculture. Journal of fish diseases, 36(3), 171-194.

Tucker, C. & Hargreaves, J. (2009). Chapter 13: Economics of Aquaculture Better Management Practices. In Environmental Best Management Practices for Aquaculture (pp534–568). Hoboken, NJ: Wiley-Blackwell.

USDA, 2009. Ghana Fishery Product Report.

Verdegem, M. C. J., & Bosma, R. H. (2009). Water withdrawal for brackish and inland aquaculture, and options to produce more fish in ponds with present water use. Water Policy, 11(S1), 52-68.

Vincke, M. M. J., & Awity, L. K. A. (1990). Description and assessment of fish farms in Ghana.

Welcomme, R.L. & Barg, U. (1997). FAO technical guidelines for responsible fisheries. No. 5. 40 FAO.

Welcomme, R.L. (1988). International introductions of Inland aquatic species. FAO Fish. Technical Paper, FAO, Rome.

Wikipedia (2009). Fish farming. In: Wikipedia, the free encyclopedia. [Online] Available at: http://en.wikipedia.org/org/wiki/fish_farming

World Bank (2004) Saving Fish and Fishers: Toward Sustainable and Equitable Governance of the Global Fishing Sector. Report No. 29090-GLB Washington, DC: World Bank, Agriculture and Rural Development Department.

# APPENDIX

## UNIVERSITY OF CAPE COAST

## SCHOOL OF BUSINESS

## DEPARTMENT OF MANAGEMENT STUDIES

## QUESTIONNAIRE TO THE TILAPIA FARMERS

Dear Sir/Madam,

This research is being conducted by a student from the University of Cape Coast on the operation of Tilapia farmers in Asuogyaman District of Ghana; as part of her master's degree programme. You are assured that all information will be treated as confidential.

Thank you.

**SECTION A: SOCIO-ECONOMIC BACKGROUND OF RESPONDENTS**

1. SEX: Male [ ] Female [ ]
2. Age: ……………………………………………………………………
3. Marital status: {a} Married {b} Single {c} Divorced
   {d} Separated {e} Widowed
4. Educational status:
   {a} No formal education {b} Primary
   {c} JHS/Middle school {d} SHS {e} Degree
5. What is your ethnicity?.......................................................................

6. Do you engage in Tilapia Farming as a full time occupation?

   Yes [ ] No [ ]

7. Apart from Tilapia Farming, are you involved in any other business?

   Yes [ ] No [ ]

8. If yes to Q 7 above, please mention the other businesses in order of importance to you?

   a) ……………………………………………………………………

   b) ……………………………………………………………………

   c) ……………………………………………………………………

9. How much do you earn at the end of each production?

   a) Less than GHs 1,000.00

   b) Between GHs 1,001.00 and GHs 2,000.00

   c) Between GHs 2,001.00 and GHs 3.000.00

   d) Between GHs 3001.00 and GHs 4000

   e) 4,001.00 and more

10. How long have you been engaged in Tilapia Farming?

    a) Since infancy b) More than 10 years ago

    c) Between 5 and 10 years d) Less than 5 years

11. Do you employ other people to help you with the Tilapia Farming?

    Yes [ ] No [ ]

12. How did you get into tilapia farming?

    ………………………………………………………………………..

**SECTION B: THE SOURCES OF TILAPIA SEED FOR THE TILAPIA FARMERS**

13. How do you get the seed or fingerlings that you use for your farming?

    {a) Fisheries Directorate {b} pound source {c} Wild source

    {d} Fellow Farmers {e} Hatchery Operators {f} Other

    (Specify) ………………………………………………………………..

14. Do you have any kind of knowledge about how to get the tilapia fish seed?

    Yes [ ] No [ ]

15. If yes, how did you acquire that knowledge?

    {a) Fellow Farmers {b} Agricultural Extension Officers

    {c}Books on Tilapia Farming {d} Fisheries Directorate

16. What quantity of the seed do you need for a farming period?

    ……………………………………………………….……………

17. Are you able to get the quantity you need during a farming period?

    Yes [ ] No [ ]

18. If no, why are you not able to the quantity you need?

    ……………………………………..……………………………..

19. How much do you get the quantity you need for a period?

    ………………………………………………………………..………

20. Does all the seed you purchase survive the period of harvesting?

    Yes [ ] No [ ]

21. If no, why don't they survive the period of harvesting?

………………………………………………………………………………

22. In your opinion, are the seed affordable?

Yes [ ] No [ ]

23. If no, why are the seed not affordable to you?

……………………………………………………………………………...

24. Are you able to make payment for the seed you buy?

Yes [ ] No [ ]

25. If no, why are you not able to pay for the seed?

………………………………………………………………………………

26. How long does it take for the seed to mature for harvesting?

……………………………………………………..……………………..

27. Can you mention any other problem you encounter in sourcing Tilapia Fish seed? …………………………………………………….……………

28. Do you belong to the Tilapia Farmers Association you have in this district? Yes [ ] No [ ]

29. If no, move to section C and do not answer questions (Q54 to 56).

30. If yes, do they assist you in sourcing for the Tilapia Fish seed?

Yes [ ] No [ ]

31. If yes, how do they assist you?

………………………………………………………………………………

32. If no, why don't they assist you?

…………………………...……………………………………………….

## SECTION C: SOURCES OF CAPITAL FOR TILAPIA FARMING OPERATIONS

33. Are you aware of any government policies regarding assistance in rising capital for Tilapia farming?

    Yes [ ] No [ ]

34. If yes, specify the kind of assistance that is known to you

    ……………………………………………………………………………

35. Have you received any of the assistance in the operation of your Tilapia farming? Yes [ ] No [ ]

36. If yes, in what ways?

    ………………………..…………………………………………………

37. What was your source of funds to start your Tilapia Operations?

    {a} Self Source {b} Family Source {c} Friends Source

    {d} Credit/loan Source {e} Others (specify) ……………………..

38. Where you involved in any credit activity in the past?

    Yes [ ] No [ ]

39. What kind of credit/loan was it?

    {a} Grant {b} With interest {c} Without interest

    {d}Others (specify)........…………………………………………….

40. Can you easily get more credit/loan if you want it?

    Yes [ ] No [ ]

41. When was the last credit/loan received?

{a} Less than 3 Month {b} Six (6) Months ago

{c} Nine (9) Months ago {d} One year ago

{e} Others (Specify) ………………………………….

42. What type of credit/loan was it?

Cash [ ] In Kind [ ]

43. If in Kind, what was it?

{a} Fingerlings {b}Equipment {c} Infrastructure

{d} Others (Specify) ……………………………………………………..

44. From which organization did you receive the credit/loan?

{a} Private Financial Institutions

{b} Government Financial Institutions

{c} Cooperative Society

{d} Agriculture Finance Corporation

{e} Micro finance Institution

45. Do you require collateral for the credit/loan?

Yes [ ] No [ ]

46. If yes, are you able to raise the collateral?

Yes [ ] No [ ]

47. If no, can you elaborate on the difficulties you encounter in raising the collateral?.....…………………………………………...…………………

48. What was the purpose of seeking the credit/loan?

{a} Purchase of Fingerlings {b}Purchase of Equipment

{c} Marketing of the Tilapia {d} Others (Specify) .................

49. Was the credit/loan received in time to be useful?

Yes [ ] No [ ]

50. Was the amount of the credit/loan sufficient?

Yes [ ] No [ ]

51. Has the credit/loan facility helped to improve your business?

Yes [ ] No [ ]

52. If yes, could you explain how it helped to improve your business?

……………………………………………………...………………

53. What is the period of the credit/loan repayment?

{a} Six Months {b} One year {c} Two years

{d} Others (Specify) ………………………………………………..….

54. Does the association help you to source for funds?

Yes [ ] No [ ]

55. If yes, how do they provide the assistance?

……………………..……………………………………………..…

56. If no, why don't they assist you in sourcing for funds?

………………………………..………………………………………

**SECTION D: SOME OF THE SYSTEM OF FARMING USED BY THE TILAPIA FARMERS**

57. Are you aware of any kind of system farmer's use in Tilapia farming?

    Yes [ ] No [ ]

58. If yes, specify the kind of farming system you use in your operations

    {a}Extensive fish farming systems

    {b} Semi-intensive fish farming systems

    {c}Intensive fish farming systems

    {d} Other (specify) ……..…………………………….…………

59. For how long have you been using this system of farming?

    …………………………………………………………………………

60. Why that choice of farming system for that long period?

    …………………………..………………………………………………

61. How is that affecting your business?

    ………..……………………………………………………………….

62. Can you mention any of the challenges you have encountered with that type of farming system?

    …………………………………………………………………………

63. Have you ever received the services of an extension officer?

    Yes [ ] No [ ]

64. If yes, how many times?

    ……………………..…………………………………………………

65. If no, why?

………………………….………………………………………………….

**SECTION E: SOME CHALLENGES FACED BY TILAPIA FARMERS**

66. Can you mention some of the challenges you face in the Tilapia farming business? ………………………………………………………

67. Having identified these challenges, how do you address them?

………………………………………………………………………….

68. Does the Association assist you in addressing the challenges you have identifies in Q 59 above?

Yes [ ] No [ ]

69. If yes, how do they assist you?

…………………………………………………………………………

70. If no, why don't they assist you?

……………………………………………………………………….