# Development potential and financial viability of fish farming in Ghana

Thesis submitted for the degree of Doctor of Philosophy

By

Ruby Asmah
(B.Sc (Hons) Chemistry, M.Sc Ecological Marine Management)

Institute of Aquaculture
University of Stirling
Stirling, FK9 4LA
Scotland

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# Declaration

I hereby declare that this thesis has been composed entirely by myself and has not been previously submitted for any other degree or qualification. All sources of information have duly been acknowledged.

Ruby Asmah

# Dedication

To my husband, Robert and children: Gladys, Jude and Lois and all who assisted in making this work a success.

In loving memory of my mum

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# Abstract

The potential for aquaculture development to make up for an annual 400,000mt shortfall in domestic fish supply was investigated. This involved an overview of the sector to determine its trends and operations and identifying strengths and constraints, a financial viability assessment of the sector, based on mode and levels of operation of existing farms, an assessment of the market and trade for cultured fish with a focus on *Oreochromis niloticus*, and finally, a GIS approach to update and reassess the potential for aquaculture development in Ghana. Data were obtained from both primary and secondary sources, the former, via fish farmer, dealers and consumer questionnaire surveys.

Results of the study showed that interests in fish farming continue to grow with an overall annual average growth rate of 16% since 2000. The existing farms, 1300 in number were however very small with a mean farm size of 0.36ha and a median 0.06ha of which commercial farms accounted for less than 3%. Based on sizes, mode of operation and levels of input and output, five subsistence farm types were identified. Mean production from these pond-based farms ranged from 1436kg/ha/yr$^{-}$ to 4,423kg/ha/yr while that of a medium sized intensive commercial pond farm was 45,999kg/ha/yr. Commercial farming accounted for about 75% of 2006 aquaculture production. The main strength identified was the growing interest in both commercial and non-commercial fish farming and the main constraints were lack of quality seed, low levels of technical support and of knowledge in fish farming practices among non-commercial farmers.

Net profits of commercial farms ranged from GH¢ 3,341 (US$ 3480)/ha/yr to GH¢ 51,444 (US$ 53,587)/ha/yr with payback from 1 to 4yrs, IRR at 35% to 105% and NPV from GH¢ 5,898 to GH¢ 236,412. By contrast, only two of the five non-commercial farm types made positive net returns ranging, from GH¢158 to GH¢1100/ha/yr, with minimum payback period of 14yrs, NPVs of less than 1 and the best IRR being just 4%,

when initial capital requirements are full costed. Uncosted family labour inputs and negligible land opportunity costs improved viabilities for two farm types, where net returns/ha/yr increased by more than 50%, minimum payback dropped to 2 years, NPV from GH¢ 4839 to GH¢ 9330 and minimum IRR of 45%. Main constraints identified as affecting the profitability of subsistence farming were the relatively low prices of fish and the low levels of output which could be improved through better farming practices.

From the market survey, a huge market potential for tilapia was identified with a current supply deficit of 41,000mt. The most preferred sizes by consumers and with potentially good market price for traders were those weighing at least 200g. For dealers, trading in cultured fish was found to be more profitable than trading wild capture tilapia because of lower wholesaler prices, gross profit margins were GH¢ 0.49/kg and GH¢ 0.25/kg respectively. Preference for tilapia was influenced by taste, availability, and its perceived health benefit. A key constraint to the sector was poor post-harvest handling and preservation of the fish resulting in shorter shelf life.

From the GIS study, 2% (3,692 $km^2$) of available land area was identified as very suitable for subsistence and about 0.2% (313.8$km^2$) for commercial farming. A further 97.4% and 84.0% were identified as suitable for subsistence and commercial farming respectively. Areas with potential for cage culture were also identified, which were largely in the southern and mid-sections of the country.

The overall conclusions are that based on natural resource requirements, market potential and financial viability, Ghana has the potential to totally make up the shortfall in domestic fish supply through aquaculture production. The current 400,000mt shortfall in domestic fish production can be achieved by 2020 by increasing overall aquaculture production by 60% per annum.

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# Chapter 1 - Introduction

## 1.1 General introduction

### 1.1.1 Fisheries and food supply

This thesis addresses the potential for aquaculture development in Ghana. The context of this development concerns the improved supply of fish, a valuable and nutritious food, and an essential, often irreplaceable source of high quality and cheap animal protein crucial to the balance of diets in marginally food secure communities (Barg et. al. 1999). More than half the world's population depend on fish as their principal source of animal protein. In many countries, people derive more than 50% of their daily animal protein requirements from fish products (World Bank, 2004). Fish contribute to people's well-being both through food supply and income. More than 120 million people are estimated to depend on fish for all or part of their incomes. In Africa, as much as 5% of the population depend wholly or partly on the fisheries sector for their livelihood. Fish comprise about 19% of the less developed countries' animal protein intake, or 5% of the total protein intake from both plant and animal protein (Pedini and Shehadeh, 1997).

Globally, most of the total fish supply is still obtained from marine and inland capture fisheries, the remainder deriving from aquaculture. The contribution of capture fisheries to per capita food supply has stabilized at 10 to 11kg during the period 1970-2000 (FAO, 2003). Since fish is such a nutritious food, aims in meeting the needs of growing populations are to increase supply, rather than reducing per capita demand to meet supplies. As the expansion potential of capture fisheries is increasingly limited (FAO, 1996; Pedini and Shehadeh, 1997; Pillay and Kutty, 2005), the major prospects for increasing supplies lie in aquaculture.

### 1.1.2 Aquaculture

The formal definition of aquaculture, by the UN Food and Agriculture Organization (FAO) is 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. Farming also implies individual or corporate ownership of the stock being cultivated. 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 and Barg, 1997)

Aquaculture is believed to have begun in China in the fifth century (Pillay and Kutty, 2005). Farming oyster inter-tidally was reported to have begun in Japan 3000 years ago and by the Romans nearly 2000 years ago (Stickney, 2005). However, much of the growth in aquaculture has only happened in recent decades, over which it has become the world's fastest growing food sector with an overall growth rate of 11 % per year since 1984 compared to 1.4 and 2.8% for capture fisheries and terrestrial farmed meat production, respectively (FAO, 2002; FAO, 2003). The rapid growth of the sector has been attributed to the increasing demand for aquaculture produce, generating profit and income, the urgent need for sustainable food supply, the increasing scientific, technological and entrepreneurial skill in managing species lifecycles and production environments, and in meeting market and commercial objectives (Barg, 1992). Institutional and development support has also played an important role, and has brought access to key skills and resources, as well as investment capital (Muir, 1995). Amongst various food production systems, aquaculture is also generally viewed as an important domestic provider of much needed high-quality animal protein and other essential nutrients, that is easily digestible and of high biological value, generally at affordable prices to the poorer segment of the community (Tacon, 2001). Another factor has also been the recognized need of many countries to achieve greater self-reliance in food production and greater balance of international trade (Pillay and Kutty, 2005).

In 2004 aquaculture products accounted for about 32.4% of total seafood production by weight, up from about 16.2% in 1990. A great proportion of this production comes from the developing world (87.7% in 2000), in particular Low Income Food Deficit Countries (LIFDCs) (83.9% in 2000) (FAO, 2003). Currently all the major aquaculture producing countries are in Asia. Two hundred and ten different species are cultured globally (FAO, 2002).

Aquaculture makes a significant contribution to food security. At the global level it helps fill the gap between the rising global demands for fishery products and the limited increases in capture fisheries production (FAO, 2003). Fish produced from farming activities currently accounts for over one-half of all fish directly consumed by humans. As the human population continues to expand beyond 6 billion, its reliance on farmed fish production as an important source of protein will also increase (Naylor et al. 2000).

Aquaculture plays an important role in the development of many national economies and a key role in the socio-economic resilience of rural areas, potentially offering valuable and skill-based employment opportunities, and in some cases stabilising the economic base of otherwise fragile communities (Edwards, 1999; Haylor and Bland, 2001; Muir, 1999). It provides livelihood options in rural areas of the developing world, as well as income and employment in both remote regional and more developed economies. Benefits are either direct to households farming aquatic products or indirect from the increased availability of low cost fish in local markets, or from employment within the aquaculture sector. It also plays a useful role in many development initiatives, in rural areas, often around coastal margins, and frequently in regions or locations where social, economic and environmental issues are critical (Haylor and Bland, 2001; Muir, 1995).

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[1] (FAO, 2003) which reflects the diversity of the sector, particularly the wide variety of candidate species cultivated and different production systems used. 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, et al. 2000).

[1] There is a contrasting view though. Bilio (2008) believes the number of domesticated aquatic species is over-estimated compared to that of terrestrial animals because of the use of different criteria in comparison.

### 1.1.3 Aquaculture in Africa

Aquaculture was introduced to Sub-Saharan Africa in the 1950s with main objectives of improved nutrition in rural areas, generation of additional income, diversification of activities to reduce risk of crop failures and the creation of employment in rural areas (Hecht, 2006). About 43% of the African continent is assessed as having the potential for farming tilapia, African catfish and carp (Ridler and Hishamunda, 2001). Of which according to the authors, 15% is considered most suitable, with the potential for yields of up to 2.0 crops/year for Nile tilapia and 1.7 crops/year for African catfish.

Though aquaculture has grown strongly in most regions of the world where the potential exists, it has not done so in Sub-Saharan Africa. In spite of various efforts since the 1950s, returns on government and international aquaculture investments appeared to be insignificant (FAO, 2004b) with less than 5% of the suitable land area being used (Kapetsky, 2004). Sub-Saharan Africa contribution to world aquaculture production is less than 1% (Hecht 2006).

The population of Africa is expected to reach 1.18 billion by 2010. To maintain average food fish consumption at present levels of 8 kg per person per year, supplies would need to increase from some 6.2 to 9.3 million tonnes per year in 2020. To support future needs, capture fisheries will need to be sustained and if possible enhanced, and aquaculture developed rapidly, to increase by over 260% i.e. an annual average of more than 8.3% by 2020 in sub-Saharan Africa alone (Muir et al. 2005), which is significantly higher than recent levels. If production from Egypt, the major regional producer, increasingly limited by land and water resources (J. Muir, 2008 pers. comm., Institute of Aquaculture) is excluded, the growth rate for the rest of the region would have to be substantially higher.

A number of reasons have been suggested for the poor rate of growth in aquaculture development in the region. These include causes relating to fish consumption preferences, the general level of economic development in rural areas, the policy and governance environment, and limiting social factors (FAO, 2006), together with a lack of access to available information (Moehl, 1999).

## 1.2 The Study Area – Ghana

### 1.2.1 Geographical context

Ghana is located in West Africa, a few degrees north of the equator. It has a total land area of 238,540 $km^2$ and a coastline length 550 km which is mostly a low, sandy shore backed by plains and shrub and interconnected by several rivers and streams, most of which are passable only by canoe. The population of the country is about 20 million of which 66% is rural (Ghana Statistical Service, 2002).

Ghana is divided into 10 administrative regions - the Greater Accra, Volta, Central and Western Regions located in south along the coast, the Ashanti, Eastern and Brong-Ahafo Regions located in the middle belt and the Northern, Upper East and Upper West Regions located in the northern part of the country (Figure 1.1). The capital city Accra is located in the Greater Accra Region, the smallest of the ten regions. The ten regions are sub-divided into 138 individual metropolitan, municipal and district assemblies. Governance is decentralised. Each district has its capital and it is overseen by a head, the District Chief Executive who is assisted by the members of the district assembly who are elected into office by the community.

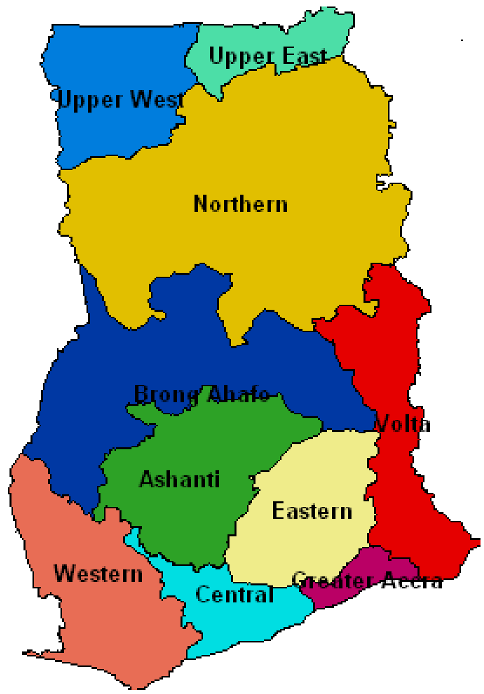



Figure 1.1: Administrative map of Ghana showing the ten regions

### 1.2.2 The national economy

The economy of the country is largely natural resource and agriculturally based and is dominated by primary commodity production and export, particularly cocoa, timber and gold. Incomes from agricultural activities account for about 50% of the Gross Domestic Product (GDP) and two-thirds of foreign earnings from export. The performance of the agricultural sector, comprising crops, livestock, fisheries and forestry, therefore has serious implications for the entire national economy.

Agriculture in Ghana is principally rain-fed, which makes food crop production susceptible to uncertainties associated with climate and weather conditions. Food crop production is mainly at subsistence level, with only a small but growing proportion being commercial scale enterprises. The subsistence nature of food crop production implies that output and marketable surpluses are subject to large fluctuations; usually patterned after uncertainties associated with rainfall (Asuming-Brempong and Asafu-Adjei, 2004). Domestic livestock production, except for poultry which is now commercialized mainly as a peri-urban activity, is more of an artisanal activity and is mainly found in the northern savannah regions and the coastal plains. National production of cattle, sheep and goats accounts for only 30% of demand, the rest being imported (Asuming-Brempong and Asafu-Adjei, 2004). Live animals are imported from Burkina Faso and neighbouring countries (Institut du Sahel, 1998) and processed meat from Europe and the United States of America.

The agricultural sector employs the largest proportion (55.0%) of the total work force of the country followed by trading (18.3%) and then manufacturing (11.7%). As could be expected, the proportion is higher (70.1%) in rural than in urban areas (19.9%). About 57.2% of household heads in the country are engaged in the agriculture/forestry/fishing sectors, this rising to about three-quarters (74.7%) of rural household heads. Rural household heads also constitute the largest proportion (87.1%) of household heads in the poorest quintile (Ghana Statistical Service, 2002).

The fisheries sub-sector accounts for about 5% of the agricultural GDP and 3% of the national GDP (FAO, 2004a). Fish and fish products, including shrimp, tuna loins and canned tuna, contributed US$ 58.138 million in 1997, some 21% of the total value non-traditional exports (i.e. excluding cocoa, timber and gold) from Ghana (FAO, 1998). Directly or indirectly, the sector provides livelihoods for more than 2.2 million people (Seini et al. 2004).

### 1.2.3 Domestic fish production

There are six distinct sources of domestic fish supply in Ghana: marine fisheries; lagoon fisheries, Lake Volta, other inland fisheries, aquaculture, and imports.

Marine fisheries are by far the most important source of fish supply. Average annual domestic production between 1993 and 2000 was about 358,000 metric tonnes and was approximately 80% of overall fish supply (FAO, 2004a). It has three sub-sectors, small scale, (artisanal or canoe), semi-industrial (or inshore) and industrial. The artisanal sector is the most important in terms of output, with between 60-70% of the total (Akrofi, 2002).

Ghana's inland (freshwater) fishing is carried out by some 71,861 fishermen using canoes of various sizes. Lake Volta is the single most important source of inland fishery, supporting about 140 species of fish (Braimah, 2001). It was estimated to have produced over 70,000 tonnes of fish in 2002 which is about 16% of total domestic production and 85% of inland fishery output. Common among the landings are various species of tilapia, *Chrysichtys sp.*, *Synodontis*, *Mormyrids*, *Heterotis*, *Clarias sp.*, *Bagrus sp*. and *Citharinus*. Peak and lean fish seasons on the lake run from July to August and January to February respectively. Other lake fisheries include Bosomtwi, Weija, Barekese, Tano, Vea and Kpong. Other inland fish sources include numerous rivers covering approximately 1,000,000 hectares, and over 50 lagoons covering 40,000 hectares. Popular inland fish species include various species of tilapia, African perch (*Lates niloticus*) and *Bagrus sp*.

### 1.2.4 Fish consumption and demand

Fish plays an important role in the diets of Ghanaians. It represents 60% of average animal protein intake, making it the single most important source. A survey of national living standards conducted between 1987 and 1999 showed that the proportion of the average household food budget spent on fish ranged from 13 to 19% in urban areas and 17 to 29% in rural areas (Ghana Statistical Service, 2002). With respect to the household budget on animal products, consumption of fish accounted for about 53% of expenditure in urban households in 1998/1999 and in rural households, from 55 to 79% in the three ecological zones i.e. rural coastal, rural forest and rural Savanna (Seini et al. 2004).

The country has a self sufficiency ratio of 60% for fish (Table 1.1). Fish consumption therefore is sustained by a growing level of import of frozen fish which is becoming an important part of low income urban and rural consumer's diets (Adutwum, 2001).

Average per-capita consumption of fish is between 20 and 25 kg, making it one of the highest in the Africa. Marine fish contributes over 80% and inland fish about 14%. The contribution of aquaculture to total domestic fish production is currently less than 1%.

Table 1.1: Average Balance Sheet for fish in Ghana, 1981-2000

| Period | Domestic production ('000mt) | Imports ('000mt) | Export ('000mt) | Available for consumptio n ('000mt) | National Requiremen t ('000mt) | Balance/Deficit | |
|---|---|---|---|---|---|---|---|
| | | | | | | ('000mt) | % |
| 1981-1985 | 267 | 2 | 29 | 240 | 478 | -238 | 49.8 |
| 1986-1990 | 359 | 13 | 31 | 341 | 550 | -210 | 38.2 |
| 1991-1995 | 378 | 24 | 28 | 374 | 639 | -265 | 41.5 |
| 1996-2000 | 453 | 32 | 51 | 434 | 735 | -301 | 41.0 |

Source: (Seini et al. 2004)

### 1.2.5 The case for aquaculture

The 301,000mt shortfall in domestic fish production which has since 2006 increased to 400,000mt (Ministry of Fisheries, 2006) could be decreased in three ways; by increasing imports, from better management of capture fisheries or through aquaculture. However, imports are becoming increasingly expensive as regional and global supplies are under increasing competitive pressure, and will place an increasing burden on household and national economies. Most perspectives for national capture fisheries also suggest that the major prospects for increasing fish supplies lie in aquaculture and not management of wild stocks. Aquaculture worldwide has helped fill the gap between the rising global demands for fishery products and the limited increases in capture fisheries production and is expected to do the same in Ghana.

Aquaculture is now therefore considered to be an important and integral part of agriculture/food sector development activities. A proposed aquaculture policy focuses on increased farm yields and improved access to marketing, with a view to expanding production, increasing farm incomes, contributing to poverty reduction and creating the conditions for a viable and sustainable economic activity (Directorate of Fisheries, 2004). Features determining suitability and potential for aquaculture would however include market demand and price of product, supply and seasonality features, environmental requirements, ease of culture and early rearing, ease of feeding, disease resistance, ease of handling and harvesting, and the quality and stability of product forms (Muir, 1996). Clearly, if aquaculture is to succeed in Ghana, and to play the part expected of it, these criteria would have to be satisfied.

### 1.2.6 Objectives and approach

The research question is; has Ghana the potential to make up for the shortfall in domestic captured fisheries through aquaculture production?

The question was addressed by:

Undertaking an overview of aquaculture development in Ghana at this stage, how it has evolved over recent years and what are the current obstacles.

- Assessing the financial viability of aquaculture operations at different levels of production.
- Assessing the size and nature of national markets and trade for aquaculture products.
- Identifying areas which are economically and environmentally suitable for freshwater aquaculture development.

The thesis is organized in six chapters. Following this introduction, the second chapter assesses the potential for aquaculture development based on overview of current farm operations, identifying trends and constraints. The third chapter assesses the financial viability of aquaculture operations in Ghana at different levels of production. The fourth examines the size and the nature of trade for aquaculture products. The fifth chapter outlines locations and areas with potential for aquaculture development in Ghana and the sixth integrates these into a broader prospectus for development, provides recommendations, and suggestions for further work.

# Chapter 2 - Overview of fish farming in Ghana

## 2.1 Introduction

Aquaculture development in Ghana as in many African countries started in the 1950s. Before then, there were in practice traditional forms of aquaculture such as ‘atidja’ (brush parks in lagoons and reservoirs) ‘hatsi’ (fish holes) ‘whedo’ (mini dams in coastal lagoons) and the culture of bivalves (*Egeria radiata*) in the lower Volta which involved the transplanting of clams from areas along the Volta estuary where they bred, to family “owned” sites up the river for on-growing during the dry season (Brown 2007). Yields of up to 8000mt/annum were reported for this system of culture (Whyte, 1981 - as reported in Brown, 2007).

Between the 1950s and the early 1970s, the conventional form of aquaculture was practiced by stocking fish in small reservoirs and dugouts, as well. In the early 1980s, a nationwide campaign to promote fish farming in Ghana was launched by the Fisheries Department. This led to a number of people entering fish farming but, poor provision of technical support in all key aspects of fish farming such as site selection, pond design and construction, pond management, availability of fingerlings, fertilization, feeding, harvesting strategies, and marketing and processing, led to poor performance of many of the farms and a general failure of the sector to develop (Prein and Ofori, 1996).

Despite this, the government of Ghana has continued to support aquaculture and has taken several steps towards its development, including: provision of free extension services, training in fish farming techniques, local and foreign study tours for fish farmers and staff, training groups of youths to construct ponds, strengthening the organizational capacity of fish farmers' associations through training in book keeping, group dynamics and preparation of business plans, fingerling production for sale to fish farmers, and the prohibition of farmed fish imports, except with a permit from the Ministry of Fisheries, to ensure a good price for aquaculture products in the country (FAO, 2006b).

With a shortfall of about 400 000mt in domestic fish production from capture fisheries, resulting in an annual fish import of US$ 200 million, the government of Ghana has increasingly been focusing on aquaculture development to compensate (Ministry of Fisheries, 2005), moving distinctly from the initial objective of developing it as a food-supply activity for local subsistence. The approach this time is to stimulate the development of aquaculture as a business-oriented enterprise and to uncover and create economic opportunities in the sector.

### 2.1.1 Objectives

The objective of this chapter is to assemble an overview of aquaculture development in Ghana at this stage, to describe how aquaculture has evolved over recent years and what are its current obstacles and drivers. This was done using three areas of enquiry:

- Establishing the location and scale of current activities;
- Defining the recent trends and directions;
- Understanding the obstacles and opportunities;

Information was obtained from both primary and secondary sources. The main sources of secondary information were the Fisheries Directorate of the Ministry of Fisheries and the Africa Regional office of the Food and Agriculture Organization (FAO) based in

Accra, both of which undertook national surveys in 2003. Data on number and general distribution of fish farms across the country compiled by the Fisheries Directorate form a 2004 census was also obtained.

## 2.2 Methodology

### 2.2.1 Data collection

Primary information on aquaculture development in Ghana was obtained via questionnaires in four of the ten regions, namely the Greater Accra, Eastern, Ashanti and Volta Regions. The regions were selected primarily because from a 2004 fish farm census undertaken by the Fisheries Directorate (Unpublished data), 644 of the estimated 966 fish farms in the country were located in these regions (Table 2.1), and as limited funds for the work required proximity and accessibility, selection was based primarily on aquaculture as defined by ‘pond farms’ rather than ‘culture based fisheries’. The data were collected with the assistance of fisheries extension officers and two first degree graduates who were hired to assist in data collection for other aspects of the research (fish market, dealers and consumer surveys) being undertaken concurrently. Time spent in each region was limited to one week to minimise costs of board and lodging which was adequate for administering questionnaires but prevented the team from “exploring” the regions and issues more widely.

The first place of call in each region was the Fisheries Directorate’s regional office, where a list of fish farms in the region and their locations was obtained and as many as could be visited within the week were allotted and scheduled. This was done starting with the closest in terms of distance from the regional capital where the team stayed for the week. To facilitate data collection, questionnaire forms were completed with the farm owner or manager, whichever was available, at the time of visit. Where none was present, the farmers were traced to their homes where the information was taken. Collection of data by phone was done only in one instance, which was to the owner of a commercial farm whose manager was not ready to give out any information. The surveys were conducted between June 2006 and December 2006. Primary data from 134 fish farms were obtained.

Table 2.1 Regional distribution of fish farms and culture based fisheries (CBF)

| Region | No. of pond farms | No. of reservoirs |
|---|---|---|
| Ashanti (AsR) | 267 | 5 |
| Brong-Ahafo (BAR) | 106 | 2 |
| Central (CR) | 180 | 33 |
| Eastern (ER) | 166 | 9 |
| Western (WR) | 36 | 2 |
| Greater Accra(GAR) | 110 | 129 |
| Volta (VR) | 101 | 88 |
| Northern (NR) | 0 | 311 |
| Upper East (UE) | 0 | 156 |
| Upper West (UW) | 0 | 152 |
| Total | 966 | 887 |

Sources: Fisheries Directorate (Unpublished data)

The questionnaire was in two parts. The first sought to gather personal information on the farmers in relation to their social and economic status, and a profile of the fish farm in relation to size, method of construction, level of operation, as well as the kinds of inputs and equipment used. The second part of the questionnaire concentrated on the economic aspects of their farm in relation to sources of finance, annual production and revenue figures, harvesting and marketing. The questionnaires were first tested among 10 fish farm owners in the Greater Accra Region before being more widely administered. A sample of the questionnaire is presented in Appendix 1.

Secondary data from the Fisheries Directorate (FD) of the Ministry of Fisheries, and from the FAO, derived from nationwide and regional surveys covering the profiles and operations of 275 and 161 fish farmers respectively. The survey by FAO covered fish farms in the Ashanti, Western and Central regions and that of the FD covered all the regions except the northern region. Data for the Upper East and Upper West regions was relatively limited. During the primary data collection, 36 fish farms visited by the two organizations were re-visited to verify their data and almost all the data information provided were confirmed.

Excluding overlaps, data for a total of 391 fish farms were obtained, representing 40.5% of the existing number of fish farms in 2004 – with distribution by region shown in Table 2.2.

Table 2.2 Number of fish farm data obtained and percentage of region's total

| Region | No. of fish farms | % of region's fish farmers |
|---|---|---|
| Greater Accra | 20 | 18.2 |
| Eastern | 40 | 24.0 |
| Ashanti | 63 | 23.6 |
| Volta | 61 | 60.4 |
| Western | 48 | 35.3 |
| Brong-Ahafo | 80 | 75.5 |
| Central | 74 | 41.1 |
| Upper East | 4 | 1.0 |
| Upper West | 1 | <1.0 |
| Northern | 0 | - |
| Total | 391 | 40.5 |

### 2.2.2 Data analysis

All the data gathered were coded and entered in both Statistical Package for Social Sciences version 14 (SPSS 14) and Microsoft Excel 2003 spreadsheets. Data were analysed using SPSS 14, the main descriptive statistics tools used being "frequency", "cross tabulation" and "explore". The farms were categorised based on the year of pond construction, on the assumption that the farms were started same year the ponds were constructed (Table 2.3) Data analysis was in three parts, the first part being descriptive - with the purpose of defining recent trends and directions. To achieve this, the farms prior to analysis were grouped by the years in which they were established (Table 2.3). The second part provided general background information on the farmers and the third part providing a numerically based analysis of specific culture practices. The fish farms were run through a two tier classification. The first, classified the farms as non-commercial (subsistence), small scale commercial or medium scale commercial based on the characteristics that define the farm operations (Table 2.4) (Ridler and Hishamunda, 2001) and the second by factor analysis followed by a cluster analysis. Factor analysis was applied only to non-commercial farms as there were insufficient commercial farms to enable its use. Two tier classification was necessary to separate commercial and non-commercial farms as the higher levels of input and outputs of the former would have acted as outliers, potentially impacting correlations and distorting factor analysis (http://www2.chass.ncsu.edu/garson/pa765/factor.htm - accessed 30/06/07).

Table 2.3 Categories of period of construction/operation

| Group | Period of Construction |
|---|---|
| 1 | <1966 |
| 2 | 1966 – 1975 |
| 3 | 1976-1985 |
| 4 | 1986-1995 |
| 5 | >1995 |

Table 2.4 Principal characteristics of non-commercial and commercial farms

| Main Characteristics | Non-commercial farms | Commercial farms | |
|---|---|---|---|
| | | Medium | Large |
| Main Goals | Maximise family utility; risk diversification | Maximise profits | Maximise profits |
| Main Location | Rural/Suburban/Urban | Suburban/Urban | Suburban/Urban/Rural |
| Main Market | Domestic (Family/Rural) | Domestic (Middle income/Urban) | Exports; Domestic Urban |
| Inputs | | | |
| Main Labour | Unpaid family labour | Paid/Local area | Paid/local and distant areas |
| Capital | Equity | Debt and equity | Debt and Equity |
| Seed | Mostly external | Other hatcheries | Own hatcheries |
| Fertiliser | None/organic | Organic | None or limited |
| Feed | None/waste | Wastes/supplement | (Inorganic) Balanced |
| Pond/System size | Small ponds | Larger ponds | Larger ponds |
| Dependence to other hatcheries | Low to medium | Medium to high | Low |
| Main Beneficiaries | Family | Owner, traders, urban consumers, local population | Shareholders, processors, governments, contract farmers, local population |
| Some other stakeholders | Fish seed traders | Transporters | Co-users |
| Main Constraint | Seed and feed | Seed, feed and credit | Cost of inputs, environmental quality control |
| Average Employment per unit of land/water (L/N) | High | Average | Low |
| Average Capital-Labour ratio (O/L) | Low | Average | High |
| Average wages | Low (imputed) | Average | High |
| Average Yield per unit of land/water (O/N) | Low | Average | High |

Source: (Ridler and Hishamunda, 2001)

### 2.2.3 Classification of farms

All farms classified as non-commercial via the characteristics outlined in Table 2.4 were reclassified based on the size of the ponds, the levels of inputs such as quantities of feed applied per hectare and stocking density, level of production or output, labour and the levels of resources (equipment) using factor analysis, followed by a cluster analysis. Unlike previous classification methods this allows for a multivariate approach where a combination of factors that define production practices are used (Stevenson et al. 2004).

## Factor analysis

The objective of these statistical techniques is to represent a set of variables in terms of a smaller number of hypothetical variables. This is based on the assumption that some underlying factors, smaller in number than the number of observed variables, are responsible for the covariation among the observed variables. These factors produced by factor analysis are mathematical entities, which can be thought of as classification axes for plotting the tests as points on a graph. The greater the value of a text coordinate, or loading, on a factor, the more important that factor is in accounting for the correlations between that test and the other set (Kinnear and Colin, 2006).

Factor analysis can be exploratory or confirmatory. Exploratory factor analysis is the most commonly used (Field, 2005) and was the method employed in this study. The main difference is that in exploratory analysis, the number of factors required to explain the variables are not predetermined whilst in confirmatory factor analysis the number of factors required to explain the variables are predetermined, often based on a null hypothesis.

Factor analysis takes place in three stages. First the generation of a matrix of correlation coefficients from the input variables, secondly the extraction of factors and finally the rotation of factor axes to maximize the loadings of the variables on some of the factors and reduce them on others. Principal Component Analysis was used in the extraction of factors and the maximization of factor loadings was done using Varimax rotation, which maintains independence among the mathematical factors (Kinnear and Colin, 2006). An advantage is that it tries to maximize the dispersion of loadings within factors resulting in more interpretable clusters of factor (Field, 2005). The appropriateness of the data for factor analysis was determined using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test of sphericity. The KMO varies from 0 to 1. A value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating a diffusion in pattern of correlations hence factor analysis is likely to be inappropriate. A value of 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors (Field, 2005). Although values of 0.5 could be tolerated for a good analysis, the KMO should be greater than 0.7. Values between 0.5 and 0.7 are considered adequate but not very good. Bartlett's test of sphericity is used to test the null hypothesis that the variables in the population correlation matrix are uncorrelated (Field, 2005).

Six variables were selected for the analysis. These were farm size (ha), quantities of organic and inorganic fertilizer applied (kg/ha/yr), total feed applied (kg/ha/yr), stocking density for tilapia (fry/$m^2$) and labour inputs (man days/ha/yr).

### Cluster analysis

Cluster analysis seeks to identify homogeneous subgroups of cases in a population such that the relationship between members of the same group are strong and while they are weaker between members of different clusters. Each cluster thus describes, in terms of the data collected, the class to which its members belong (http://www.clustan.com/what_is_cluster_analysis.html).

The hierarchical cluster method of classification which allows for the generation of a range of clusters, was used in the analysis. Two to six clusters were generated and the most suitable, based on the cluster agglomerations was selected which in this case was the one with five clusters.

## 2.3 Results

### 2.3.1 Development profile

*Distribution of fish farms*

Regional distribution of fish farms surveyed is presented in Table 2.5. As indicated above, data was obtained for ponds in all the regions except the Northern region. The two other regions in the north - Upper East and Upper West regions accounted for less than 1.5% of the data set. These regions are generally thought to be more suitable for culture-based fisheries (CBF) because there are large numbers of artificial water bodies but low amounts of rainfall (Kapetsky et al. 1991). These regions, according to the 2003 fish farm census by Fisheries Directorate account for about 70% of CBF in the country (Table 2.1). The Brong Ahafo region had the largest number of farms of 80 accounting for 20.5% of the data. The Greater Accra region had the least number of farms of 20 (5.1%) after the three northern regions.

Table 2.5 Regional distribution of fish farms surveyed

| Region | No. of fish farms | % of total |
|---|---|---|
| Greater Accra | 20 | 5.1 |
| Eastern | 40 | 10.2 |
| Ashanti | 63 | 16.1 |
| Volta | 61 | 15.6 |
| Western | 48 | 12.3 |
| Brong-Ahafo | 80 | 20.5 |
| Central | 74 | 18.9 |
| Upper East | 4 | 1.0 |
| Upper West | 1 | 0.3 |
| Northern | 0 | 0 |
| Total | 391 | 100.0 |

*Trends in rate of fish farm development*

National and regional trends in rates of fish farm development are presented in Figure 2.1 and Figure 2.2 respectively. Both graphs indicate continuous growth in the numbers of fish farms, nationally and across seven of the ten regions of Ghana. Overall, more than 63.8% of existing farms were established after 1995. From the data, the average growth rate in the number of farms being established since 2000 was estimated to be 16%.

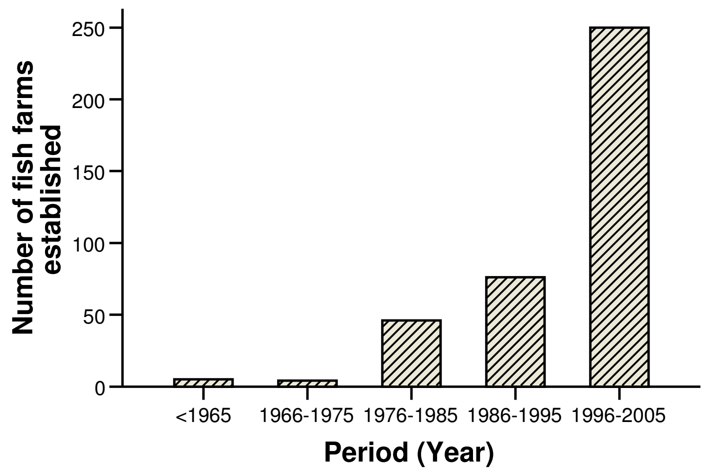



Figure 2.1 Trends in rate of fish farm development in Ghana

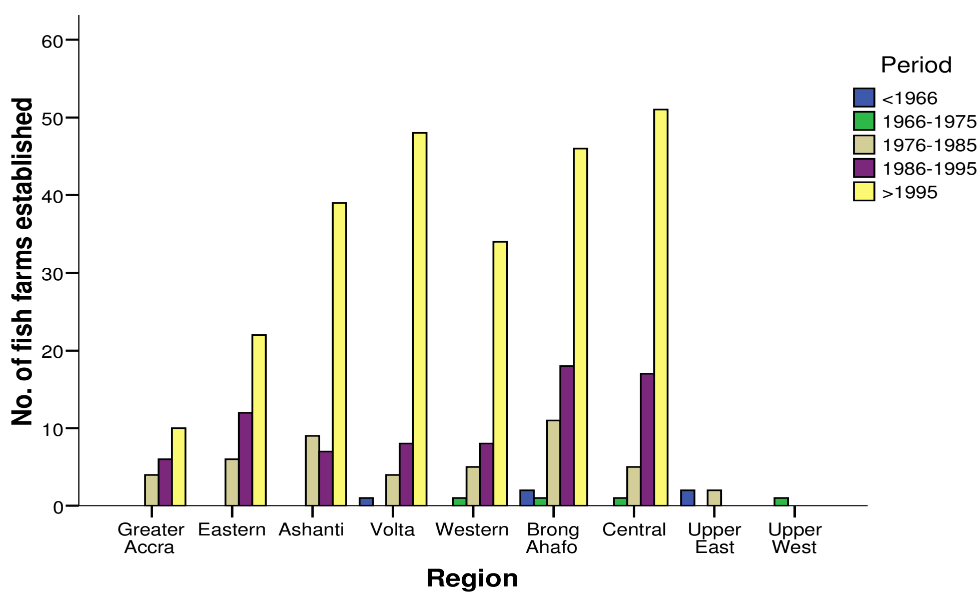



Figure 2.2: Regional trends in fish farm development in Ghana

*Production systems*

Three main fish production systems were in use; ponds, pens and cages. Regional distribution of the culture systems is presented in (Figure 2.3). Ponds were most common, at about 98% of the total surveyed. Of these, 96% were earthen and the rest were concrete. Less than 1% of farmers operated cages and about 1% used pens. All the existing cages (2) at the time of the survey were located in Asuogyaman district of the Eastern region; one in the Kpong irrigation dam at Akuse and the other in the Volta lake at Dodzi Ashantikrom. Two more cage farms have since been established, both in the Volta Lake, one at Mpakadam in the same district as the previous two and the other at Dzemeni, South Dayi district of the Volta region (Figure 2.4). All the pens visited were located at Adidome in the North Tongu district of the Volta region. Others have been reported at Mepe also along the Volta and in the same district. The establishment of cages and pens more of recent developments (Table 2.6).

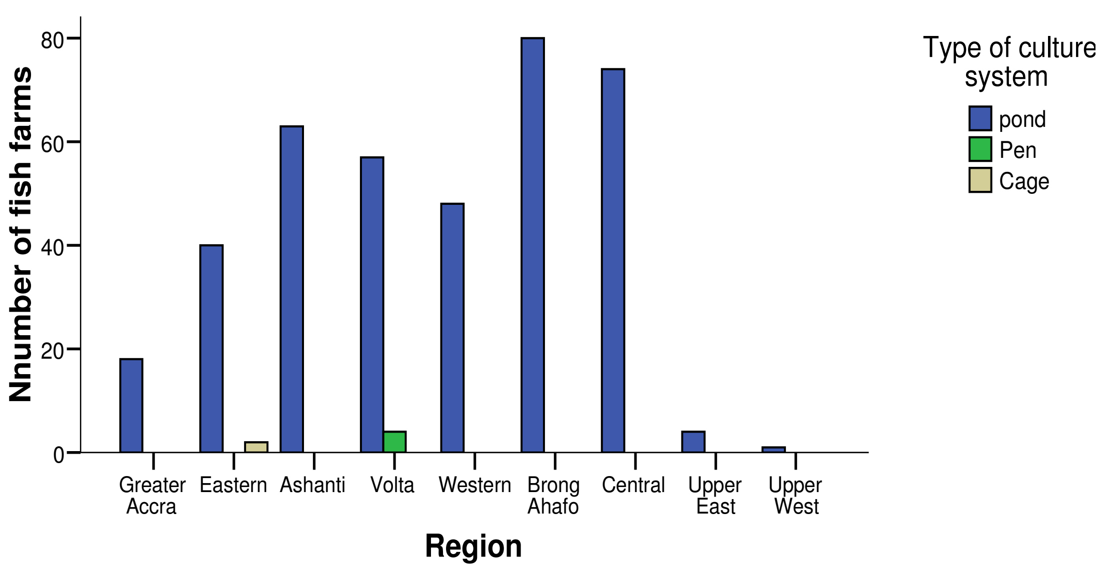



Figure 2.3: Regional distribution of fish farm types

Table 2.6 Types of culture systems and the periods established

| Period | Pond | Pen | Cages |
|---|---|---|---|
| <1966 | 5 | - | - |
| 1966-1975 | 4 | - | - |
| 1976-1985 | 46 | - | - |
| 1986-1995 | 76 | - | - |
| >1995 | 244 | 4.0 | 2 |
| Total | 375 | 4 | 2 |

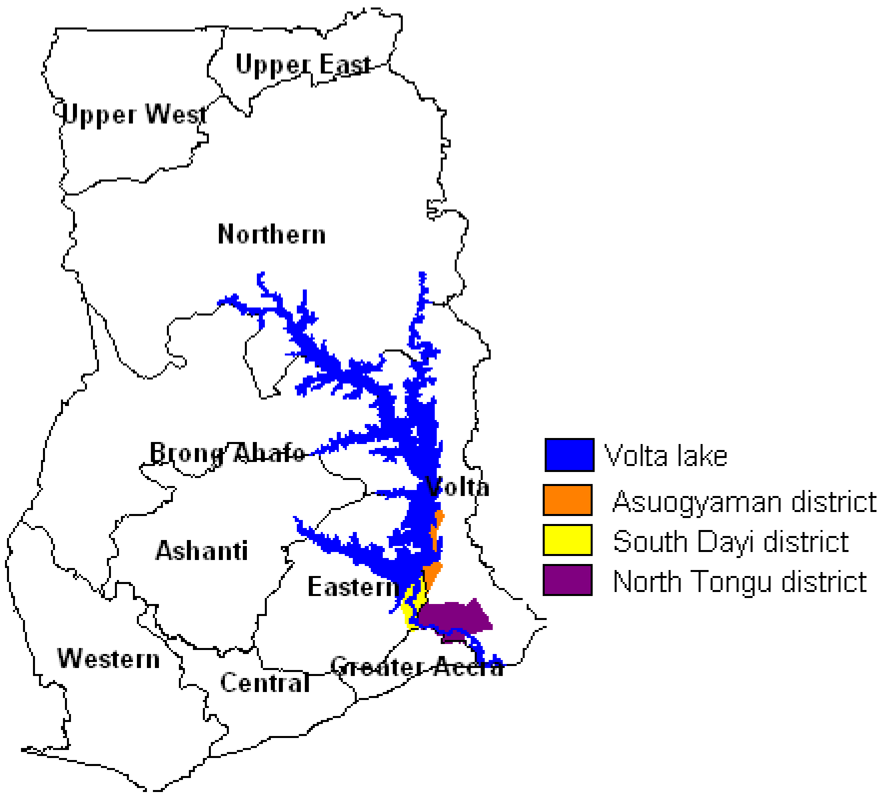



Figure 2.4 Map of Ghana showing the districts with the cage and pen culture systems

*Farm sizes*

The sizes of the fish farms, defined by the total size of ponds per farm, were generally very small. Close to 60.0% of the fish farms had total pond size of 0.10ha or less with just over 8.0% being bigger than a hectare (Table 2.7). Overall the average pond size was 0.36ha. The small farm sizes appear to have been more common since the mid 1980s, though ponds constructed prior to this period were relatively larger. About 18.0%

of farms then had total pond areas exceeding 1ha and over 65.0% were bigger than 0.10ha. This period (the early 1980s) is interesting as it falls within the era of the first massive aquaculture promotion in the country. Regional distribution of farm sizes is presented in (Figure 2.5). The Greater Accra and Ashanti regions had relatively larger farms with 60.0% and 43.0%, respectively, being larger than 0.5ha. The very small fish farms were concentrated in the Central, Brong-Ahafo, Volta and Western regions where about 61.0 to 80.0% of the fish farms were less than 0.11ha in size.

*Farm types*

Using the fish farm classification criteria given in Table 2.4 above, 96.7% of the fish farms were classified non-commercial, 2.6% as small scale commercial and 0.8% as large scale commercial (Table 2.8). The average size of the non-commercial farms was 0.30ha with a median of 0.06ha showing that size of the farms is not normally distributed, it is skewed to towards the small sizes. That of the small scale commercial farm was 0.78ha (median = 0.52ha) and the medium to large scale commercial farm was 6.39 (median = 6.2).

Table 2.7 Size distribution of fish farms in Ghana from 1950 to 2006 (% of total)

| Period | No. of ponds | Total pond size per farm (ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | | <0.01 | 0.01-0.05 | 0.06-0.10 | 0.11-0.50 | 0.51-1.00 | >1.00 |
| <1966 | 4 | -* | - | 25.0 | 25.0 | - | 50.0 |
| 1966-1975 | 3 | - | 50.0 | - | - | 25.0 | 25.0 |
| 1976-1985 | 46 | 5.1 | 17.9 | 10.3 | 33.3 | 15.4 | 17.9 |
| 1986-1995 | 74 | 16.9 | 26.8 | 12.7 | 28.2 | 8.5 | 7.0 |
| >1995 | 250 | 15.0 | 31.0 | 16.0 | 23.0 | 7.3 | 6.0 |
| Total | 377 | 14.0 | 29.1 | 14.8 | 25.4 | 8.5 | 8.3 |

* No farm of such size

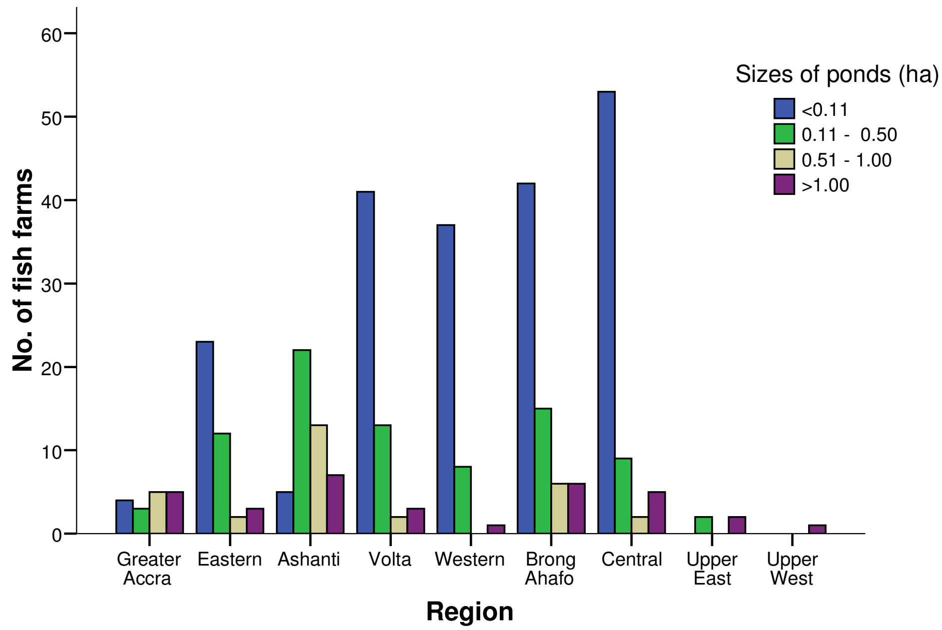



Figure 2.5 Sizes of fish farm across the regions

The smallest small scale commercial farm of 0.02ha was a farm cultivating fish by pen culture. Fish production from 10.5% of the non-commercial farms were primarily for household consumption. All the commercial farms were established after 1995 (Figure 2.6).

Table 2.8 Classification of farm types

| Farm Type | No. of farms | % of total | Average farm size |
|---|---|---|---|
| Non-commercial | 379 | 96.7 | 0.3 ± 0.03 (<0.01 – 3.00) |
| Small scale commercial | 10 | 2.6 | 0.78 ± 0.31 (0.02 – 2.50) |
| Medium scale commercial | 3 | 0.8 | 6.39 ± 2.61 (2.0 – 11.0) |
| Total | 390 | 100 | |

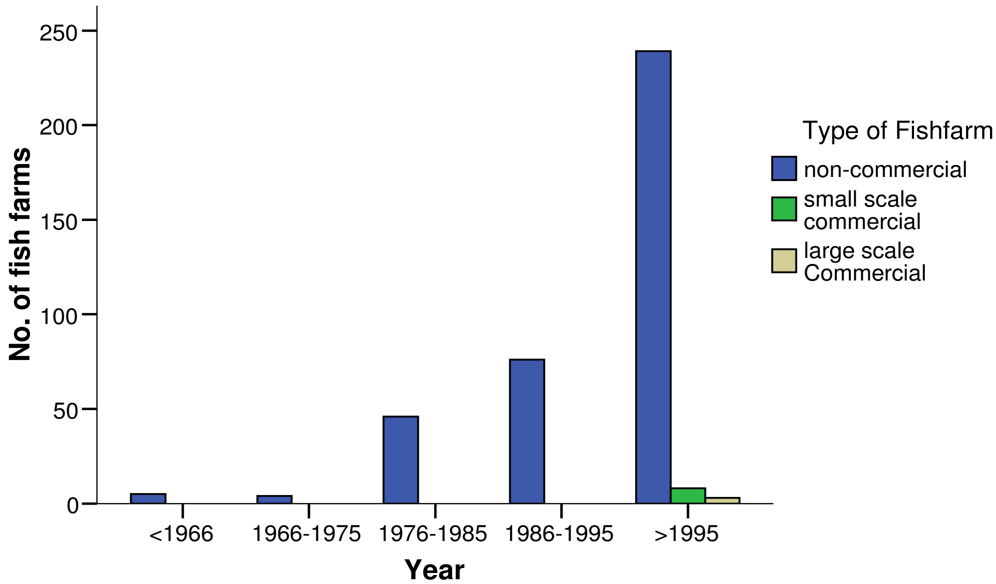



Figure 2.6 Farm types and the periods established

*Pond construction*

Over 78% of ponds were constructed manually, the remainder using mechanical excavation (Table 2.9). A distinct feature in the table is the periods 1966 and earlier, and 1976 – 1985, where relatively more ponds were constructed by mechanical excavation. A chi square text comparing pond size with method of construction showed a significant relationship between the two variables ($\chi^2 = 46$, df = 4, $p < 0.001$) where the percentage number of ponds constructed manually decreased with increasing pond size (Figure 2.7). The years before 1966 and 1976 – 1985 were the only periods when less than 32% of ponds constructed were larger than 0.10ha and that may account for the difference.

The general preference for manual excavation for small ponds may be attributed to the fact that most farmers perceived the cost of mechanical construction to be much higher than manual construction. This perception may however be misplaced as the data showed mean cost of mechanical construction to be GH¢11,900 as against GH¢12,800 for manual construction. This observation was consistent with estimates made by Wijkstrom and Vinke (1991) where mechanical means of pond construction were found to be slightly cheaper.

From the survey, about one in three ponds constructed in 1966 were undrainable and this has not changed much, with a similar ratio in ponds constructed after 1995 (Table 2.9). There have however been some improvements in the number of non-functional ponds since 1995 with 17.2%, as against 25.0% between 1966 and 1995. Design, construction problems and unsuitable siting were the main reasons cited by the farmers.

Table 2.9 Statistics on pond construction

| Period (Year) | No. of ponds constructed | Manually constructed (%) | Mechanically constructed (%) | Undrainable (%) | Non-functional (%) |
|---|---|---|---|---|---|
| <1966 | 5 | 40.0 | 60.0 | 33.3 | 25.0 |
| 1966 – 1975 | 4 | 75.0 | 25.0 | 25.0 | 25.0 |
| 1976 – 1985 | 46 | 40.9 | 59.1 | 33.3 | 18.3 |
| 1986 – 1995 | 74 | 86.5 | 13.5 | 43.1 | 34.9 |
| >1995 | 250 | 84.2 | 15.8 | 34.0 | 17.2 |
| Over all | 379 | 78.8 | 21.2 | 36.1 | 20.6 |

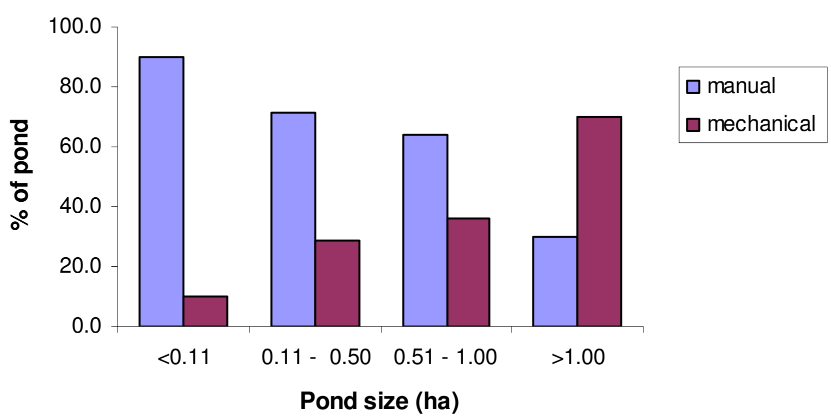



Figure 2.7 Relationship between pond size and method of construction

*Water sources*

The main sources of water to the fish farms were streams/rivers, groundwater in the forms of springs and wells, and rainwater. Other very minor sources were lakes/reservoirs or dams and sewage water. Twelve percent of the farmers depended solely on rainwater, 45.4% on rivers and streams, 40.4% on groundwater, 1.9% on dams and less than 1% on waste water from sewage plants (Table 2.10).

Table 2.10 Sources of water used by fish farmers

| Sources of water | Number of farms | % fish farms |
|---|---|---|
| Rainfall | 44 | 12.0 |
| Stream/river | 166 | 45.4 |
| Spring/groundwater | 147 | 40.4 |
| Reservoirs/lakes | 7 | 1.9 |
| Waste water | 1 | 0.3 |
| Total | 366 | 100 |

*Equipment and machinery*

The equipment and machinery used in fish farming are listed in Table 2.11. The number, type and sizes of equipment used by the fish farmers varied with the size of the farm and level of production. The most common equipment were basic farm tools such as shovels, boots, buckets, cutlasses, and wheelbarrows. Equipment such as pumps, weighing scales, and nets were owned by less than 35% of the farmers, most of whom were either small scale commercial or medium scale commercial producers. The mere size of the subsistence farms does not probably justify the purchase of such equipment as that would increase the cost of production. Besides the basic equipment mentioned above, a few of small scale commercial farms and all medium sized commercial farms visited had their own hatcheries, and aerators for hatchery tanks, feed mills as well as pelletizers to produce pressure pellets for their farms and sometimes for sale to others and canoes (for cage and pen farm operators). Only one commercial farm had pedal wheel aerators for ponds. All the farms equipped with feed mills and feed pelletizers were established within the last six years - suggesting improved capitalization of the sector. It applies though to the medium scale commercial sector which accounts for less than 1% of existing farms.

Table 2.11 List of equipment used and the percentage number of farmers having them.

| Equipment | Non-commercial (N=380) | Small scale commercial (N=8) | Medium scale commercial (N=3) | % of total |
|---|---|---|---|---|
| Basket | 3.2 | 16.7 | - | 3.9 |
| Boots | 64.5 | 71.4 | 100.0 | 65.4 |
| Buckets | 50.5 | 66.7 | 100.0 | 52.3 |
| Cutlass | 56.4 | 71.4 | 100.0 | 58.3 |
| Earth Chisel | 1.1 | - | - | 1.0 |
| Head pan | 13.0 | 33.3 | 100.0 | 16.0 |
| Hoes | 20.4 | 66.7 | - | 22.8 |
| Mattock | 24.5 | 33.3 | - | 24.5 |
| Milling machine | - | - | 100.0 | 1.1 |
| Nets | 26.6 | 50.0 | 100.0 | 30.5 |
| Pelletizer | - | - | 100.0 | < 1.0 |
| Water pump | 21.3 | 37.5 | 100.0 | 22.3 |
| Shovels | 76.3 | 42.9 | 100.0 | 74.5 |
| Wheelbarrow | 48.4 | 100.0 | 100.0 | 50.0 |
| Weighing scale | 4.6 | 100.0 | 100.0 | 7.1 |
| Canoe | - | 29.0 | - | 2.0 |
| Aerator (aquarium) | - | 12.5 | 100.0 | 1.1 |
| Aerator (pedal wheel) | | | 33.3 | < 1.0 |

*Labour*

There were five categories of labour available on the fish farms, all of which played key roles in aspects of farming activities. These were the farm owner, spouses, children, hired labour and others - made up of friends, neighbours and fisheries extension officers. Labourers employed by non-commercial farmers were generally unskilled and did most of the tedious jobs such as pond construction and major pond maintenance (Table 2.12). About 61% (61.3%) of fish farmers hired labour to construct their ponds and 48.7% for major pond maintenance works. Only 32.0% undertook pond construction by themselves. Less than 5% of spouses and 7.0% of children were involved in pond construction. Other roles undertaken by the farm owners or members of their family were feeding, minor pond maintenance, fingerling production (very likely from in pond production), stocking and harvesting. Prominent among the roles played by the spouses were feeding, processing of fish after harvests and selling.

Forms of compensation for hired labour besides money were; the offer of fish or meals, clothes or school uniforms, payment of children's school fees or provision of accommodation. The number of labourers employed per hectare of pond was difficult to estimate from the survey as they were commonly working on a range of farm activities of which fish farming was only a small part.

Commercial farmers on the other hand hired both skilled and unskilled labour, paid to work fully on the fish farms. Labour costs incurred by small scale commercial producers ranged from GH¢ 360 (US$ 380) per annum for unskilled labour to GH¢ 1,440 (US$ 1500) per annum for a technician. Salaries paid by commercial farmers whose staff included qualified graduate employees were not given.

Table 2.12 Farm activities and roles undertaken by owners, spouses, children, hired labour and other

| Farming activities | Owner (%) | Spouse (%) | Children (%) | Labourer (%) | Others (%) |
|---|---|---|---|---|---|
| Pond construction | 32.0 | 4.0 | 7.3 | 61.3 | 2.7 |
| Major pond maintenance | 23.3 | 2.7 | 6.0 | 48.7 | 2.7 |
| Minor pond maintenance | 56.7 | 8.0 | 20.7 | 30.7 | 2.0 |
| Pond management | 61.3 | 9.3 | 14.7 | 10.0 | 2.0 |
| Fingerling production | 65.3 | 4.0 | 7.3 | 4.0 | 8.0 |
| Stocking | 68.0 | 2.7 | 4.7 | 2.7 | 6.7 |
| Feeding | 83.3 | 42.0 | 42.7 | 11.3 | 3.3 |
| Draining/harvesting | 57.3 | 17.3 | 29.3 | 20.0 | 7.3 |
| Processing | 22.0 | 46.7 | 8.0 | 6.7 | 2.0 |
| Market/transport | 29.3 | 44.0 | 14.0 | 0.7 | 2.0 |

### 2.3.2 Social characteristics of farmers

*Gender*

Fish farming in Ghana was male dominated. Women accounted for less than 5% of the producers at the subsistence level of production. Figure 2.8 shows the participation of men, women and groups in aquaculture over the years. From the graph, women have so far owned fish farms the least and there has been very minimal increase in their numbers over the years (Figure 2.8). Over 70% of the non-commercial farms owned by married men were however operated jointly with their wives and children who often took on the role of feeding, processing and selling the fish after harvests.

The establishment of fish farms by groups is the second least common category after ownership by women but has seen relatively better growth since 1995. These are fish farms owned by institutions such as churches, offices, non-governmental organizations (NGO) and members of a community. In an example of a community group farm in the Ga West District of the Greater Accra Region, farming operations were coordinated by an NGO, labour was provided by men in the community and when fish is harvested, they are sold very cheaply to the members of the community and proceeds from the sale are deposited in the community's coffers.

Contrary to female ownership in subsistence fish farming, two of the five producers at the small to medium scale commercial farming levels were female, both of whom started operations within the last ten years.

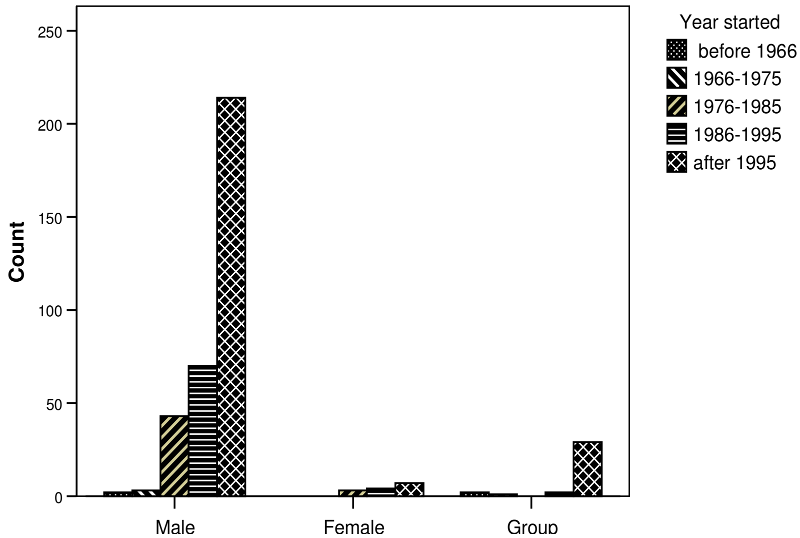


Figure 2.8 Aquaculture development and gender in Ghana

*Educational level*

The educational backgrounds of the fish farmers were categorised in six groups; no formal education, basic school level education, vocational/commercial school level, secondary school qualification, post-secondary qualifications, and university degree and above. About 8% of fish farmers had no formal education, 44% had only attained basic level education i.e. primary to middle school leaving certificate level education. Twelve percent had attained secondary level education whilst 12.3% and 10.4% had post-secondary qualifications and university degree education respectively. The rates at which people of different educational background entered aquaculture are presented in Figure 2.9. There was a general increase in people of all educational backgrounds going into fish farming. The group of people least entering the sector are those with no formal education.

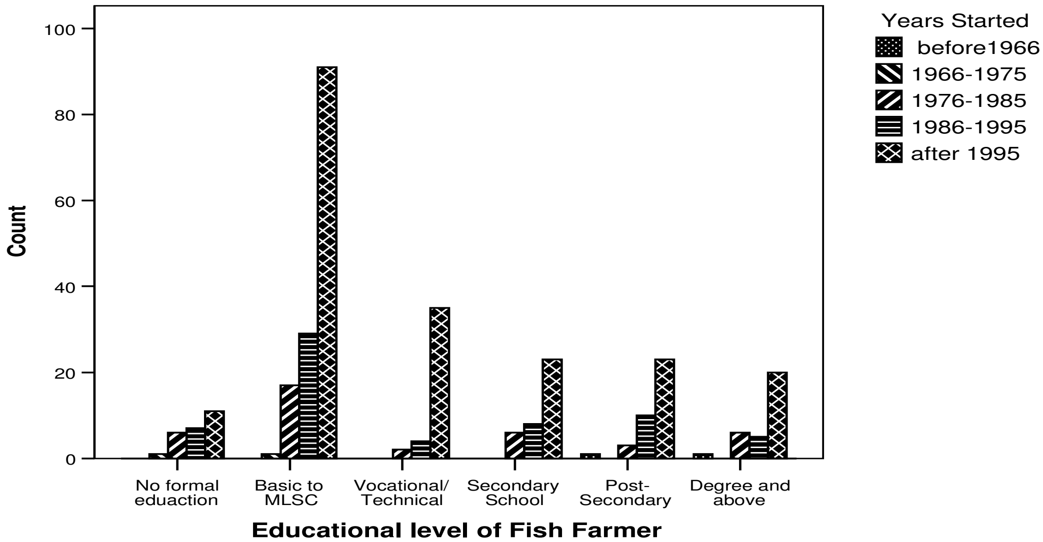



Figure 2.9: Educational background of fish farmers and the year they started fish farm

*Land ownership*

Land ownership in Ghana is either by stools[b], clans, families, individuals or the state. The stools, clans, families and the individual together are custodians of about 70% of the land (Larbi et al. 1998).

Sixty-seven percent of the farmers interviewed owned (with legal title) the land they operated on, 1% operated on family owned lands, 1.4% on state lands and 30.5% on lands leased from chiefs, individuals or the state. The sizes of land owned by the farmers ranged from less than 1ha to 100ha. Over 50% of the lands owned were less than a hectare in size (Table 2.13). There was a significant relationship between sizes of land holding and level of education of the fish farmers ($\chi^2 = 38$, df = 20, $p<0.01$) with 75.0% of the farmers with a minimum of first degree owning lands of at least a hectare in size compared to 26.4% of those with no formal education (Figure 2.10). There was however no significant relationship between size of land holdings and pond sizes

[b]In Ghana a Stool is a term literally used to represent the traditional office for chiefs in the south. Stool lands are lands entrusted in the appropriate Stool on behalf of and in trust for the subjects of the Stool (Source -http://www.ghana.gov.gh/ghana/lands_and_natural_resources.jsp).

(Figure 2.11). Across the regions relatively more farmers (over 60%) in the Eastern, Ashanti, Volta, Brong Ahafo and Central regions operated on own lands while in the Greater Accra, Western and Upper East regions more than half operated on leased lands (Figure 2.12). The size of land holdings are generally considered to be one of the important indicators of social status in rural areas (Singh, 2003).

Table 2.13 Sizes of lands owned by farmers

| Land Size (ha) | Frequency | Percentage |
|---|---|---|
| ≤0.10 | 19 | 7.8 |
| 0.11 to 0.50 | 57 | 22.1 |
| 0.51 – 1.00 | 56 | 21.7 |
| 1.01 – 5.00 | 72 | 27.9 |
| > 5.00 | 54 | 20.9 |
| Total | 258 | 100 |

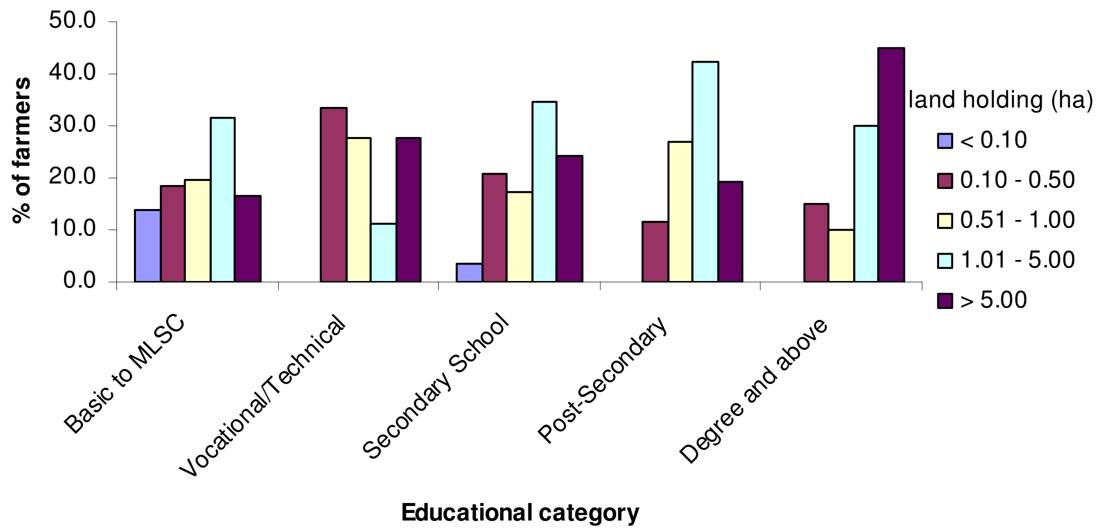



Figure 2.10 Relationship between fish farmers' land holding educational level

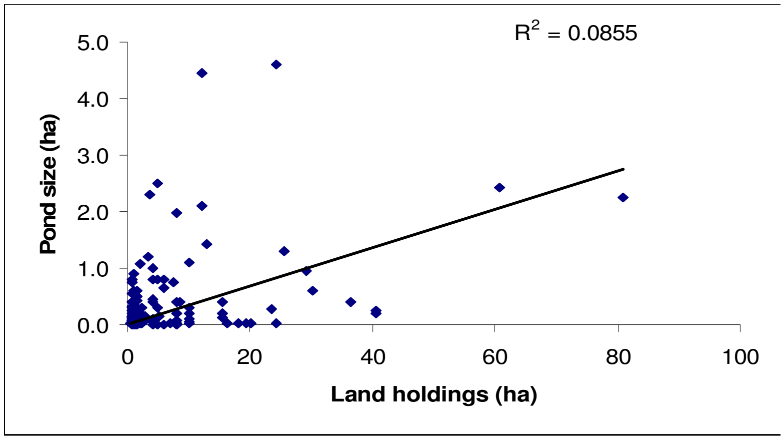



Figure 2.11 Relationship between land holdings and farm size

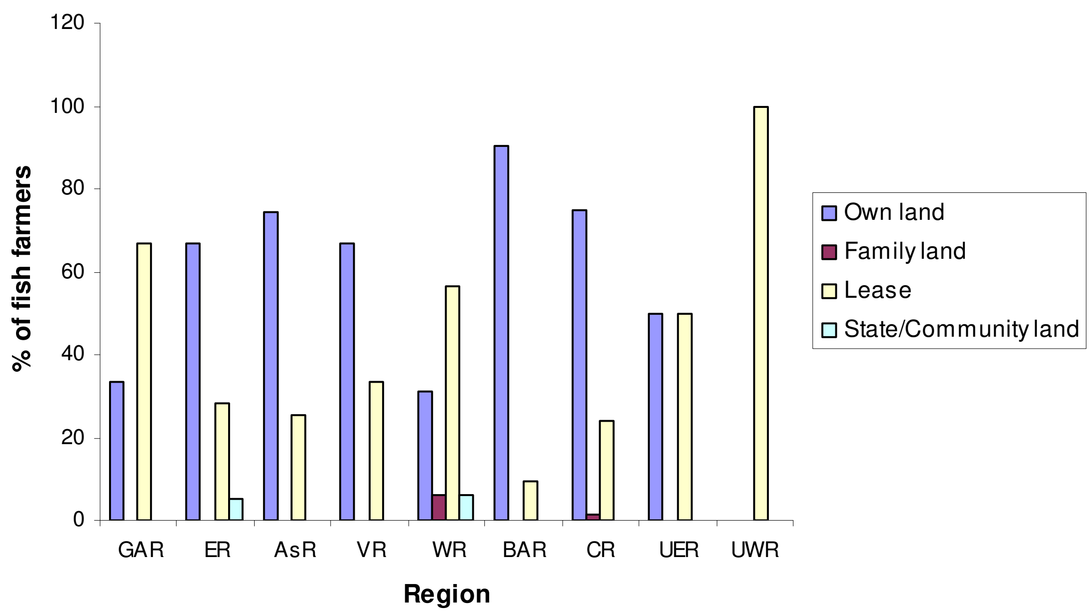



Figure 2.12 Ownership of lands by farmers by region

*Main occupations*

Only 9.8% of the respondents considered aquaculture as their main economic activity (Figure 2.13). Other occupational backgrounds were varied, ranging from small scale farmers to skilled professionals. About 58.0% were engaged in some form of agricultural activity of which 54.9% were engaged in commercial agriculture involving crops, livestock or both and the rest (45.1%) were engaged in small scale agriculture.

About a quarter (24.6%) was engaged in various jobs including civil servants, artisans, self-employed etc. A total of 7.4% were high level skilled professionals. More than 92% of the subsistence farmers indicated not considering aquaculture as their main source of income primarily because of poor net returns. With the commercial farmers, 75% of the small scale commercial and 25% of the medium scale producers did not consider aquaculture as the main source of income but as one of several income generating activities they were involved in.

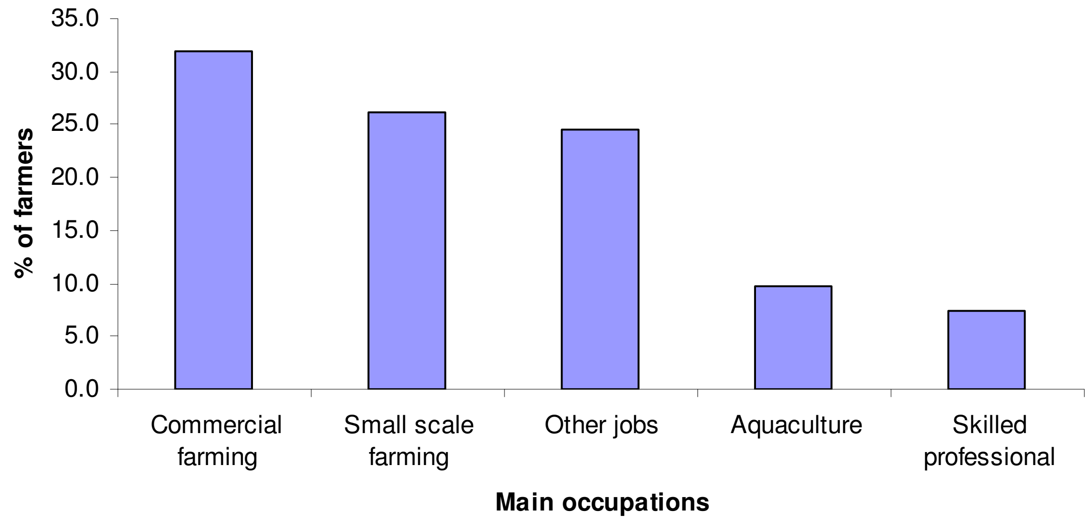



Figure 2.13 Main occupations of non-commercial farmers

*Sources of funding*

The fish farm development and operations by the farmers were primarily self-financed (Figure 2.14). Eighty-three percent of the non-commercial producers, 77.7% of small scale commercial producers, and 66.6% of the commercial producers established the farms with their own funds. With the rest, it was a combination of personal funds and bank loans, as well as family and friends.

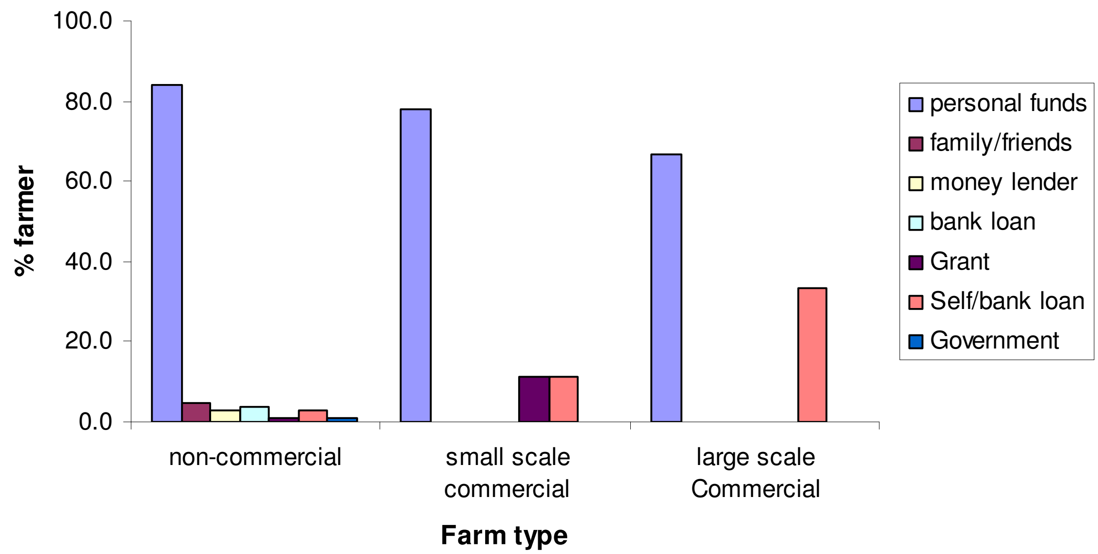



Figure 2.14 Sources of funding for fish farming

### 2.3.3 Aquaculture practices

*Species cultured*

The primary species cultured by about 90% of all the farmers was tilapia (*Oreochromis niloticus*), with 54% producing it in a mixed culture with catfish (*Clarias gariepinus)* and mudfish (*Heterobranchus spp*.), about 14% in a mixed culture with snake head (*Channa striata*), grey mullet, heterotis and variety of other endemic species. Mixed cultures and monoculture of catfish were primarily in ponds. All the pens and cages visited were used for monoculture of tilapia. Only 23.7% and 14.5% of ponds farm operators practiced monoculture of tilapia and catfish respectively (Figure 2.15).

A third (33.7%) of farmers obtained fingerlings from the government institutions which from the surveyed data supplied 2,445,634[c] of fingerlings accounting for 31.3% of total fingerlings supplied. Fingerlings from the wild accounted for 37.0% (2,894,292),

[c] This figure was estimated from the sum total of fingerlings stocked per hectare per annum by farmers who mentioned institutions for instance as their main source of tilapia fingerling. A similar method was used to determine the number of fingerlings supplied by the other sources.

hatcheries accounted for 8.4% (660,593) and 23.3% from in pond production. Tilapia fingerlings from "own/fellow farmers" were mainly from in pond production and by subsistence farmers. According to five farmers involved in this, initial fingerling production was accidental but this venture was found to be more profitable than growing fish to table size and had then become a major activity. Relatively more fish farmers (46.9%) relied on catfish fingerlings from the wild than other species.

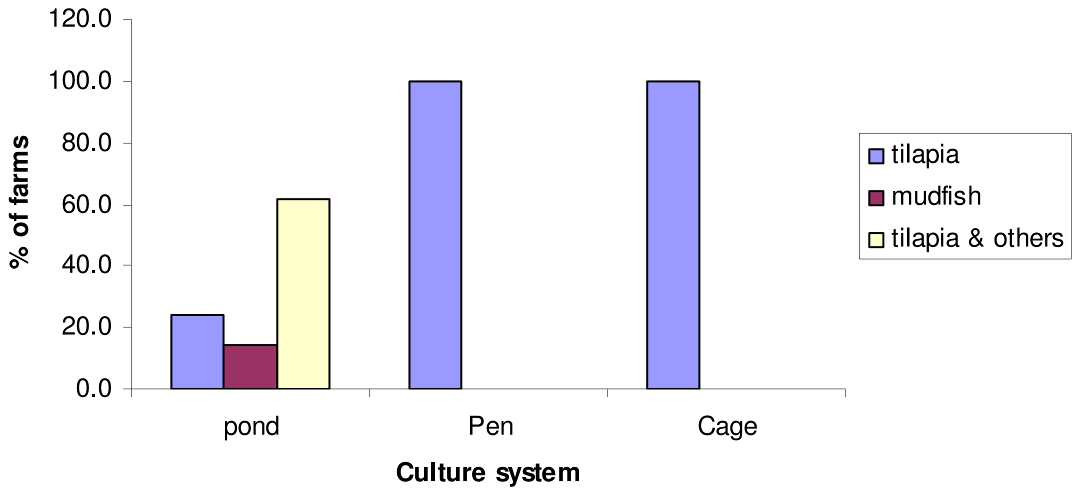



Figure 2.15 Culture systems and commonly types of species cultured in them

Table 2.14 Types of fingerlings and main sources of supply to farmers

| Sources of fingerlings | % of farmers total number of respective species obtained | | | Total |
|---|---|---|---|---|
| | Tilapia | Catfish | Others | |
| Institutions | 33.7 (2,445,634)** | 43.9 (63,418) | 41.7 | 37.2 |
| Private hatchery | 13.2 (660,593) | 2.8 (47,583) | 2.8 | 7.0 |
| Own/Fellow farmer (Inbreeding*) | 26.6 (1,820,329) | 6.1 (7,945) | 27.8 | 25.9 |
| Wild | 26.5 (2,894,292) | 46.9 (60,187) | 27.8 | 29.9 |
| Total | 100 (7,820,848) | 100 (179,133) | 100 | 100 |

* Applies mainly to tilapia
** The figures in brackets are estimated quantities of fingerling supplied

The quantities of wild catfish fingerlings supplied accounted for 33.6% of the total number of catfish fingerling stocked. The institutions supplied the largest quantity of catfish fingerlings of 63,418 (35.4%) (Table 2.14).

Table 2.15 Incidence of in pond production and survival rates of tilapia fingerlings obtained by farmers from a range of sources

| Sources of Fingerling | Incidence of in pond production | | Survival rates (mean ± SE) |
|---|---|---|---|
| | Yes | No | |
| Own/Fellow farmer (n = 20) | 51.2 | 48.8 | 46.3 ± 6.0 (3.0 – 82.5) |
| Institution/Hatchery (n = 8) | 53.5 | 46.7 | 29.0 ± 9.4 (4.8 – 66.7) |
| Wild (n = 9) | 12.5 | 87.5 | 40.3 ± 11.4 (10.0 – 80.0) |
| Over all mean | 46.9 | 53.1 | 41.6 ± 4.3) (3.2 – 85.7) |

n = sample number (Number of farms)

Survival rates for tilapia fingerlings ranged from 3.2 to 85.7% with mean survival rate of 41.6% and a median of 38.1% which is not very different from the mean suggesting that the survival rates are about evenly distributed over the population (Table 2.15). Only 30% had survival rates exceeding 50%. Tilapia in pond seed production occurred in several ponds irrespective of the source of fingerlings (Table 2.15). Ponds stocked with fingerlings from the institutions/hatcheries had the highest incidence of in pond seed production and the lowest survival rates. The second highest occurrence of in pond seed production was in ponds stocked with fingerlings from fellow farmers or own ponds. These were sometimes made up of tilapia in production ponds which could not be caught in the net during harvesting because of their stunted growth and are used as fingerlings (FAO 2006b). Survival rates for these fingerlings were better than those from the institutions/hatcheries. In pond seed production was lowest in ponds stocked with fingerlings from the wild.

Survival rates of catfish from fingerling were slightly higher than that of tilapia ranging from 5.0 to 80.0% with a mean of 44.6% (median = 40.7%). There were very minimal variations in survival rates of catfish fingerlings from the four main sources (Table 2.16). The number of ponds with incidence of in pond seed production was also very low compared to that of tilapia with about 19% of farmers reporting it. Ponds stocked with catfish fingerlings from the wild again had the lowest incidence of in pond seed production, followed in increasing order by that produced from the institutions/hatcheries, and own/fellow farmers.

The stocking density for tilapia ranged from less than 1 per $m^2$ to 38 per $m^2$ and that of catfish was generally less ranging from 0.01 to about 1 per $m^2$.

Based on the survival rates, the total number of fingerlings stocked, an assumed average harvest size of 200g irrespective of species and extrapolating to include all the fish farmers in the country, fish production was estimated at 1,455mt for 2006 which is higher than the officially reported output of 1,150mt.

Table 2.16 Occurrence of in pond seed production and survival rates of catfish fingerlings obtained from different sources

| Sources of Fingerling | Incidence of in pond seed production? | | Survival rates (mean ± SE) |
|---|---|---|---|
| | Yes | No | |
| Own/Fellow farmer (n* = 20) | 23.1 | 76.9 | 45.2 ± 6.4 (5.0 – 81.1) |
| Institution/Hatchery (n = 8) | 14.3 | 85.7 | 45.7 ± 11.9 (7.7 – 80.0) |
| Wild (n = 9) | 13.3 | 86.7 | 43.2 ± 6.6 (13.3 – 80.0) |
| Over all mean | 18.7 | 81.3 | 44.6 ± 4.7 (5.0 – 81.0) |

n = sample number (number of farms)

The price per fingerling was quite varied ranging from GH¢0.02 to GH¢0.10 for tilapia and GH¢0.10 to GH¢0.20 for catfish. Fingerlings produced in ponds by subsistence farmers were cheapest while that from the hatcheries/institutions were relatively more expensive (Table 2.17) at GH¢0.10 per tilapia fingerling or GH¢0.20 per catfish fingerling.

The main sources of fingerlings by fish farmers across the regions is presented in Figure 2.16. A large proportion of fish farmers in the Greater Accra, Eastern, Ashanti and Volta regions obtained their fingerlings from Institutions, largely the Fisheries Directorate – directly from their hatcheries in regions where they exist or were obtained from other sources but through the assistance of an extension officer. Main sources of fingerlings for farmers in the Brong-Ahafo, Western and Central regions were from fellow farmers, which were produced in ponds, and wild sources. Overall, the institutions were the main sources of supply at 35.1% followed in decreasing order by fingerlings from the wild, fingerlings from fellow farmers, and those from hatchery operators Table 2.17.

Table 2.17 Sources and prices of fingerlings used by the fish farmers

| Sources of fingerlings | % of Total | Cost per fingerling GH¢ | |
|---|---|---|---|
| | | Tilapia | Catfish |
| Institutions | 35.1 | 0.10 | 0.20 |
| Fingerling producer | 7.0 | 0.10 | 0.20 |
| Own hatchery | 1.1 | 0.10 | 0.20 |
| Fellow farmer/own farm | 25.2 | 0.02 | 0.10 |
| Wild | 31.6 | 0.03 | 0.10 |
| Total | 100.0 | | |

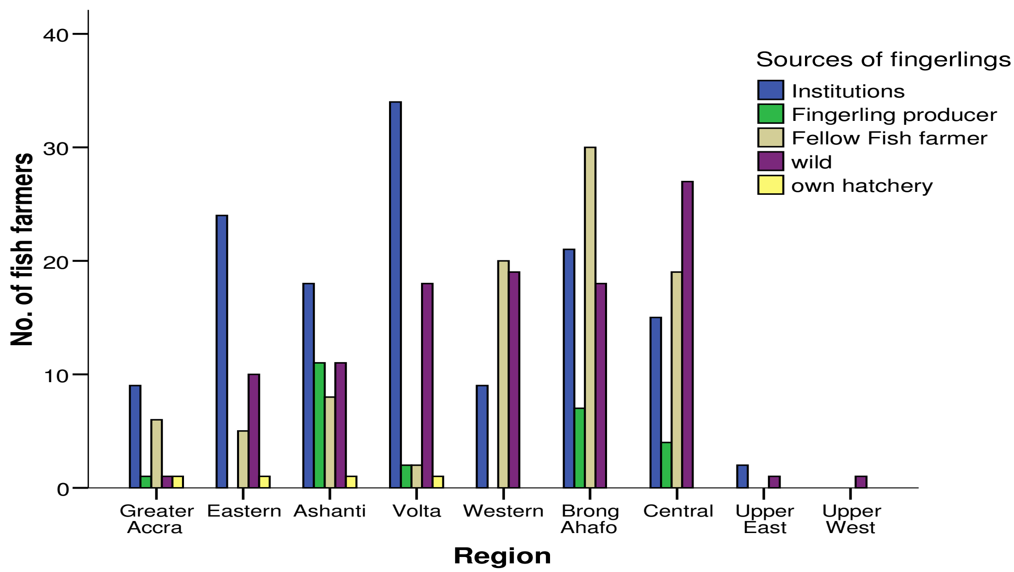



Figure 2.16 Source of fingerling by farmers by region

*Fertilizer and manure*

The need for the application of manure was common knowledge among the fish farmers. In excess of 72% (72.4%) of the farmers applied organic fertilizer in the form of chicken droppings, pig manure, sheep manure or cow dung. About 2% (1.8%) applied inorganic fertilizer and 3.6% applied both organic and inorganic fertilizer. Twenty-two percent (22.1%) of farmers applied no manure or fertilizer, though most of these had virtually abandoned their ponds due to poor performance, harvesting them only for own consumption. Quantities applied ranged from 6kg to 13,888kg/ha/yr with a mean of 2,502 kg/ha/yr and median of 1,263 kg/ha. These quantities seemed quite low as the mean level amounts to only 6.8kg/ha/day, and the maximum only 38.0kg/ha/day. McGeachin and Stickney (1982) found that the application of 70-140kg/ha/day dry, laying hen manure yielded the best growth and survival of *Oreochromis aureus* cultured in sewage lagoons, depending on water quality. Mean costs of organic manure applied per hectare per production cycle was about GH¢ 12.40 which was mostly cost of transportation and a source of modest additional revenue for workers on the poultry farm who gather these wastes for the farmers to collect free of charge. Inorganic fertilizer was applied by relatively few farmers, most of whom were commercial producers. Quantities applied ranged from 11kg/ha to 965kg/ha with mean and median values of 313kg/ha and 187kg/ha respectively. The average cost per hectare per production cycle was not immediately known as no prices were provided by the farmers. It is however expected to be relatively higher than that of manure. None of the farms visited mentioned difficulties in acquiring manure. Other ways of pond fertilization observed on two farms and on experimental ponds of the Aquaculture Research and Development Centre (ARDEC) of the Water Research Institute are direct integration of fish farming with livestock farming whereby manure are channelled directly into the pond either by pipes as in the case of a pig – fish integrated farm (Plate 2.1) or poultry/ducks – fish integrated farms where the dropping are directly from the birds to the pond (Plate 2.2)

Plate 2.1 Waste from a piggery channelled (arrowed) directly via drains to a pond in the Ashanti region

Plate 2.2 A duck farm next to a pond in the Greater Accra region

*Supplementary feeds*

The most common feeds used by non-commercial farmers were wheat bran, maize bran, rice bran and other cereal brans, which were readily available on the market.

Other supplementary feeds used by non-commercial farmers included agricultural wastes such as cocoyam leaves, cassava chips and leaves, ripe pawpaw fruits and leaves; agricultural-industrial by-products such as oil cakes, local brewery waste and maize grits; kitchen wastes and food left-overs; termites, maggots and leucaena (*Leucaena leucocephala*) leaves.

Very few of the subsistence farmers used formulated feed which is relatively expensive. Posted prices varied considerably; that produced by a local commercial farmer was selling for GH¢ 0.50/kg (US$ 0.52/kg), GH¢ 4.0/kg (US$ 4.27/kg) by a commercial feed factory and GH¢ 9.0/kg (US$ 9.38/kg) for feed imported from Israel. Main differences between the imported and locally produced feeds are that the former comes in different pellet sizes (2mm to 6mm) making it suitable for fish of varying sizes, and is extruded, whilst the locally produced feeds come in a single size (6mm diameter), are not extruded and have no defined food conversion rates (FCR) (E. Abban, formerly of Water Research Institute, pers. comm., 2008). The cheapest feeds were the cereal brans and the other feeds, at GH¢ 0.10 (US$ 0.10/kg) and GH¢ 0.05 (US$ 0.05/kg), respectively. All the commercial farms visited used pelletised feed which they either manufactured themselves or purchased from the market.

Table 2.18 Types of supplementary feeds used by farmers

| Feed Type | % farmers (N = 358) |
|---|---|
| Pelletised formulated feed | 3.0 |
| Cereal bran and fish meal | 4.7 |
| Cereal bran only | 65.6 |
| Others | 25.7 |
| Total | 100 |

Feeding by most of the farmers interviewed was done arbitrarily with no regard to standing crop. The efficiency with which the feeds were utilised for growth by the culture animals as may be expected varied from one feed type to the other. Very crude estimates of the FCR of the different feed types used by the farmers are presented in Table 2.19. These were obtained by dividing the total quantity of feed reported to be used per production cycle, by the reported yield.

Table 2.19 Estimated feed conversion ratios of feeds used

| Feed Type | Mean FCR | Range | Feed cost/production (GH¢/kg fish) |
|---|---|---|---|
| Pelletised formulated feed (n = 8) | 1.45 ± 0.61 | 1.00 – 3.00 | 1.36 |
| Cereal bran and fish meal (n = 7) | 4.62 ± 1.53 | 1.00 – 12.00 | 2.08 |
| Cereal bran only (n = 68) | 5.89 ± 0.78 | 1.00 – 18.00 | 1.84 |
| Others (n=30) | 4.89 ± 0.92 | 0.86 – 26.67 | 1.32 |

Pelletised feeds yielded the best FCR, about three times as good as that of the cereal bran and fish meal feed and four times as good as that of cereal bran only. Mean FCR of the feed categorised as others, made up of food left overs, fresh fruits, farm produce, termites, vegetables etc. was very close to that of the cereal bran fish meal feed. Variations in FCRs of particular feed types could be attributed to differences in the quality and digestibility of specific nutrients in for example, the cereal bran types (wheat bran, rice bran, maize bran), on feeding regimes, environmental factors and the species cultured as the estimate did not take into consideration the species. Feed costs per kilogram production were less varied ranging from GH¢1.32 for the “other” feed to GH¢ 2.08 for the cereal bran – fish meal feed. Although the cost per kilogram of pelletised feed was relatively more expensive, its low conversion ratio effectively made up for the difference in price. Quantities of feed applied by the farmers per hectare of culture area ranged from 3kg to about 15,000kg per month. The quantities applied per standing crop were however not available. Since feed is one of the major costs for aquaculture operations, clearly the suitability of the feed used, the efficiency with which it is utilised for growth by the culture animals and the feeding practices used will be major factors determining the profitability of the aquaculture operation.

### 2.3.4 Harvesting and marketing

Production cycles of the non-commercial fish farms ranged from three months to two years with mean production period of 8½ months and median of 12 months which implied that many of the farmers were taking more than a year to produce fish for harvest. Harvesting by small producers in this group was done with the assistance of fisheries extension officers as they did not have the required nets. Production ranged from 80kg to 10,839 kg/ha/year with a mean production figure of 2,952kg/ha/year and median of 2,414kg/ha/year. The mean falls well within the range of 2,500 to 4,000kg/ha/year reported by Diana and Lin (1998) and Diana et al. (1991) for *O. niloticus* in fertilized ponds but below the range of 5,000 to 12,000 kg/ha in fertilized-fed ponds (Diana et al. 1994). Less than 10% of the farmers attained annual yields within the latter range. These farmers were largely owners of very small ponds culturing intensively.

The sale price depended very much on the size of fish. Farmers who produced fish weighing around 200g or more reported having no difficulties in selling it as these had a ready market and relatively better price. Producers of relatively smaller fish had difficulties selling them at good prices and in several cases, according to the farmers the dealers decided what they would pay for it. Harvested fish were mostly sold fresh (Table 2.20). Unsold fish were kept frozen or processed by smoking, salting and/or fermenting. Marketing costs for subsistence farms were relatively low as most of fish were sold at the farm gate.

Table 2.20 Product forms sold by farmers

| Product form sold | No. of fish farms | % of total |
|---|---|---|
| Live | 14 | 5.0 |
| Fresh | 197 | 70.9 |
| Processed | 9 | 10.4 |
| Fresh, frozen, processed | 38 | 23.7 |

Production by the commercial farms was an average of a 7 month production cycle. Close to 80% of fish harvested by the commercial farms visited in the Eastern and Volta regions, were transported to Accra for sale. In the Ashanti region, according to the owner of the commercial farm visited, harvested fish, particularly catfish, were bought by dealers who go on to smoke it and exported to ethnic markets in Europe and the USA. A study by Diei-Ouadi and Mensah (2005) revealed that fish dealers in fish communities along the Volta lake, preferred to transport and market their fish in the main cities like Accra, Kumasi and Yeji because returns after sale were much higher.

In all the regions, except the Ashanti region where wholesale price per kilogram of fish were pre-determined by the region's fish farmers' association, prices varied from farm to farm, from a minimum of GH¢ 2.0/kg for fish weighing between 150 and 200g to a high of GH¢ 3.8/kg for fish weighing about 500g. Although the prices of fish by the commercial producers were generally fixed per weight of fish, very large wholesale buyers were given discounts ranging from 10% to 20% off the per kilogram price.

### 2.3.5 Farm classification using factor analysis

A final set of analysis was the classification of fish farms based on size and levels of input and output using a factor analysis followed by cluster analysis. Results of the KMO test and Bartlett's text of sphericity are presented in Table 2.21, confirming that data was suitable for factor analysis. The communalities are presented in Table 2.22. The extraction communalities indicate the amount of variance in each variable that is accounted for by the factors in the factor results. Small values usually indicate that the variables do not fit well in the factor solution and should be dropped. The significance of a factor loading is however related to the sample size and according to guidelines for identifying significant component loadings by Hair et al. (1998), with a sample size of 320, factor loadings of about 0.33 and above should be considered significant (Table 2.23). All the component loadings obtained exceeded this value and were therefore considered significant. More than half of the original variances for all the variables except feed were accounted for in the extractions (Table 2.22).

Table 2.21 KMO and Bartlett's statistics for the data set

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy. | | 0.69 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 201.46 |
| | Df | 15 |
| | P | <0.001 |

Table 2.22 Factor analysis communalities

| Variable | Initial | Extraction |
|---|---|---|
| Total Fertilizer | 1.000 | 0.526 |
| Stocking density | 1.000 | 0.541 |
| Total feed | 1.000 | 0.396 |
| Pond size | 1.000 | 0.777 |
| Labour | 1.000 | 0.756 |
| Equipment | 1.000 | 0.822 |

Table 2.23 Guidelines for identifying significant factor loadings based on sample size

| Factor loading | Sample size |
|---|---|
| 0.30 | 350 |
| 0.35 | 250 |
| 0.40 | 200 |
| 0.45 | 150 |
| 0.50 | 120 |
| 0.55 | 100 |
| 0.60 | 85 |
| 0.65 | 70 |
| 0.70 | 60 |
| 0.75 | 50 |

Source: (Hair et al. 1998)

Table 2.24 Component solution matrix

| | Component | |
|---|---|---|
| | 1 | 2 |
| Total Fertilizer | 0.34 | 0.64 |
| Stocking density | 0.71 | 0.18 |
| Total feed | 0.62 | -0.13 |
| Pond size | -0.85 | 0.24 |
| Equipment | -0.08 | 0.87 |
| Labour | -0.88 | 0.22 |

## Component loadings

*Component 1 – Small ponds / production intensity*

Two main components were identified from the factor solutions (Table 2.24). Stocking density per $m^2$ and total feed quantity per hectare per year loaded positively on the first component whilst pond size and labour loaded negatively. The first component thus describes very small farms with relatively high inputs of fingerlings and feed but with very low hired labour input. Most fish farmers in Ghana applied inputs without much consideration to the standing crop. Farmers with smaller ponds therefore stood a better chance of applying sufficient amounts of inputs than farmers with larger ponds and that may explain the trend observed. This component accounted for about 45% of the variances observed in the entire data.

*Component 2 – Resourced farms*

Only two variables loaded significantly on the second component. These were total cost of equipment which is an indication of the resource level of the farm and the quantity of fertilizer applied per hectare per year which loaded negatively, suggesting an inverse relationship between the two variables.

## Cluster results

Five non-commercial farm groups were identified. Their scores and number of farms in each category for each component are presented in Figure 2.17 and Figure 2.18. Farm types 2 and 4 featured prominently in components 1 and 2 respectively. Major characteristics of the five farm types and their owners are listed in Table 2.25 and Table 2.26 respectively. The main differences were in the sizes of the ponds, the levels of input in relation to feed, manure, stocking density and hired labour.

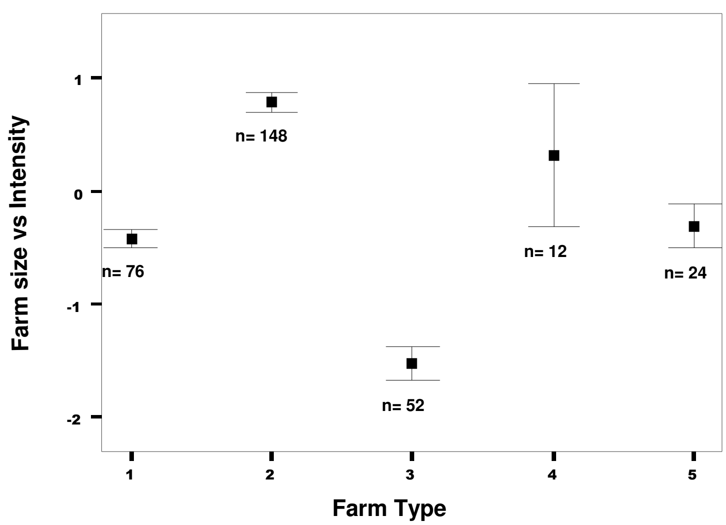



Figure 2.17 Cluster solutions for component 1 with scores for pond size and farming intensity

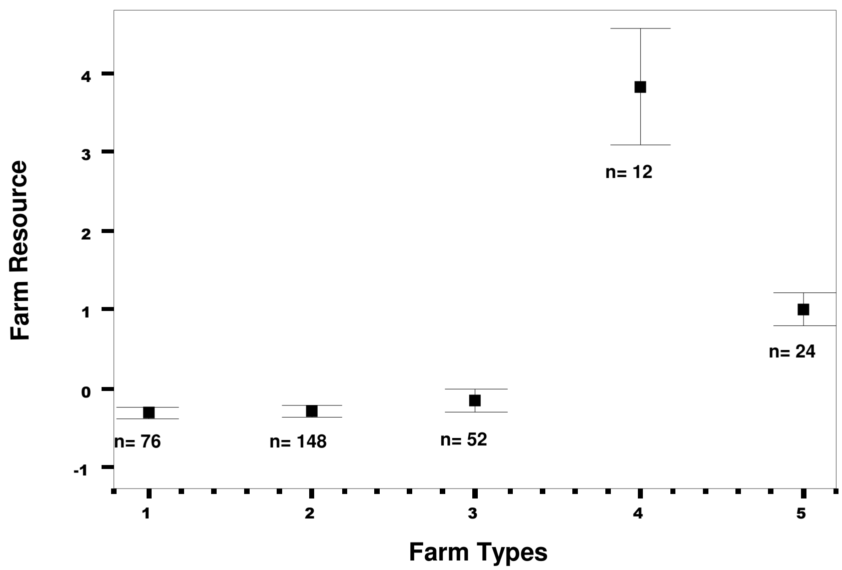



Figure 2.18 Cluster solutions with scores of the farm types for farm resource

Farm type 1 comprised 76 farms most of which were quite small farms with sizes ranging from 0.02 to 0.4 ha with mean and median values of 0.11ha and 0.10ha respectively. Stocking density was the second highest of the five groups at about 4.6/m$^2$. Fingerlings were sourced from fellow farmers/own farms (58.4%) or from hatcheries/institutions (41.5%). Compared to farm types 3, 4 and 5 use of hired labour was very low suggesting that much of the farm duties were either undertaken by the owners or family and friends. The main feed types applied were cereal bran (66.7% of farmers) and other feeds (30.4%). The rest (2.9%) applied cereal bran/feed meal. Mean quantity of fertilizer applied was 471kg/ha/annum, the second highest after farm type 2. About 83% of farms were owned by males, 7.9% by females and 9.2% by groups. In terms of education, 9.4% had attained a university degree but the majority (40.6%) only had basic to middle school level education. Only 6.3% of members in this group considered aquaculture their main economic activity. 25.0% were commercial crop and/or livestock farmers, 18.8% were also involved in agriculture but on a smaller scale.

The largest proportion (48.3%) were involved in non-agriculture activities. Funding for projects was largely equity with only 11.0% borrowing money to start the farm. More than three-quarters (76.4%) of farmers owned the land they operated on (with legal title), 20.8% on leased land, 1.4% used family land and another 1.4% state land. This group was the second largest after farm type 2. Fish yield per hectare per annum was 2284kg.

Farm Type 2 which comprised 148 farms was made up of much smaller farms with mean farm size of 0.03 ha and median of 0.02ha - smaller than all the other types. These had the lowest inputs of hired labour per hectare but had relatively higher stocking density at 4.7/m$^2$. Mean quantities of feed and manure inputs per hectare were significantly higher than those applied by farmers of the groups. This group again compared to the others hardly used hired labour (10 man days/ha/annum) (Table 2.25). The Farmers were again male dominated (94.6%). A relatively smaller number (4.8%) had attained university level education but the general levels of education by members were the lowest of the five groups. Less than 25% had attended school beyond the vocational level compared with a range of 33.3% to 51.5% in the other groups. The main occupation of these farmers was again agriculture but unlike type 1 farmers a larger proportion (38.5%) were involved in small scale crops and/or livestock farming and a relatively larger proportion (11.7%) considered aquaculture their primary economic activity. 87.6% self funded their projects. The majority (68.3%) again owned the lands they operated, but less than those of type 1. 28.9% operated on leased lands. Fish yield per hectare per annum was the highest at 4,423kg.

Table 2.25 Operational characteristics of the five non-commercial farm types

| Characteristics | Farm Types | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Sample Size | N = 76 | N = 148 | N = 52 | N = 13 | N = 24 |
| Mean pond size (ha) | 0.11 ± 0.01 | 0.03 ± 0.02 | 0.66 ± 0.07 | 0.47 ± 0.22 | 0.25 ± 0.06 |
| Size Range (ha) | 0.02 – 0.40 | 0.01 – 0.10 | 0.04 – 2.31 | 0.01 – 2.25 | 0.04 – 1.46 |
| Main Inputs | | | | | |
| Fertilizers (Kg/ha/yr) | 471.6 ± 74.0 | 1397.3 ± 195.0 | 277.0 ± 39.0 | 176.1 ± 23.6 | 154.3 ± 11.9 |
| Supplementary feed(Kg/ha/yr) | 8973.3 ± 736.0 | 14443.6 ± 734.8 | 5864.7 ± 532.7 | 8419.7 ± 572.8 | 9607.0 ± 698.8 |
| Tilapia fingerlings (fry/m2) | 4.6 ± 0.1 | 4.7 ± 0.1 | 0.8 ± 0.1 | 3.2 ± 1.0 | 2.6 ± 0.7 |
| Catfish fingerlings (fry/m2) | 0.3 ± 0.1 | 0.3 ± 0.0 | 0.2 ± 0.0 | 0.2 ± 0.3 | 0.4 ± 0.2 |
| Labour (man days/ha/yr) | 41.1 ± 2.3 | 10.6 ± 0.6 | 249.0 ± 19.8 | 175.7 ± 79.00 | 91.2 ± 21.9 |
| Equipment Costs (GH¢/ha/yr) | 184.0 ± 39.0 | 323.0 ± 56.0 | 197.0 ± 86.0 | 1149.0 ± 408.0 | 756.0 ± 138.0 |
| Output(kg/ha/annum) | 2284.0 ± 108.0 | 4423 ±216.0 | 1436 ± 86.8 | 1787 ± 310.0 | 1518 ± 219.7 |
| Type of culture (% of farms) | | | | | |
| Tilapia monoculture | 23.3 | 26.2 | 29.6 | 25.0 | 24.2 |
| Catfish monoculture | 8.7 | 26.9 | 6.4 | - | 16.2 |
| Polyculture | 71.0 | 46.9 | 63.8 | 75.0 | 59.6 |
| Sources of fingerling (% of farms) | | | | | |
| Hatcheries | 41.5 | 34.5 | 45.7 | 36.4 | 45.3 |
| Fellow farmer /Own farm (in pond production) | 58.5 | 58.2 | - | 18.2 | 45.3 |
| Wild | - | 7.5 | 45.5 | 45.5 | 13.0 |
| Types of manure used (% of farms) | | | | | |
| Organic | 96.9 | 90.0 | 87.5 | 100.0 | 100.0 |
| Inorganic | 1.7 | 3.3 | 5.0 | - | - |
| Both | 1.7 | 6.7 | 7.5 | - | - |
| Feed Types (% of farms) | | | | | |
| Cereal bran only | 66.7 | 60.6 | 76.6 | 69.2 | 78.3 |
| Cereal bran/fish meal | 2.9 | 4.9 | 2.1 | 23.1 | 8.7 |
| Compound feed | - | 2.1 | 2.1 | - | 4.3 |
| Others | 30.4 | 32.4 | 19.1 | 7.7 | 8.7 |

Table 2.26 Socio-economic status of farmers in the five farm types. Figure are percentages.

| Variable | Description | Farm Type 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Gender | Male | 82.9 | 94.6 | 84.6 | 83.3 | 87.0 |
| | Female | 7.9 | 2.0 | - | - | - |
| | Group | 9.2 | 1.6 | 15.4 | 16.7 | 13.0 |
| Marital status | Married | 97.2 | 97.9 | 91.1 | 100 | 100 |
| | Single | 1.4 | 0.7 | 8.9 | - | - |
| | Others (widowed or divorced) | 1.4 | 1.4 | - | - | - |
| Education | No formal education | 4.7 | 11.9 | 6.5 | - | 15.0 |
| | Basic to Middle School level | 40.6 | 51.6 | 32.3 | 8.3 | 45.0 |
| | Vocational School level | 10.9 | 12.7 | 9.7 | 58.3 | 10.0 |
| | Secondary School level | 34.4 | 19.0 | 32.3 | 8.3 | 30.0 |
| | First degree and higher | 9.4 | 4.8 | 19.4 | 25.0 | - |
| Main Occupation | Commercial crops and/or livestock farming | 25.0 | 19.2 | 16.7 | 27.3 | 42.9 |
| | Small scale crops and/or livestock farming | 18.8 | 38.5 | 38.9 | 45.5 | 35.7 |
| | High level professionals | 6.3 | 11.5 | 11.1 | 27.3 | - |
| | Aquaculture | 6.3 | 11.5 | 5.6 | - | - |
| | Others | 48.3 | 19.2 | 27.8 | 21.4 | 23.5 |
| Source of funding | Own funds | 89.0 | 87.6 | 86.3 | 100 | 82.6 |
| | Loan | 11.0 | 11.7 | 7.8 | - | 17.4 |
| | Grant/government | - | 0.70 | 5.9 | - | - |
| Land Ownership | Own land | 76.4 | 68.3 | 56.3 | 41.7 | 77.3 |
| | Family land | 1.4 | 2.1 | - | - | - |
| | Lease | 20.8 | 28.9 | 43.8 | 33.3 | 22..7 |
| | State land | 1.4 | 0.7 | - | 25.0 | - |

Table 2.27 List of equipment and the percentage number of fish farmers owning it

| Equipment | Farm Type | | | | | % of total |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Basket | - | 8.3 | 8.3 | - | - | 3.7 |
| Boots | 50.0 | 70.8 | 75.0 | 83.3 | 64.7 | 67.9 |
| Buckets | 43.8 | 50.0 | 41.7 | 91.7 | 58.7 | 55.6 |
| Cutlass | 50.0 | 70.8 | 53.8 | 75.0 | 64.7 | 63.4 |
| Earth Chisel | 6.3 | - | - | - | - | 1.3 |
| Head pan | 6.3 | 8.7 | 18.2 | 33.3 | 11.8 | 13.9 |
| Hoes | - | 25.0 | 27.3 | 50.0 | 23.5 | 23.8 |
| Mattock | 12.5 | 16.7 | 33.3 | 33.3 | 35.5 | 24.7 |
| Feed mill | - | - | - | - | - | - |
| Nets | 23.5 | 20.8 | 25.0 | 50.0 | 35.5 | 29.3 |
| Pelletizer | - | - | - | - | - | - |
| Pick-axe | 41.2 | 50.0 | 54.4 | 50.0 | 58.8 | 50.6 |
| Water pump | 5.9 | 4.2 | 25.0 | 83.3 | 17.6 | 20.7 |
| Shovels | 70.6 | 70.8 | 81.8 | 91.7 | 82.4 | 77.8 |
| Wheelbarrow | - | - | 8.3 | 8.3 | - | 2.4 |

Farms grouped under type 3 were relatively larger and comprised 52 farms, with a mean farm size of 0.66ha, median of 0.56ha the largest of all the groups and a relatively broad range from 0.04 to 2.32ha. Feed and fertilizer inputs per hectare were very low whilst mean stocking density was the lowest of all the farm types at 0.81/m$^2$. Farmers in this group were relatively better educated than those in the two previous groups discussed. Half (50%) had attained at least secondary school level education. Only 6.5% had no formal education about a third (32.2%) having attained only middle school level education. Close to 17% of these farms were engaged in commercial crop and livestock farming, 38.9% small scale crop and livestock, 11.1% were high level professionals and 27.8% were engaged in various occupations – civil servants, self employed etc. Only 5.6% had aquaculture as their main occupation. A specific characteristic of this group is the large inputs of hired labour per hectare. Fish yield was about a third of that of type 2 at 1436kg/ha/annum

Farm type 4 had the fewest number of farms of 13 but was also made up of farms with varying sizes with the entire range of farm sizes being represented i.e. 0.01 to 2.25ha (Table 2.25). Mean pond size was 0.47ha and median of 0.16ha which did not vary significantly from those of the other four, probably due to the wide size range represented. Farmers in this group were the most resourced in terms of equipment (Table 2.28). Their general educational level was about the highest of the five groups, none with no formal education, a quarter (25%) had university level education, 58.3% vocation education and 8.3% had only attained middle school level education. Over 70% were into commercial or small scale crop and livestock farmers; none considered aquaculture as their main occupation or source of income (Table 2.26). 27.3% were high level professionals. Funding for starting the farms was 100% equity. Only 41.7% operated on lands they own with legal title making it the group with the least land owners. 33.3% used leased lands and 25.0% on state lands. Fish yield was 1,787kg/ha/annum less than half that of farm type 2.

Type 5 farms may be described as small to medium sized with a total of 24 farms. This was the second smallest group after farm type 4. Mean pond size was 0.25ha and was significantly different from that of farm types 2 and 3 but not from 1 and 4. Median pond size was 0.18ha. Eighty-seven percent of the farms were owned by males and the rest (13%) by groups. One of the main differences between this and the other groups was in the low levels of application of fertilizer, which varied significantly from all other types except for type 4. None of the farmers in this group had attained university level education. 15.0% had had no formal education, 45% had only middle school level certificate, 10.0% vocational level education and 30.0% secondary level education.

Over 78% of farmers in this group were also crop and livestock farmers, more than half of which were into commercial production of these. Labour input per hectare per year was the second highest after farm type 3. None of these farmers like those of type 4 considered aquaculture their main occupation. Funding of farm operation by 82.6% was equity whiles 17.4% relied on loans. 77.3% owned the lands they operated on (with legal title) and 22.7% on leased lands. Fish output was 1,518kg/ha/annum.

Table 2.28 Operational characteristics of the commercial farm types

| Characteristics | Farm A | Farm B | Farm C |
|---|---|---|---|
| Production type | Semi-Intensive | Semi-intensive | Intensive |
| Total pond size (ha) | 1.01 | 2.01 | 1.97 |
| Main Inputs | | | |
| Manure (Kg/ha/annum) | -[a] | -[a] | -[b] |
| Inorganic fertilizer (kg/ha/annum) | n/a | n/a | 1500 |
| Supplementary feed(Kg/ha/annum) | 2400 | 11143 | 24365 |
| Tilapia fingerlings (fry/m2) | | 1.5 | 3 |
| Catfish (fry/m2) | 0.4 | 3 | 5 |
| Labour (man days/ha/yr) | - | - | - |
| Equipment Costs | 218 | 231 | 2421 |
| Type of culture | polyculture | polyculture | polyculture |
| Source of fingerling | hatchery | hatchery | Own hatchery |
| Feed Types | Cereal bran and fish meal | Cereal bran and fish meal | Imported formulated feed, cereal bran and fish |
| Pond Drainable | Yes | Yes | Yes |

[a] Data not provided
[b] Manure from the animal barns were channelled directly to the ponds through pipes. The quantities applied could not therefore be estimated
n/a not applicable

*Regional distribution of farm types*

Only the western region (WR) had all five farm types. Farms in the Volta (VR), Eastern (ER) and Central (CR) regions were largely the type 2. Farms in the Brong-Ahafo (BAR) regions were mainly types 1 and 2 with a few types 3 and 5 but no type 4 (Figure 2.19).

The Northern (NR) and Upper East (UE) region farms were all of type 3; no other farm types were available. The Ashanti region (AsR) was dominated by farm types 1, 3, 4 and 5 but no type 2 whiles farms in the Greater Accra Region (GAR) were primarily types 1, 2, and 3, no types 4 or 5.

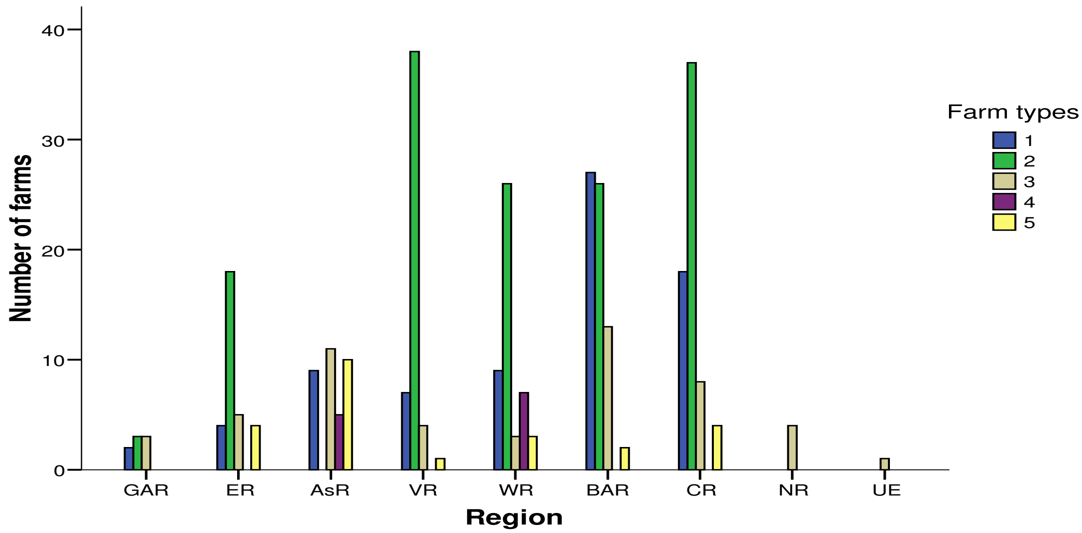



Figure 2.19: Regional distribution of farm types

## 2.4 Discussion

Fish culture in Ghana is widespread and undertaken in all ten regions of the country but more prominently in the southern and mid sections. Results from the survey indicated growing interest in the sector with increasing number of fish farms being established yearly. The growth rate was estimated at 16%. A large number of the farms (97.3%) being classified non-commercially operated with an overall average farm size of 0.30ha but a median of 0.06ha an indication that at least half the farms are smaller than 0.06ha. Family members played key roles in the day to day running and operations of these farms, seed supplies were largely from in pond production and wild sources and the farms were largely self-financed.

The main production systems were ponds, cages and pens. The cages and pens were of more recent development and accounted for less than 2% of the existing culture systems. Cage culture is currently one of the most rapidly growing sectors in aquaculture (Muir, 2005). Advantages of cages over other rearing systems include low capital costs, relatively simple management, better quality of fish, and use of existing water bodies (Beveridge, 2004). They can also be relocated if unfavourable weather or other environmental conditions occur (Pillay and Kutty, 2005).

The main sources of water were surface water, ground water and rainfall. Although rainwater plays an important role in ponds, particularly where it is the only means to fill the pond, it is not considered an ideal sole source as during dry or drought periods, water losses from the pond may result in higher densities of fish in the pond, which can lead to various water quality problems, resulting in the loss of all the fish (Kelly and Kohler, 1997). The advantage of utilizing water from rivers and streams, the main source of water used by majority of the farmers, is that the water usually has high oxygen concentrations and, if the topography is right, pumping into the ponds may be unnecessary (Kelly and Kohler, 1997). Groundwater, the second most sourced is said in general terms to be the most preferred for aquaculture, particularly if an abundant supply of good-quality water could be obtained without having to drill a deep well (Stickney, 2005). Problems however arise when it renders the pond un-drainable, and where water exchange depends primarily on infiltration. The main disadvantage to the use of the surface waters (rivers, streams, lakes and reservoirs) in fish farming is that they are susceptible to climatic changes and pollution.

Waste water has successfully been used to grow tilapia in other parts of the world (Khalil and Hussein, 1997) and the growth rate of fish is reportedly significantly higher than that of fish reared in the natural habitat (Bayoumi and Khalil, 1988). The main constraints to its use however are largely for aesthetic reasons and the possibility of spreading human diseases. However, a study in Ghana by Ampofo and Clerk (2003) on the diversity of bacteria in a sewage treatment plant found the bacterial types to be relatively non-pathogenic to humans.

Pond construction was largely by manual excavation. From an economic point of view, mechanical methods of construction are considered to have many advantages (Pillay and Kutty, 2005). Besides reduced cost as seen from this study, other advantages according to them are that the need for recruitment of a large labour force is reduced and in a majority of cases more efficient structures can be achieved. The reason for more farmers going for manual construction may have been influenced by how much of the costs of manual construction had to be contributed as family labour or in kind contributions rather than directly borne. Socio-economically however, manual construction has an advantage in that it is able to generate employment in deprived areas, through the use of intensive labour.

A report by Prein and Ofori (1996) addressing problems faced by previous aquaculture development projects cited pond siting and design among others as areas receiving little support and that failures in any of these may place an entire operation in jeopardy.

While twelve years on there are still problems associated with site selection, pond design and construction, the percentage of ponds with such problems have however reduced suggesting either an improvement in this technical aspect of fish farming in Ghana or simply that poor units have gone out of production.

Equipment-wise, the basic types of farm tools being used had generally not changed except after 1995 where the establishment of commercial farming saw the introduction of more “sophisticated” tools like the feed mills, pelletizers and aerators. These are however very much restricted to the commercial sector which accounts for less than 1% of the farmers.

Sole ownership of farms by women in subsistence fish farming has remained small and quite unchanged over the years with women accounting for less that 5.0% of the farm owners. This may be attributed to the fact that traditionally men are deemed to be the heads of the household unit in Ghana and farms owned and run by a family are likely to be in the name of the head of the family. The involvement of women in subsistence fish farming activities also remains relatively unchanged and limited to feeding, processing of harvested fish and marketing. This appears to be quite contrary to their level of participation in crop farming where the male to female ratio is about 1:1 (Ghana Statistical Service, 2002). This trend was thought to reflect defined roles played by men and women in the fisheries sector in Ghana where men are involved in the main fishing activities and harvesting in the artisanal, semi-industrial and the industrial sectors while women played key roles in on-shore post-harvest activities, undertaking fish processing, storage and trade activities (Akrofi, 2002). Low participation of women in aquaculture have been reported in some Asian countries as well, where the role of women in aquaculture have been limited to mechanical and menial tasks, limited access to production resources, i.e. credit and land; problems of lack of involvement in training and extension activities (Setboonsarng, 2002). Where they have been involved however, women have been thought to play a crucial role in aquaculture production. Nandeesha and Heng (1994) found that in Cambodia ponds in which women carried out 50% or more of the tasks associated with the culture of fish showed higher yields than others.

An area of improvement still in the profile of the fish farmers has been in their educational background with the entry of more people with some form of formal education. This is very important for the sector as the level of education of the fish farmers is generally thought to affect the knowledge level, skill development, exposure to production technology and marketing practices, and adoption level of improved technology (Singh, 2003). The number of full time fish farmers however remains small, a problem attributed to poor incomes by the farmers.

Tilapia (*Oreochromis niloticus*) remains the primary species cultivated. Globally tilapia (including all species) is the second most important group of farmed fish after carps, and the most widely grown of any farmed fish (FAO, 2006). Advantages of culturing tilapia have been attributed to the facts that they are herbivorous, feed low in the food chain and consume a variety of materials. They have high growth rates, adaptability to a wide range of environmental conditions and ability to grow and breed in captivity and low susceptibility to disease (El-Sayed, 2006). They also have desirable qualities as a food fish; with white flesh, bland taste and firm texture (Suresh, 2005) and in Ghana has a readily available consumer market (Chapter 4).

A reliable supply of good quality seed obtained at a reasonable cost is one of the most important requirements for aquaculture (Shang, 1985). General quality of seed supplied to farmers irrespective of source was poor characterised by low survival rates and high incidence of inbreeding which was contrary to expectation. Seed from hatcheries/institutions were expected to do better. Reliance of farmers on fingerlings from wild stocks and fellow fish farmers could however serve as a major constraint to the sector as fingerlings available from the wild are considered an unreliable source in large scale farming as their abundance in nature depends on a number of unprecedentable factors and are also either matured or of poor genetic quality and health or are undesirable species (FAO 2006). Fingerlings obtained from fellow farmers which are more of accidental production are at risk of stunted growth. High inbreeding as observed in the farms can result in a 30% decrease or more in growth, survival and reproduction in fish (Pillay and Kutty, 2005). The authors linked the inability of stocked fish to reach a minimum final size in a season (100 – 200g) to inbreeding and/or introgression with poor quality feral strain especially those derived from *O. mossambicus*.

The application of manure as being practiced by most of the farmers is considered to be the cheapest way to increase pond productivity at minimal cost (Mataka and Kang'ombe, 2007). The type of manure has been found to influence pond productivity differently in relation to abundance and prevalence of phytoplankton and zooplankton, as well as in the benthic materials developed (Kang'ombe et al. 2006). Poultry manure, used by over 80% of farmers has been found to enhance production of phytoplankton more than any other organic fertilizers, or chemical fertilizer (Boyd, 1982). None of the farms visited mentioned difficulties in acquiring manure but mean quantities applied by farmers were considerably lower than the 70-140kg/ha/day, dry laying hen manure mentioned earlier and which was said to yield the best results for *O. aureus* (McGeachin and Stickney, 1982). Appropriate application rates of manure is considered important as inadequate fertilization may result in low yield whiles excessive application can result in significant deterioration in water quality (El-Sayed, 2006).

Feed is one of the major costs for aquaculture operations, typically making up between 30 and 60% of total operating costs, depending on intensity of production (Hepher and Pruginin, 1981). Its requirements by fish changes with age, size, health and water condition. Yield in semi-intensive aquaculture, as practiced by most of the farms visited, depends to varying extents on natural food production and supplemental feeding. A daily feeding rate of about 3% body weight in fertilized ponds has been found to be the most effective feeding technique for small-scale production of tilapia in ponds (Abdelghany and Ahmad, 2002). From enquiry during the survey, feeding by farmers besides the commercial producers was done arbitrarily with no regard to standing crop. A difficulty in this area though may stem from the constant variation in biomass because of the high incidence of inbreeding in a number of ponds. Knowing the right quantities of feed to apply is very important as inadequate feeding can result in low yields and low survival rates whiles over feeding may result in higher production costs and subsequent low profit and potential water deterioration.

Average fish yields by farmers were quite low in view of the fact that they applied both fertilizer and supplementary food. As indicated in the results, less than 10% achieved the expected output range of 5000 to12000 kg/ha in fertilized-fed ponds (Diana et al.

1994). Comparison of performance of the farm types based on output per yield per hectare showed a relationship between the performance and level of input whereby farmers who stocked more fingerlings and applied more feed per hectare/annum obtained better outputs and which were attributed to the better performance of farms types 1 and 2. Improving yields will therefore require more inputs by farmers.

In the commercial sector, the performance of the small to medium scale commercial farms especially that of the intensive commercial farm whose yield/ha/yr was about 46mt was much better than those of the non-commercial farms. Increasing aquaculture production in Ghana sufficiently to improve domestic fish supply may lie in encouraging development of commercial rather than the non-commercial farms, whose production is quite insignificant.

# Chapter 3 - Financial viability of fish farming in Ghana

## 3.1 Introduction

Aquaculture in Ghana is based almost entirely in the freshwater environment with over 2,366 fish ponds and 882 reservoirs with total surface areas of 252.9ha and 2,543.9ha respectively (Fisheries Directorate, Unpublished data). Although there are a few commercial farms, production is largely at the subsistence level with average pond size being 0.36ha. Based on the Ridler and Hishamunda (2001) classification of fish farms, the previous chapter defined over 96% as non-commercial, about 3% as small scale commercial less than 1% as medium to large scale commercial farms. Aquaculture contribution to domestic fish production is currently less than 1%.

As noted earlier, there is a major development interest in expanding aquaculture to meet national needs for aquatic products, and a concern for the potential of the current sector to grow and develop. Though technical ability is a prerequisite for aquaculture development of a given species, it will obviously fail to survive and expand if it is commercially unviable. Aquaculture development requires a mix of practical scientific knowledge, economic and profitability studies, and knowledge of potential areas for site selection, development and expansion. Cultivation must be biologically and technically feasible and the net returns, at least enough to compensate for risks (Ridler and Hishamunda, 2001).

Analysis of financial and economic aspects of the sector is therefore essential as it helps evaluate viability of investment and efficiency of resource allocation, to improve existing management practices, evaluate new culture technology, assess market potential, and identify areas in which research would have high potential payoffs (World Bank, 2004). It is also an important tool for business planning, seeking financial assistance from formal institutions, and identifying economically sustainable enterprises.

However, very little attention has so far been paid these issues in Ghana. A brief profitability assessment of fish farming in Ghana by Manu (2004) was based mainly on assumptions and speculations rather than actual farm data. A more detailed study had been undertaken earlier by Amevenku (1999), though based only on hatchery operations.

### 3.1.1 Objectives

The objectives of this study are to determine the financial feasibility of fish farming in Ghana, using fish farm data, at different levels of production and to identify the most profitable technologies to be pursued. Based on this information it should be feasible to determine whether and what kinds of aquaculture are likely to have the potential for development, and the conditions – eg resource costs, production efficiency and market price, in which profitability and growth can occur.

## 3.2 Methodology

### 3.2.1 Data collection

Data were obtained from the surveys described in chapter 3, using the same method of data collection. A copy of the questionnaire used is presented in appendix 1. Data for a total of 392 farms comprising 1101 ponds were obtained from both primary and secondary sources. Multiple ponds belonging to a particular farm were added together and treated as a single unit for the analysis.

All the data gathered were coded and entered in both Statistical Package for Social Sciences version 14 (SPSS 14) and Microsoft Excel 2003 spreadsheets. The analysis began with harmonization of the data collected. The viability assessment was done per farm type as defined in the previous chapter, i.e.: farm type 1, farm type 2, farm type 3, farm type 4 and farm type 5. Main characteristics of the farms are summarized in Table 3.1.

Table 3.1 Summary of main defining characteristics (mean values for the farm groups)

| Farm type | % of farms (n=312) | Mean farm size (ha) | Labour (man days/ha/yr) | Equipment Costs (GH¢) | Stocking density (fingerlings/$m^2$) | Feed quantity (kg/ha/yr) | Output (kg/ha/yr) |
|---|---|---|---|---|---|---|---|
| 1 | 24 | 0.11 | 41.1 | 184.0 | 4.6 | 8,973.3 | 2,248.0 |
| 2 | 47 | 0.02 | 10.6 | 323.0 | 4.7 | 14,443.6 | 4,423.0 |
| 3 | 17 | 0.66 | 249.0 | 197.0 | 0.8 | 5,864.7 | 1,436.0 |
| 4 | 4 | 0.47 | 175.7 | 1,149.0 | 3.2 | 8,419.0 | 1,787.0 |
| 5 | 8 | 0.25 | 91.2 | 756.0 | 2.6 | 9,607.0 | 1,518.0 |

### 3.2.2 Data harmonization

As data for the study besides those collected by the author, were sourced from different organizations, collected at different periods, costs and prices had to be harmonised to reflect their present value (year 2006). This was done by estimating 2006 values of the prices quoted by the farmers from the year of purchase using the yearly average inflationary figures given in Table 3.2.

The formula used is given in Equation 3.1.

The estimation was done from the time the equipment was purchased till 2006.

$P_{0} = P_0 (1+r)$ Equation 3.1

Where:

P = Current Price

$P_0$ = Original cost of the item

r = yearly rate of inflation

Table 3.2 Mean annual rates of inflation

| Year | Inflation rate | Year | Inflation rate |
|---|---|---|---|
| 1995 | 39.7 | 2001 | 45.4 |
| 1996 | 61.7 | 2002 | 22.9 |
| 1997 | 38.6 | 2003 | 29.8 |
| 1998 | 15.4 | 2004 | 10.3 |
| 1999 | 14.9 | 2005 | 11.5 |
| 2000 | 24.9 | 2006 | 13.0 |

Source: Institute of Statistical Social and Economic Research (ISSER). Annual State of the Ghanaian Economy reports, 1995 to 2006

### 3.2.3 Financial analysis

Cost-return analysis was used to evaluate the financial performance of farms at different levels of production for non-commercial production, and at small to medium scale commercial production. Analyses were in four parts - first, an estimation of production costs, and gross revenues, followed by determination of a number of viability indicators such as net returns, return of variable cost, returns on total cost, pay back period, internal rate of return, net present value and cost-benefit ratio; then a sensitivity analysis and finally an economic production function analysis was used to assess the influence and elasticities of some of the major inputs (feed, fertilizer and stocking density) on annual yield per hectare. Indicators were estimated for production over a 365 day/year period and projected over a ten year period.

### Production cost

The total cost of production (operating cost) was calculated as the sum of annualised fixed costs and variable costs. Fixed costs were estimated from the cost of land, cost of pond construction amortized over a 20 year period, depreciated costs of equipment, and a 9% interest on equity and maintenance costs. The interest rate of 9% was the interest payable on a 182 day treasury bill in Ghana.

Capital cost was made up the cost of land, cost of pond construction (which included the cost of land clearing), cost of equipment and an initial start-up investment which was assigned a value equivalent to a farm's annual operating cost. A large number of the farmers owned the land they operated on, the cost of land per year was therefore imputed, and estimated as the opportunity cost of land for maize production, which is GH¢160/ha/year (Quagrainie et al. 2004). Equipment costs were generally obtained from the survey data but for farmers for whom no information was available, equipment costs were assigned.

A second set of costs was estimated for the very small non-commercial farms. Most of ponds used by these farmers were constructed by themselves with the help of friends and family. Actual monies spent were therefore much lower than for those constructed entirely by hired labour. Another cost omitted was that of land. Most subsistence farmers operated on land owned by themselves or by family and therefore paid nothing towards it. The opportunity cost of land was therefore omitted on the basis that the land was not previously being used for any income generating activity, or would not be so. Variable costs incurred by these farmers in relation to feed, manure and fingerlings however remained the same as the fully costed ones.

Capital costs for small to medium scale commercial farmers had to be estimated for individual farms, as only three of the commercial farms visited provided data adequate for the assessment. Mean cost of pond construction per hectare was GH¢ 11,894.00 for mechanically constructed ponds and GH¢ 12,960.00 for manually constructed ponds. Cost of land leased by the commercial farmers were commonly fixed at GH¢ 500.00 per year. A list of equipment used by the farmers, their estimated useful life and mean prices is presented in Table 3.3. Depreciated equipment costs were determined using the straight line method (Jolly and Clonts, 1993).

Table 3.3 list of equipment, annual depreciation rates, unit cost and salvage

| Equipment | Useful life | Unit Price GH ¢* | Annual rate of depreciation (%) | Salvage value |
|---|---|---|---|---|
| Cutlass | 2 | 3.85 | 50 | 0 |
| Shovels | 2 | 5.51 | 50 | 0 |
| Boots | 2 | 10.22 | 50 | 0 |
| Head pan | 2 | 3.70 | 50 | 0 |
| Buckets | 2 | 3.32 | 50 | 0 |
| Wheel barrow | 3 | 56.40 | 33 | 0 |
| Weighing scale | 4 | 6.50 | 25 | 0 |
| Nets | 3 | 130.42 | 33 | 0 |
| Pumps | 5 | 725.27 | 20 | 0 |
| Aerator | 5 | 2500.00 | 20 | 0 |

* 1 US$ = GH¢ 0.94

$$\text{Annual depreciation} = (\text{Cost} - \text{Salvage Value}) \times R \qquad \text{Equation 3.2}$$

Where:

R = annual rate of depreciation

The rates were based on the useful life of the item. The salvage value for all equipment and culture systems were assumed to be zero.

Labour represented a mixed cost particularly for the commercial producers. The manager's annual salary which is paid irrespective of the level of production and the temporary labour which is hired on a daily basis for pond maintenance, harvesting and other menial jobs as they arise. Annual pond maintenance costs were estimated at 2% of capital cost for non-commercial farms as they do relatively less maintenance and 6.6% for commercial producers as suggested by (Shang, 1990). Pond maintenance included work carried out in pond liming and fertilization, regular clearing of weeds around the pond and general maintenance work. Labour costs were estimated per hectare pond size per year. The daily rate for labour was fixed at GH¢1.6 which was the 2006 government recommended minimum daily wage. The number of hours assigned each labour activity are presented in Table 3.4. Feeding was done daily by most farmers, and estimated to take an hour daily. From the harvest data provided by the farmers, and an assumption that each harvest was total, a production cycle of 1.4 and 1.7 crops per annum was estimated for non-commercial and commercial producers respectively. This is the equivalent of 8 ½ and 7 months production cycles respectively.

Table 3.4 Estimated labour hours per hectare per year's activity for a non-commercial farmer

| Activity | Number of labourers | Hours per production cycle | Hours per annum | Number of person days |
|---|---|---|---|---|
| Stocking | 1 | 1 | 1.4 | 0.20 |
| Feeding | 1 | 258 | 365.0 | 45.6 |
| Harvesting | 4 | 32 | 44.8 | 5.6 |
| Total | | 281 | 411.2 | 51.4 |

### Gross revenue

This is defined as the total farm value of production per annum, obtained from the total quantity of fish harvested per annum, which includes the quantity sold, quantities given out as gifts and those consumed by the farm household. Average prices per kilogram of tilapia were extracted from the data provided by the farmers. Taxes on purchases, sales or profits and also tax relief were not considered in the analyses, as they were not likely to apply or be incurred in practice.

Gross revenue = annual yield (kg) x price of fish per kg  Equation 3.3

### 3.2.4 Financial viability indicators

Analyses evaluating the viability of the farms were conducted in two parts. First, from the cost and revenue data collected, static indicators were determined to evaluate the viability of a farm. These were the yield per hectare of pond, net profit, rate of return to variable cost, rate of return to capital cost, gross margin, and the payback period. The different indicators were defined as follows:

Gross profit = (gross revenue) – (variable operating cost)

Net profit = (gross revenue) – (total operating costs)

Gross profit margin = (gross profit) ÷ (gross revenue)

Return on variable costs = (Gross profit) ÷ (variable operating costs)

Return on capital costs = (net profit) ÷ (total capital costs)

Payback period = (Total capital cost) ÷ (net profit)

The second part of the assessment dealt with discounted cash flows. These indicators included the Benefit-Cost ratio (B/C), Net Present Value (NPV) and the Internal Rate of Return (IRR). The indicators were defined as follows (Shang 1990):

Benefit-cost ratio (B/C)

$$B/C = \frac{\sum_{i=1}^{n} \frac{Y_i}{(1+r)^i}}{\frac{K_i}{(1+r)^i}} \quad \text{Equation 3.4}$$

Where:

Y = the net annual benefit

K = the capital outlay for assets

r = discount rate

i = year

The B/C ratio was estimated for a projected 10 year period. Operational cost was discounted at the average 2006 inflationary rate of 13%. The yield per hectare was assumed to remain the same for the entire period but the price per kilogram and the cost of production were assumed to increase yearly at the mean inflationary rate given above. An investment is acceptable if the B/C is greater than 1.

Net Present Value (NPV) was defined as

$$NPV = \sum_{i=1}^{n} \frac{B_i - C_i}{(1+r)^i} \quad \text{Equation 3.5}$$

Where;

Bi = Gross revenue of year i

$C_i$ = production cost of year i (including initial investments)

r = discount rate

n= the number of years in operation (10 years in this case)

i = the ith year

The criterion for the NPV is that if it is positive (i.e. >0) then the rate of return exceeds the defined discount rate and the investment would be viable. If NPV is less than zero (< 0), the investment is not viable and if NPV equals zero (NPV = 0) it would be a break-even situation (Shang 1990). The larger the NPV for a given investment level the more viable is the project.

The Internal Rate of Return (IRR) was defined as

$$IRR = \sum_{i=1}^{n} \frac{B_i - C_i}{(1+K)^i} \qquad \text{Equation 3.6}$$

Where the definition for Bi, Ci, i and n are the same as defined in the NPV formula.

K is the internal rate of return.

This defines an interest rate that will equate the sum of the net cash flows to the initial investment. Where an exact match is not found, the interest rate which gives the closest match to the initial invested capital is considered the true rate (Jolly and Clonts, 1993).

In the estimation of the NPV, IRR and the B/C, the price per kilogram of fish and the total cost of production were assumed to appreciate at an average rate of 13% per annum which is the annual average inflation rate for 2006. The yields per hectare were assumed to remain the same over the 10 year period. A business venture is considered viable if the IRR exceeds the annual rate of inflation (or the average cost of capital, which is usually at least this rate).

### 3.2.5 Other analyses

### Break-even analysis

The break-even analysis presented here represents short-run analysis (one year) costs and revenue data for farm types under static conditions of farm size and technology. Break-even cost is as defined below (Jolly and Clonts, 1993).

$$\text{Break-even cost} = \frac{\text{Cost per unit of production}}{\text{Yield per unit of production}} \qquad \text{Equation 3.7}$$

### Production function analysis

Production functions are based on the assumption that in a given system or enterprise type, levels of output can be predicted by a given set of inputs, the mix of which basically describes the conversion of inputs into outputs. An understanding of the technology of production is central to the development of realistic theories and to the formulation of a wide range of policies (Bosworth, 1976). The Cobb-Douglas production function model (Equation 3.8) which is widely used in farm and general agricultural economic production studies was used. Three variables - fingerling, supplementary feeds and fertilizer were selected. The advantage of this model is that it conforms to economic theory and provides a compromise between an adequate fit of data, computational feasibility and sufficient degrees of freedom to allow statistical testing (Munzir and Heidhues, 2002).

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3}$$ Equation 3.8

Where:

Y = Gross output of fish (kg /ha)

a = intercept

$X_1$ = Supplementary feed (kg/ha)

$X_2$ = manure/fertilizer (kg/ha)

$X_3$ = Stocking density (fingerlings/ha)

$b_1$ to $b_3$ = regression coefficients of respective variables

**Sensitivity analysis**

Sensitivity analyses were conducted by working out percentage changes in net profit and the internal rate of return with changes in production feed price, costs of fingerlings, fixed costs, variable costs and the wholesale price per kilogram of fish. This makes it possible to gain a better understanding of nature and level of risk associated with all the key variables associated with a particular project (Fitzgerald, 1988)

## 3.3 Results

These were described according to the farm categories defined in the previous chapter.

### 3.3.1 Cost of production

Cost of production as defined above was the sum of fixed costs and variable costs.

## Fixed costs

Fixed cost per farm type ranged from a minimum average of GH¢1,912.00 (US$ 1,991.67) for farm type 1 to a maximum average of GH¢ 4,650.00 (US$ 4,675.11) for farm type 2 with an overall mean of GH¢ 2,113.00 (US$ 2,124.42) and a range of GH¢ 599.00 (US$ 602.23) to GH¢ 6,527.00 (US$ 6,562.25) (Table 3.6). With the exception of farm type 2 fixed costs were at least 50% of the cost of production. A major contributor to fixed costs for all farm types was the interest payable on capital costs most of which was equity. Its contribution to fixed cost was at least 52% for all farm types. Capital costs for non-commercial farms ranged from a minimum GH¢ 12,859.00 for farm type 3 to a high GH¢ 18599.00 for farm type 4 and for the commercial farms GH¢ 12,979.00 to GH¢ 54,245.00. The second major contributor was the depreciated cost of pond construction. Land and depreciated cost of equipment per annum had relatively less impact on the total amount.

Table 3.5 Estimated capital costs (GH¢) per hectare for the non-commercial farm type categories

| | Farm types | | | | | Overall average |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Sample size | 75 | 148 | 57 | 13 | 24 | |
| Pond cost (GH¢) | | | | | | |
| Mean | 11,882.00 | 13,065.00 | 11,686.00 | 15,500.00 | 12,847.00 | 12,639.00 |
| SE | 254.00 | 329.00 | 295.00 | 2340.00 | 1757.00 | 230.00 |
| Equipment(GH¢) | | | | | | |
| Mean | 184.00 | 323.00 | 197.00 | 1,149.00 | 756.00 | 333.00 |
| SE | 39.00 | 55.00 | 87.00 | 408.00 | 149.00 | 38.00 |
| Additional Investment(GH¢) | 1813.00 | 2558.00 | 976.00 | 1652.00 | 1366.00 | |
| Mean | | | | | | |
| SE | | | | | | |
| Total (GH¢) | 13,879.00 | 15,946.00 | 12,859.00 | 18,599.00 | 14,969.00 | 12,972.00 |

## Variable costs

These ranged from GH¢ 976.00 (US$ 981.27) to GH¢ 2,558.00 (US$ 2,571.81) per hectare per annum, accounting for 33.5% to 55% of the total cost of production (Table

3.6). Variable costs per kilogram of fish produced ranged from GH¢ 0.58 for farm type 2 to GH¢ 0.92 for type 4. Feed was a major component of variable costs for farmers in farm types 1 and 2 accounting for more than 60% of the variable cost and over 30% of the total cost of production. The cost of fingerlings on the other hand featured prominently in the variable costs of farm types 4 and 5 where it exceeded amounts spent on feed. The contributions of the cost of manure as well as other variable items to variable cost were generally below 10%. Comparison of mean variable costs for the farm types showed significant variations ($F(4, 300) = 5.92$; $p<0.001$). Post-hoc analysis however revealed that the significant variation existed only between farm types 2 and 3. Variable costs generally relate to the quantities of input applied, and can reach as high as 93% of production cost in intensive cultures (Panayotou et al. 1982).

Table 3.6 Annual cost analysis (GH¢) of the five non-commercial farm types (Annual operating costs based on per hectare pond size)

| arm Types | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| ariable Cost | | | | | | | | | | |
| upplies | Cost (GH¢) | %TC | Cost(GH¢) | %TC | Cost (GH¢) | %TC | Cost (GH¢) | %TC | Cost (GH¢) | %TC |
| ertilizers | 72.00 | 1.9 | 44.00 | 0.9 | 88.00 | 3.0 | 14.00 | 0.3 | 24.00 | 0.7 |
| ngerlings | 68.00 | 9.9 | 644.00 | 13.8 | 244.00 | 8.4 | 1,061.00 | 23.9 | 632.00 | 18.1 |
| upplementary feed | 1,159.00 | 31.1 | 1,652.00 | 35.5 | 347.00 | 11.9 | 387.00 | 8.7 | 487.00 | 13.9 |
| abour | | | | | | | | | | |
| art-time labour | 70.00 | 1.9 | 64.00 | 1.4 | 70.00 | 2.4 | 71.00 | 1.6 | 72.00 | 2.1 |
| iscellaneous | | | | | | | | | | |
| aintenance | 119.00 | 3.2 | 131.00 | 2.8 | 117.00 | 4.0 | 195.00 | 4.4 | 128.00 | 3.7 |
| arvesting | 10.00 | 0.3 | 10.00 | 0.2 | 10.00 | 0.3 | 10.00 | 0.2 | 10.00 | 0.3 |
| arketing | 15.00 | 0.4 | 15.00 | 0.3 | 15.00 | 3.4 | 15.00 | 0.3 | 15.00 | 0.4 |
| Total variable cost | 1,813.00 | 48.7 | 2,558.00 | 55.0 | 976.00 | 33.5 | 1,753.00 | 39.5 | 1,366.00 | 39.1 |
| xed Cost | | | | | | | | | | |
| and | 160.00 | 4.3 | 160.00 | 3.4 | 160.00 | 6.8 | 160.00 | 3.6 | 160.00 | 4.6 |
| epreciation | | | | | | | | | | |
| ond | 594.00 | 16.0 | 653.00 | 14.0 | 584.00 | 20.1 | 974.00 | 21.9 | 642.00 | 18.4 |
| quipment | 74.00 | 2.0 | 75.00 | 1.6 | 124.00 | 4.3 | 241.00 | 5.3 | 100.00 | 2.9 |
| terest | | | | | | | | | | |
| quity | 1,085.00 | 29.13 | 1,204.00 | 25.9 | 1,068.00 | 36.7 | 1,318.00 | 29.7 | 1,224.00 | 35.1 |
| Total fixed cost | 1,912.00 | 51.3 | 2,092.00 | 45.0 | 1,936.00 | 66.5 | 2,689.00 | 60.5 | 2,126.00 | 60.9 |
| otal annual costs (A+B) | 3,725.00[a] | | 4,650.00[b] | | 2,912.00[a] | | 4,442.0[b] | | 3,492.00[a,b] | |
| roduction(kg per annum) | 2,284 | | 4,423 | | 1,436 | | 1788 | | 1518 | |
| rice/kg | 1.7 | | 1.30 | | 1.50 | | 1.50 | | 1.50 | |
| ross Revenue | 3,883.00 | | 5,749.00 | | 2,154.00 | | 2,681.00 | | 2,277.00 | |
| et Profit | 157.80 | | 1,099.00 | | -758.00 | | -1761.00 | | -1215.00 | |

Production costs with same superscripts did not statistically vary significantly from each other.

Table 3.7 Annual cost analysis (GH¢/ha) of three commercial farms

| | Farm | | | | | |
|---|---|---|---|---|---|---|
| | A | | B | | C | |
| Intensity of Production | Semi-intensive | | Semi-intensive | | Intensive | |
| Total pond size (ha) | 1.01 | | 2.02 | | 1.92 | |
| **Variable Cost** | Cost (GH¢/ha) | % TC* | Cost (GH¢/ha) | % TC | Cost (GH¢/ha) | % TC |
| Supplies | | | | | | |
| Fertilizers | 44.00 | 0.8 | 137.00 | 1.7 | 0.00 | 0.0 |
| Fingerlings | 880.00 | 15.6 | 1,099.00 | 13.6 | 9,000.00 | 22.2 |
| Supplementary feed | 1,300 | 23.0 | 1,460.00 | 18.1 | 19,800.00 | 48.8 |
| Labour | | | | | | |
| Part-time labour | 175.00 | 3.1 | 920.00 | 11.4 | 461.00 | 1.1 |
| Miscellaneous | | | | | | |
| Maintenance | 594.00 | 10.5 | 620.00 | 7.7 | 1,490.00 | 3.7 |
| Harvesting | 100.00 | 1.8 | 100.00 | 1.2 | 100.00 | 0.3 |
| Marketing | 100.00 | 1.8 | 100.00 | 1.2 | 100.00 | 0.3 |
| **A. Total variable cost** | 3,193.00 | 56.4 | 4,438.00 | 56.0 | 3,0951.00 | 76.32 |
| Land | 500.00 | 8.8 | 500.00 | 6.2 | 500.00 | 1.2 |
| Labour | 54.00 | 1.0 | 208.00 | 2.6 | 500.00 | 1.2 |
| Depreciation | | | | | | |
| Pond | 450.00 | 8.0 | 950.00 | 11.8 | 750.00 | 1.9 |
| Equipment | 218.00 | 3.9 | 231.00 | 2.9 | 2,421.00 | 6.0 |
| Interest | | | | | | |
| Equity | 1,297.00 | 22.9 | 1,954.00 | 24.2 | 5,932.00 | 14.6 |
| **B. Total fixed cost** | 2,465.00 | 43.6 | 3,635.00 | 45.0 | 9,603.00 | 23.7 |
| Total annual costs (A+B) | 5,658.00 | | 8,073.00 | | 40,544.00 | |
| Production(kg per annum) | 4,500.00 | | 10000 | | 45,999 | |
| Price/kg | 2.00 | | 2.00 | | 2.00 | |
| **Gross Revenue** | 9,000.00 | | 20,000.00 | | 91,998.00 | |
| **Net Profit** | 3341.00 | | 11,926.00 | | 51,443.00 | |

*TC – Total Cost

Table 3.8 Estimation of capital costs for the three commercial farms in Ghana, labelled Farms A, B and C.

| Variable | Farm A | Farm B | Farm C |
|---|---|---|---|
| Pond Construction (GH¢) | 9,000.00 | 19,000.00 | 15,000.00 |
| Equipment (GH¢) | 786.00 | 540.00 | 8,294.00 |
| Investment (GH¢) | 3,193.00 | 4,438.00 | 30,951.00 |
| Total (GH¢) | 12,979.00 | 23,979.00 | 54,245.00 |

*Cost of production*

Mean cost of production per hectare per annum for the entire data was GH¢ 3,549.00 (US$ 3,697.00) with a range of GH¢ 1,343.00 (US$ 1,399.00) – GH¢ 8,291.00 (US$

8,636.00). Mean production costs per ha for the farm types were quite varied ranging from a minimum mean of GH¢ 2,912.00 (US$ 3,033.00) for farm type 3 to a maximum mean of GH¢ 4,464.00 (US$ 4,650.00) for farm type 2. Mean costs of production per kg of fish produced by the non-commercial farms was lowest for farm type 2 at GH¢ 1.05/kg and about half of that incurred by farm types 3, 4 and 5 at GH¢ 2.03, GH¢ 2.33 and GH¢ 2.30 respectively. Per kg production cost for farm type 1 was the second lowest at GH¢1.63.  Overall, the cost of production per kg for the non-commercial farms, seemed to increase with increasing farm size (Table 3.9).

Cost of production per ha of the commercial farms as expected were much higher than those of the non-commercial farms (Table 3.8) with values of GH¢ 5,658.00 for the small scale semi-intensive commercial farm (farm A), GH¢ 8,073.00 for the semi-intensive medium scale commercial farm (farm B) and GH¢ 45,999.00 for the intensive medium scale commercial farm (farm C). Cost per kilogram fish were however relatively lower than those of the non-commercial farms with Farm B incurring the lowest cost of GH¢ 0.82 (US$ 0.85) per kg of fish produced while Farm A incurred the highest cost of GH¢ 1.23 (US$ 1.28). With the exception of non-commercial farm type 2, production costs of all the commercial farms were generally much lower than those of the non-commercial farm (Table 3.9). Overall, cost of production per kilogram also decreased with increasing output per hectare (Figure 3.1).

Table 3.9 Relationship between mean costs of production per kg fish for all the farm types

| Farm type | Average farm size (ha) | Cost of production/kg (GH¢) |
|---|---|---|
| Non-commercial | | |
| 1 | 0.11 | 1.63 |
| 2 | 0.03 | 1.05 |
| 3 | 0.66 | 2.02 |
| 4 | 0.47 | 2.33 |
| 5 | 0.25 | 2.30 |
| Commercial | | |
| A | 1.01 | 1.23 |
| B | 2.02 | 0.82 |
| C | 1.92 | 0.88 |

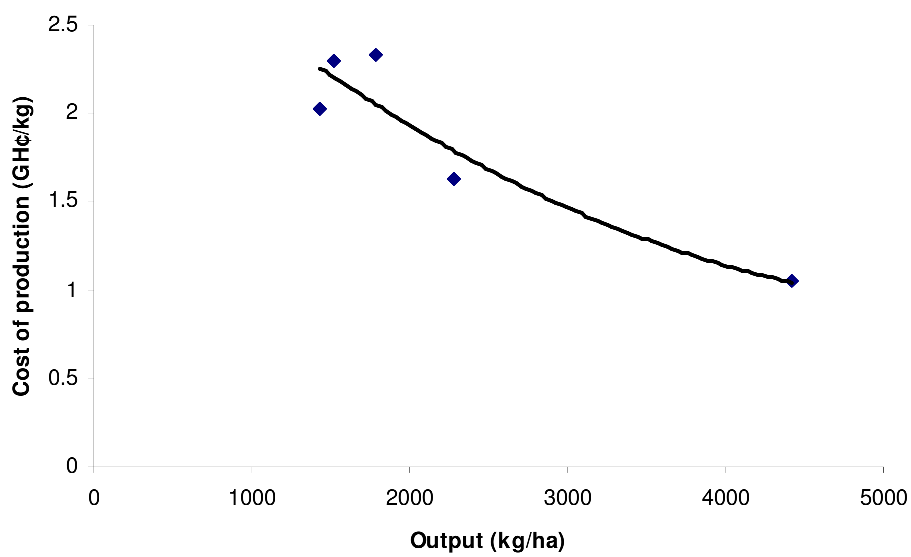



Figure 3.1 Relationship between mean output per annum and mean cost of production for the five non-commercial farm types

### 3.3.2 Gross revenue

Gross revenue as defined in the methodology (Page 75) is the total farm value of production during a specific period and this was obtained from total output multiplied by the unit (kg) farm price. The output used in the calculation covered marketed and un-marketed products i.e. the quantity of fish sold, the quantity consumed on farm, the quantity given away and the quantity used in kind payments.

Overall mean yield per hectare of pond varied very widely, from 240 kg to 10,839kg with a mean value of 3,320kg (median = 2,773kg). Farm type 2 had the highest mean yield per hectare, at 4,423 kg/ha (median = 3,707kg/ha) (Table 3.6 above). Type 3 had the lowest mean yield of 1,436kg/ha (median = 1,017kg/ha) per annum thus the low gross revenue. Mean fish yield per hectare generally decreased with increasing mean pond size ($r^2$ = 0.78) (Figure 3.2) which reflected in the gross revenues being received by the larger non-commercial farms.

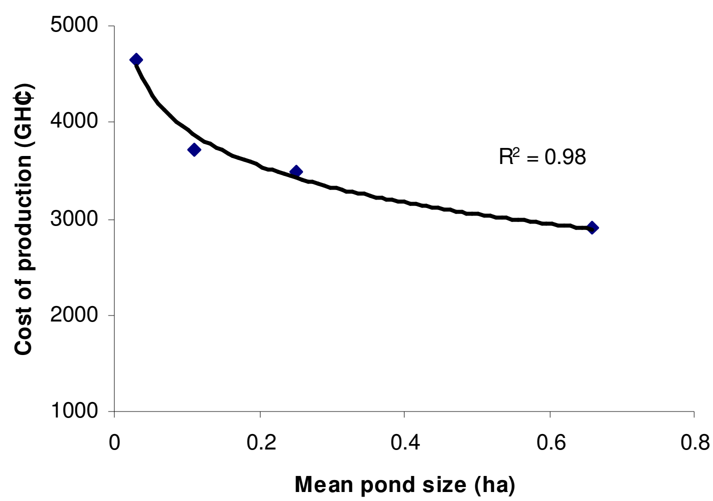



Figure 3.2 Relationship between mean fish yield (kg/ha) and mean pond size (ha) of non-commercial farm types

The gross revenue per hectare for non-commercial farms ranged from GH¢ 2,154.00 for farm type 3 to GH¢ 5,749.00 for farm type 2. Gross revenue per kg of fish produced was GH¢1.30 for farm type 2, GH¢1.70 for farm type 1 and GH¢1.50 for farm types 3, 4 and 5. Farm type 2 obtained the lowest revenue per kg production. Prices as stated were means of prices quoted by farmers in the groups. The mean price per kg of fish for the entire data was GH¢ 1.40 (US$ 1.41) with a range of GH¢ 1.30 (US$ 1.31) to GH¢ 2.80 (US$ 2.82). These figures suggest that a large proportion of the farmers were receiving very low prices for their fish compared to the GH¢ 2.0 of commercials. Two commercial farms not featured in this analysis (because the owners would not give out any information regarding their operations) but allowed visit to the farm during the survey sold their fish at price ranging from GH¢ 2.50 to GH¢ 3.80/kg. Type 2 farmers received the lowest mean price of GH¢ 1.30 per kg whilst type 5 farms had the highest mean price of GH¢ 1.90 per kg which is quite close to the GH¢ 2.00 posted by the commercial farms and also recommended by the Ashanti Regional Fish Farmers association and to which operators were expected to comply.

Gross revenues per hectare for commercial farms varied very widely, ranging from GH¢ 9,000 (US$ 9,048.60) to GH¢ 91,998 (US$ 92,494.79). These increased with increasing intensity of production; a trend which is very similar to that found with the non-commercial farms. Prices per kg for the commercial farmers were however the same at GH¢ 2.00, and so differences in gross revenue therefore stemmed from annual output per hectare.

### 3.3.3 Viability of fish farming

*Gross and net profits*

Gross profit per ha per annum was positive for all the non-commercial farms with mean values per hectare ranging from GH¢ 911.00 (US$ 916.00) to GH¢ 3,192.00 (US$ 3,209.00) for farm types 5 and 2 respectively (Table 3.10). Gross profit for the commercial farms were much higher with values of GH¢ 5,807.00 (US$ 5,838.00) for the small scale commercial farm to GH¢ 61,047.00 (US$ 61,377.00) for the medium scale intensive commercial farm.

The gross profit margin (gross profit divided by total revenue) ranged from 38% (0.38) for farm type 4 to 55% (0.55) for farm type 2. The gross profit margin for farm types 1, 2 and 3 were quite similar with values of 53%, 56% and 55% respectively. The ratio for the commercial farms on the other hand were much higher ranging from 65% to 77%. High gross profit margins are beneficial in limiting the effects of price volatility (Atrill, 2003).

Net profit by definition is the gross revenue less total production cost (including interest and depreciation on capital employed); a positive value implies profitability and potential viability, a negative value imply non-profitability and the unlikelihood of continuing unless revenues increase and/or costs decrease. Net returns for farm types varied widely ranging from a mean net loss of GH¢ -1,761.00 per ha for farms of type 3 to a mean net profit of GH¢ 1,099.00 per ha for farms of type 2 (Table 3.10). Only two of the five farm types appeared to make net profits, though these types account for over 70% of the total data. Putting all the data together, however, only 47% of farms were found to be profitable. Of these, 64.8% were from type 2, 22.2% type 1, 5.6% from type 3, 1.9% from type 4 and 5.6% from type 5. The percentages of profitable and unprofitable farms within each farm type category are presented in Table 3.17. The commercial farms on the other hand were all profitable. Net profit per annum ranged from GH¢ 3,341.00 (US$ 3,359.00) to GH¢ 51,443.00 (US$ 51,721.00) per ha (Table 3.10).

Table 3.10 Summary of the results of the cost-benefit analysis

| Farm Type | Capital costs (GH¢) | Gross Revenue (GH¢) | Variable costs (GH¢) | Total costs (GH¢) | Production costs (PC) (GH¢) | Gross profit (GH¢) | Gross Profit margin (%) | Return on VC (%) | Return on TC (%) | Net profit (GH¢) | Payback period (years) | NPV | IRR (%) | B/C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13,879 | 3,883 | 1,813 | 1,912 | 3,775 | 2,070 | 53.3 | 8.7 | 4.2 | 158 | 88 | <0 | - | 1.0 |
| 2 | 15,946 | 5,750 | 2,558 | 2,092 | 4,650 | 3,192 | 55.5 | 42 | 23.7 | 1,100 | 14 | <0 | 4 | 2.5 |
| 3 | 12,859 | 2,154 | 976 | 1,936 | 2,912 | 1,172 | 54.7 | -[a] | -[a] | -[a] | -[b] | <0 | - | <1.0 |
| 4 | 18,599 | 2,681 | 1,652 | 2,504 | 4,156 | 1,029 | 38.0 | - | - | - | - | <0 | - | <1.0 |
| 5 | 14,969 | 2,207 | 1,366 | 2,126 | 3,492 | 911 | 38.0 | - | - | - | - | <0 | - | <1.0 |
| Partial costing | | | | | | | | | | | | | | |
| 1p* | 4,700 | 3,883 | 1,813 | 457 | 2,270 | 2,070 | 53.3 | 89 | 71.0 | 1,612 | 3 | 4,389 | 45 | 2.8 |
| 2p | 5,600 | 5,750 | 2,558 | 549 | 3,107 | 3,192 | 55.5 | 103 | 85.0 | 2,643 | 2 | 9,330 | 65 | 7.0 |
| Commercial Farms | | | | | | | | | | | | | | |
| A | 12,979 | 9,000 | 3,193 | 2,466 | 5,659 | 5,807 | 64.5 | 104 | 59.0 | 3,341 | 4 | 5,898 | 35 | 2.0 |
| B | 23,979 | 20,000 | 4,439 | 3,635 | 8,074 | 15,561 | 77.8 | 269 | 148.0 | 11,926 | 2 | 43,404 | 62 | 4.1 |
| C | 54,254 | 91,998 | 30,951 | 9,603 | 40,554 | 61,047 | 66.4 | 166 | 127.0 | 51,444 | 1 | 236,412 | 105 | 7.9 |

p* - Results for partial costing of capital costs - mainly costs of pond construction for non-commercial farm types 1 and 2 on the assumption that family labour was employed.
[a] – negative returns
[b] – no payback period

Net returns on variable and total costs for the five non-commercial farm types, in contrast to the gross margin ratio, were quite varied. The percentages were less than zero for farm types 3, 4 and 5 as a result of the negative net returns, which ranged from GH¢ -758.00 to GH¢ -1761 (Table 3.6 above) and positive for farm types 1 and 2. Overall, farm type 2 had the best returns on both variable and total cost at 43% and 24% respectively. Returns on variable costs for all the three commercial farms were very good, exceeding 100%, with that of commercial farm B going as far as 269%. Returns on total cost were again generally good for all the commercial farms but that of Farm A was less than 100%.

None of the non-commercial farms were found to be financially viable in the strictest sense. Although farm types 1 and 2 had positive net returns, their various other indicator values were not favourable. The benefit cost ratios (B/C) were 1.0 and 2.5 for farm types 1 and 2 respectively. The payback periods were 88 and 14 years for farm types 1 and 2 respectively. Farm types 3, 4 and 5 had no payback periods, with negative returns. The B/C values for the commercial farms were also all greater than one, ranging from 2.0 to 7.9.

Applying partial costing to initial capital requirements of farm types 1 and 2 on the basis described in the methodology (Page 72) significantly reduced their capital costs to less than half the initial amounts (Table 3.10 – Farm types 1p and 2p). This resulted in annual cost of production per hectare reducing by about 40% and 34% for farm types 1 and 2 respectively, significantly improving the financial viability of these farms. Net profit for farm Type 1 increased from GH¢ 158.00 to GH¢1,612.00 whilst that for farm type 2 increased from GH¢1,1000.00 to GH¢2,643.00. The pay back periods also reduced from 88 and 14 years for farms 1 and 2 to 3 and 2 years respectively, which is comparable to those of the commercial farms. This is a significant change and has a major bearing on farmers' perceptions of viability, and their preparedness to commit to fish farming.

*Net Present Value (NPV)*

The net present values (NPV) were less than zero for all the fully costed non-commercial farms but positive for farms types 1 and 2 when partially costed with values of GH¢4,389.00 (US$ 4,572.00) and GH¢ 9,330.00 (US$ 9,718.00) respectively, which for farm type 2 was about 1.5 times higher than the current cost of capital. That for farm type 1 was slightly lower than its current capital cost. The NPV for the commercial farms were all positive and ranged from GH¢ 5,898.00 (US$ 6,202.00) for the small scale commercial farm to GH¢ 236,413.00 (US$ 246,263.00) for the large scale commercial farm. NPV for the medium scale commercial farm was GH¢ 43,404.00 (US$ 45,212.00). Except for the small scale commercial farm where the NPV was about half the current cost of capital, that of the medium scale and large scale commercial farms were respectively about 2 and 4 times higher than the current costs of capital. The NPV of farm type 2 is higher than that of the small scale commercial farm when partially costed.

*Internal Rate of Return (IRR)*

The internal rates of return (IRR) were less than 1% for all the fully costed non-commercial farms except for farm type 2 for which the IRR was 4% which was also lower than the 2006 average rate of inflation of 13% used in the analyses. With partial costing, the IRR for farm type 2 increased from 4% to 45% which then exceeds the rate of inflation by three fold. The IRR for the commercial farms on the other hand were all positive and higher than the average rate of inflation, ranging from 35% for the small scale semi-intensive commercial farm to 105% for the medium scale intensive commercial farm. These values also exceed the 20 – 25% interest rates commonly applied to loans by commercial banks in Ghana. The IRR for the medium scale semi-intensive commercial farm was 62%. Both IRR values of the partially costed farm types 1(1p) and 2(2p) exceeded the 13% interest rate used.

### 3.3.4 Break-even analysis

Break-even production is the level of production at which revenues equal cost, or break-even sales which is obtained by dividing the total cost of production by output, or more accurately when NPV = 0. The analysis here was based on the level of production at which revenue just covers production cost. Among the non-commercial farms, farms type 2 could be said to pose the least risk with current mean production of 4,423kg/ha being 19% (846kg/ha) higher than the break even production of 3,577kg/ha (Table 3.11). The levels of risk however seemed to increase with increasing pond size. Farm types 3, 4 and 5 were producing below capacity and needed to increase production by between 35 to 55% to break even. Mean fish production for farm type 1 was just about even.

Breakeven prices were quite varied with values of GH¢ 1.05 for farm type 2 being less than half (GH¢ 2.33) of that for farm type 4. Farm types 3, 4 and 5 can only attain the break-even prices indicated by producing larger sizes of fish. As mentioned above commercial farms producing fish of 250g and above sold their fish at wholesale prices ranging from GH¢ 2.50 to GH¢ 3.80 per kg.

Production by commercial farms was more efficient and exceeded break-even production levels by between 37 and 60%. Break even prices of GH¢ 0.81 and GH¢ 0.88 per kg of the relatively larger commercial farms i.e. Farms B and C were less than half their current wholesale prices of GH¢ 2.0 and lower than those of the non-commercial farms. Break-even price of the small scale commercial farmers was also quite low but higher than that of non-commercial farm type 2. These results suggest that commercial farms B and C can sell their fish for half the current price of GH¢ 2.0 and still make profit and the lower prices are likely to increase consumer demand for the product. Risk associated with these commercial businesses may therefore be considered low.

Table 3.11 Break-even analysis of farm types per hectare per year

| Farm Type | Non-commercial | | | | | Commercial | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | A | B | C |
| Actual production (kg/ha) | 2284 | 4423 | 1436 | 1787 | 1518 | 4500 | 10000 | 45999 |
| Break-even production (kg/ha) | 2191 | 3576 | 1941 | 2770 | 2328 | 2830 | 4037 | 20277 |
| Break-even production as % of actual production | 96.0 | 81.0 | 135.0 | 155.0 | 153.0 | 63.0 | 40.0 | 44.0 |
| Break-even price (GH¢) | 1.64 | 1.05 | 2.03 | 2.33 | 2.31 | 1.26 | 0.81 | 0.88 |

### 3.3.5 Production function analysis

Results of the analysis are presented in Table 3.12 and Table 3.13. High coefficient of determination of ($r^2$) of 0.82 and significance of the variance ($p<0.001$) indicated that the estimated production function fitted the data well (Table 3.12). All the three parameters significantly predicted yield (Table 3.13) but most importantly was the quantity of feed applied per hectare which had a strong relationship to output with a coefficient of determination ($r^2$) of 0.73 compared to 0.35 and -0.08 for quantities of fertilizer and stocking densities respectively (Table 3.13). The sum of the variables coefficients (i.e $ß_1 + ß_2 + ß_3$) was greater than one (1.18) suggesting that there is increasing returns to scale. The equation describing the relationship between output based on the three variables (feed fertilizer and stocking density) is as presented in Equation 3.9. Using the output prediction formula, increasing quantities of feed applied per hectare per annum by 10% and holding the other variables constant increases output by 10.2% whiles a 20% increase in feed quantity will result in a 20.4% increase in output. The analysis could not however be repeated for the commercial farms because of the small sample size.

Table 3.12 Results of the analysis of variance

| Model | | Sum of squares | df | Mean square | $r^2$ | F | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | Regression | 65.12 | 3 | 21.71 | 0.82 | 1793.70 | <0.001 |
| | Residual | 3.74 | 309 | 0.01 | | | |
| | Total | 68.86 | 312 | | | | |

Table 3.13 Regression coefficients, standard error of the mean and the level of significance of the selected variable in predicting yield.

| Variables | Coefficient (ßi) | SE | $r^2$ | t | p-value |
|---|---|---|---|---|---|
| Constant | -2.84 | 0.32 | | -8.86 | |
| Feed (X1) | 1.02 | 0.04 | 0.73 | 24.85 | <0.001 |
| Manure (X2) | 0.21 | 0.01 | 0.35 | 15.7 | <0.001 |
| Fingerling (X3) | -0.05 | 0.02 | -0.08 | 3.21 | <0.01 |

$$\text{Output (Y)} = 0.06\, X_1^{1.02} X_2^{0.21} X_3^{-0.05} \qquad \text{Equation 3.10}$$

### 3.3.6 Sensitivity analysis

Analyses showed that net profit and IRR were most sensitive to changes in the wholesale price of fish. The levels of sensitivity varied from one farm type to the other. A 10% increase in wholesale price of fish for farm type 1 will for instance result in a 246% increase in net profit whilst a similar change in price for farm type 5 will only result in a 15% change. Changes in IRR were equally more sensitive for non-commercial farm types 1 and 2. A 20% increase in baseline price increases IRR for farm type 2 from 3.9% to 17.8% and from negative for farm type 1 to 3.4%, making farm type 2 potentially viable. The sensitivity of the IRR to a 20% increase in the wholesale price of fish was even more significant for the commercial farms with the IRR increasing from a baseline value of 35% for commercial farm A to 46%, from 62% for farm B to 78% and from 105% for farm C to 139% (Table 3.14 and Table 3.15). Farms B and C were still economically viable even at prices 30% lower than their current wholesale prices. Farm A will however lose its viability if its wholesale price should fall that low.

Percentage changes in fixed cost had the second largest impact on both net profit and the IRR values for all the non-commercial farms except farm type 2, whilst changes in variable costs caused the second largest change in net profit and IRR for the commercial farms and farm type 2. This was however not surprising as the percentage contribution of variable cost to the total cost of production was higher for these farms. Changes in the costs of fingerlings had the least impact when compared to production feed prices, fixed costs and variables costs. Feed prices had the second list impact on net profit. A 10% rise in production feed costs will reduce net profits by 5.2% to 73.5% for the non-commercial farms whiles a 10% reduction will increase net profits by the same margins.

The net profit of the commercial farms will only change by between 3.0 to 5.5% for any 10% change in feed costs. Contrary to the non-commercial farms, changes in feed costs will have the third highest impact on net profit after fixed costs and costs of fingerlings.

Table 3.14 Percentage changes in net profit with percentage increases in costs of feed, fingerling, fixed costs, total costs and fish yield for the different farm types

| Farm Type | Non-commercial Farms | | | | | Commercial Farms | | |
|---|---|---|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 | A | B | C |
| Feed Costs | | | | | | | | |
| 10% | 73.5 | 15.0 | 4.6 | 2.6 | 4.0 | 5.5 | 3.0 | 4.8 |
| 20% | 147.0 | 30.0 | 9.2 | 5.2 | 8.0 | 9.4 | 4.2 | 8.7 |
| Fingerling costs | | | | | | | | |
| 10% | 23.3 | 5.9 | 3.2 | 6.5 | 5.2 | 4.3 | 2.7 | 2.7 |
| 20% | 46.6 | 11.7 | 6.4 | 13.0 | 10.4 | 6.9 | 3.6 | 4.5 |
| Variable Cost | | | | | | | | |
| 10% | 114.9 | 23.3 | 12.9 | 11.2 | 11.2 | 11.2 | 5.5 | 7.0 |
| 20% | 230.0 | 46.5 | 25.8 | 22.4 | 22.5 | 26.8 | 10.8 | 13.9 |
| Fixed Cost | | | | | | | | |
| 10%* | 121.2 | 19.0 | 25.5 | 17.0 | 17.5 | 7.4 | 3.1 | 1.9 |
| 20% | 242.3 | 38.0 | 51.1 | 33.9 | 35.0 | 14.8 | 6.1 | 3.7 |
| Wholesale price (GH¢/kg) | | | | | | | | |
| 10% | 246.1 | 52.3 | 28.4 | 18.2 | 18.7 | 25.3 | 15.0 | 16.9 |
| 20% | 492.1 | 104.6 | 56.8 | 36.3 | 37.5 | 52.3 | 31.8 | 34.8 |

Table 3.15 Sensitivity of projected internal rate of return to production feed price, costs of fingerlings, variable costs, fixed costs and wholesale price per kilogram of fish

| | Non-commercial Farm Types | | | | | Commercial Farms | | |
|---|---|---|---|---|---|---|---|---|
| Variables | 1 | 2 | 3 | 4 | 5 | A | B | C |
| Feed price (GH¢/kg) | | | | | | | | |
| -30% | -* | 10.6 | - | - | - | 37.3 | 62.3 | 121.6 |
| -20% | - | 8.5 | - | - | - | 36.2 | 61.7 | 118.0 |
| -10% | - | 6.0 | - | - | - | 35.0 | 61.0 | 110.4 |
| 10% | - | 1.0 | - | - | - | 32.2 | 59.7 | 103.0 |
| 20% | - | - | - | - | - | 31.0 | 59.1 | 99.3 |
| 30% | - | - | - | - | - | 29.8 | 58.4 | 95.6 |
| Fingerling costs(GH¢/kg) | | | | | | | | |
| -30% | - | - | - | - | - | 34.3 | 61.5 | 110.5 |
| -20% | - | - | - | - | - | 32.2 | 61.0 | 108.7 |
| -10% | - | | - | - | - | 33.3 | 60.0 | 106.9 |
| 10% | - | - | - | - | - | 29.8 | 59.0 | 103.2 |
| 20% | - | - | - | - | - | 28.7 | 58.5 | 101.3 |
| 30% | - | - | - | - | - | 27.4 | 58.0 | 99.5 |
| 40% | - | - | - | - | - | 26.2 | 57.5 | 97.6 |
| Variable Cost(GH¢/kg) | | | | | | | | |
| -30 | - | 13.7 | - | - | - | 40.8 | 66.0 | 122.8 |
| -20% | - | 10.8 | - | - | - | 37.6 | 64.0 | 116.9 |
| -10% | - | 7.5 | - | - | - | 34.3 | 62.0 | 111.0 |
| 10% | - | 1.0 | - | - | - | 27.5 | 57.9 | 99.1 |
| 20% | - | - | - | - | - | 23.7 | 55.8 | 93.1 |
| 30% | - | - | - | - | - | 19.7 | 53.8 | 87.2 |
| Fixed Cost(GH¢/kg) | | | | | | | | |
| -30% | - | 12.1 | - | - | - | 47.5 | 71.0 | 128.4 |
| -20% | - | 9.6 | - | - | - | 42.2 | 67.3 | 112.8 |
| -10% | - | 6.9 | - | - | - | 36.8 | 63.6 | 112.8 |
| 10% | - | 1.0 | - | - | - | 24.7 | 56.1 | 97.2 |
| 20% | - | - | - | - | - | 17.8 | 52.3 | 89.3 |
| 30% | - | - | - | - | - | 9.5 | 48.4 | 73.5 |
| Wholesale Price (GH¢/kg) | | | | | | | | |
| -30% | - | - | - | - | - | - | 31.1 | 52.3 |
| -20% | - | - | - | - | - | 9.4 | 41.3 | 70.4 |
| -10% | - | - | - | - | - | 21.3 | 50.8 | 87.8 |
| 10% | - | 12.5 | - | - | - | 39.6 | 68.7 | 122.1 |
| 20% | 3.4 | 17.8 | - | - | - | 47.6 | 77.4 | 139.1 |
| 30% | 9.6 | 23.3 | - | - | - | 55.3 | 86.0 | 156.1 |

* Negative IRR

### 3.3.7 Comparison of Profitable and non-profitable non-commercial farms

Results showed that only 47% of all the non-commercial farms were profitable, and based on the farm type categories, only two of the five farm types had mean positive net returns. Not every farm within the profitable farm categories however made profits and neither did all the farms within the farm types with negative net returns make losses. The percentage of farms with net positive returns was however higher for farms within the profitable farm type categories than those without. A detailed look at basic characteristics of the profitable and non-profitable farms within the five type categories, presented in Tables 3.16 and 3.17, revealed distinguishing features between the profitable and the non-profitable farms within a farm type category in relation to the quantities of feed applied per hectare per year, the quality of feed, for which the price per kg was used as a surrogate, variable costs to fixed cost ratio and costs of production per kilogram of fish.

The types of feed applied by the profitable and unprofitable farms are given in Table 3.15. The basic feeds applied were cereal brans and other feeds (made of agriculture by-products, food left overs etc.). In terms of the quality of feeds applied - deduced from the prices/kg, there were no distinct trends between profitable and unprofitable farms of the same farm type category whereby all the profitable farms may be said to be applying better quality feed than the unprofitable farms. What was clear however was the general relationship between the quality of feed applied and the output /ha depicted in Figure 3.3 which followed an asymptotic relationship with a coefficient of determination ($r^2 = 0.54$). This suggested that applying quality feeds is likely to improve fish output and hence profitability.

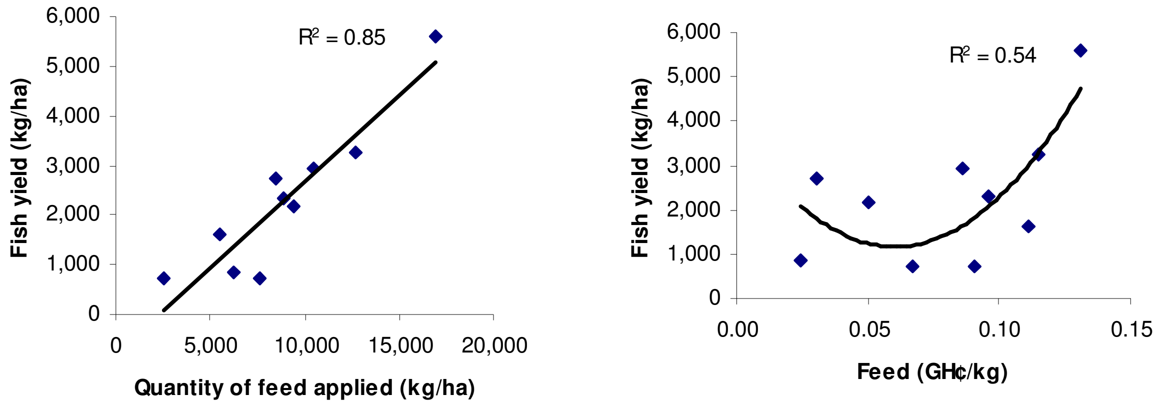



Figure 3.3 Relationship between quantities of feed applied output (left) and quality of feed applied and output (right)

Table 3.16: Basic culture information of profitable and non-profitable farms in the five farm type categories (% farmers)

| Farm type | Species cultured | | | Source of fingerlings | | | Types of feeds used | | | | No. of crops per year | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tilapia | Catfish | Mixed Culture | Hatchery | Inbred | wild | Cereal bran | Cereal bran & fishmeal | Compound feed | Others | 1 | 2 |
| 1a | 12.5 | 25.0 | 62.5 | 42.9 | 57.1 | - | 42.9 | - | - | 57.1 | 28.6 | 71.8 |
| 1b | - | 8.3 | 91.7 | 40.0 | 60.0 | - | 72.7 | 9.1 | - | 18.2 | 54.5 | 45.5 |
| 2a | 16.1 | 35.5 | 48.4 | 37.9 | 41.4 | 20.7 | 71.0 | 3.2 | - | 25.8 | 57.1 | 42.9 |
| 2b | 23.5 | 35.3 | 41.8 | 24.1 | 69.0 | 6.9 | 42.4 | 6.1 | 3.0 | 48.5 | 79.3 | 20.7 |
| 3a | 50.0 | - | 50.0 | 66.7 | 33.3 | - | 80.0 | 10.0 | | 10.0 | 36.4 | 63.6 |
| 3b | - | - | 100.0 | 66.7 | 33.3 | - | 100.0 | n/a | - | - | 33.3 | 66.7 |
| 4a | 33.3 | - | 66.7 | 33.3 | 66.7 | - | 66.7 | 33.3 | - | - | - | 100.0 |
| 4b | - | - | 100.0 | - | 100 | - | - | 100.0 | - | - | 58.3 | 41.7 |
| 5a | 14.3 | - | 85.7 | 42.9 | 42.9 | 14.3 | 100.0 | - | - | - | 33.3 | 66.7 |
| 5b | 33.3 | -* | 66.7 | 33.3 | - | 66.7 | 100.0 | - | - | - | 50.0 | 50.0 |

* not applicable

Table 3.17: Percentage of profitable and unprofitable farms in each farm type category

| Farm type | % of total | Fingerlings stocked (x 10000/ha) | | | | Feed (kg/ha) | Feed cost/ha/yr | Output (Kg/ha) | Price (GH¢/kg) | VC (GH¢/kg) | FC (GH¢/kg) | CoP* (GH¢/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <1 | 1 - 2 | 2 - 3 | >3 | | | | | | | |
| 1a | 40.0 | 50.0 | 25.0 | 25.0 | - | 5,531 | 616.00 | 1618 | 1.61 | 1131.00 | 2180.00 | 3311.00 |
| 1b | 60.0 | 66.7 | 33.3 | - | - | 10,500 | 905.00 | 2940 | 1.75 | 2495.00 | 1644.00 | 4139.00 |
| 2a | 47.8 | 31.3 | 31.3 | - | 15.6 | 12,688 | 1461.00 | 3244 | 1.30 | 2122.00 | 2194.00 | 4316.00 |
| 2b | 52.2 | 40.0 | 14.3 | 20.0 | 25.7 | 16,938 | 2221.00 | 5601 | 1.50 | 2994.00 | 1990.00 | 4984.00 |
| 3a | 78.6 | 90.9 | 9.1 | - | - | 2,519 | 228.00 | 712 | 1.50 | 573.00 | 2616.00 | 3189.00 |
| 3b | 21.4 | 66.7 | 33.3 | - | - | 9,422 | 471.00 | 2160 | 1.50 | 1379.00 | 1256.00 | 2635.00 |
| 4a | 75.0 | 66.7 | - | - | 33.3 | 6,233 | 153.00 | 852 | 1.50 | 1488.00 | 3345.00 | 4833.00 |
| 4b | 25.0 | 100.0 | - | - | - | 8,422 | | 2722 | 1.50 | 2018.00 | 2033.00 | 4051.00 |
| 5a | 70.0 | 71.4 | 14.3 | - | 14.3 | 7,609 | 507.00 | 719 | 1.90 | 1219.00 | 2319.00 | 3538.00 |
| 5b | 30.0 | 66.7 | 33.3 | - | - | 8,922 | 854.00 | 2317 | 1.90 | 1513.00 | 1933.00 | 3446.00 |

## 3.4 Discussion

Costs of production per kg of fish by non-commercial farmers were quite varied with only farm type 2 operating at what may be regarded as a practically viable level. The costs of production among other things depend on the culture techniques used and the costs of inputs to the production process (Atrill, 2003). At the technical level, the ability to produce at a low enough cost is determined primarily by species, location and feed (Hishamunda, 2004). The suitability of the feed used, the efficiency with which it is utilised for growth by the culture animals and the feeding practices used are major factors determining profitability of an aquaculture operation (Southgate, 2003).

The pay back periods for the commercial farms were all less than 5 years whilst the quickest pay back period for a fully costed non-commercial farm was 14 years. The partially costed non-commercial farms however had payback periods comparable to those of the commercial farms, ranging from 2 to 3 years. An assumption of payback period is that risk is time related (Drury, 2001), such that the longer a project takes to pay itself, the greater the chances of failure. An aquaculture enterprise not profitable in 10 years is likely to be considered an unattractive investment opportunity because high risk projects are expected to perform better and projects that can recoup their cost quickly are considered economically more attractive than those with long pay back periods (Atrill, 2003). Depending on risk levels, a commercial aquaculture enterprise may typically be required to pay back within four or five years (Muir, 2004) a time period within which the commercial farms assessed and the partially costed non-commercial farms fall but not the fully costed non-commercial farms.

The negative NPV and IRR values further confirmed the poor financial performance of the non-commercial farms. From the sensitivity analysis, increasing the wholesale price for farm type 2 and 1 by 15% and 40% respectively will make them viable. The wholesale price of farm type 1 was however high when compared to the other non-commercial farm types. Improving its viability therefore lies in producing more efficiently. Its mean yield per hectare was about 45% less than that of farm type 2.

Fish yields or the wholesale price per kilogram for farm types 3, 4 and 5 will have to increase by between 35 to 55% to break even. Fish pricing in Ghana is very much dependent on the size of the fish; the bigger the size the higher the price (Chapter 4, Fish pricing – page 126). From the fish consumer survey, tilapia weighing at least 200g were generally preferred by consumers and always fetched relatively higher prices as there was always a ready market for it. Farmers producing such fish tend to dictate the wholesale price whilst farmers producing smaller sized fish were offered prices by the wholesalers and retailers. Obtaining the right prices for the fish would therefore mean producing fish of good quality and size. The importance of price to profitability shows prominently when farm type 2 and commercial Farm A are compared. The yields per hectare were very similar but with the commercial farm having a higher cost of production, yet commercial farm A was viable while farm type 2 was not and this can only be attributed to the differences in product pricing. As mentioned earlier (Section 3.36, Sensitivity analysis, page 95) attaining a 15% increase in wholesale price will make farm type 2 viable but this depends on the possibility of these farms to produce larger fish or increase output by the same margin. Results of the production function analysis indicated that there was increasing returns to scale. Increasing the quantity of feed in particular should therefore lead to an increase in output hence profitability of the farms.

In comparing the profitable and non-profitable farms, the quantities of feed applied per hectare per year per output by the profitable farms were generally higher than the unprofitable ones. A more accurate way of determining this would probably have been the quantity of feed applied per standing crop during the culture period, as effective feeding of fish takes into account the size of culture animals among others. The higher quantities of feed applied by the profitable farms however suggested that they were engaged in a relatively more intense farming than their unprofitable counterparts. A general comparison of mean quantities of feed applied per hectare per annum and mean annual output by the profitable and non-profitable farms within the groups showed a strong positive coefficient of determination ($r^2 = 0.85$) between the quantities of feed applied and annual yields (Figure 3.3) which is more of a confirmation of the production function analysis where quantity of feed applied had a strong influence on output. Though the amount of feed presented to culture animals may have a major influence on the productivity and running costs of an aquaculture operation, overfeeding wastes feed and promotes water quality problems, and underfeeding reduces growth rates and overall yield and profitability (Southgate, 2003). Underfeeding could therefore be one of the reasons for the low yields by the unprofitable farms and subsequent losses of their farm operations.

In summary, the financial viability analyses showed that commercial fish farming in Ghana is very profitable and financially viable with NPV and B/C ratios being greater than 1, maximum payback periods of four years and IRR values much higher than the

13% rate of inflation used, it thus poses minimal risk to investment. The non-commercial farms although being able to have positive net returns, were generally, not financially viable when fully costed. However, they could be if pond construction and initial infrastructure requirements are attained at a very low cost.

The current financial analysis was based entirely on fish production via pond culture. One of the main costs affecting profitability and the other financial viability indicators was the initial costs of capital of which costs of pond construction was a major component. Production of fish by cage culture in existing water bodies will eliminate cost of pond construction though will incorporate the cost of a cage production system whose capital investment requirement is relatively low compared to other intensive culture systems (El-Sayed, 2006). A comparative analysis of land-based and relatively expensive offshore cage production system for production of sea bass and sea bream in the Mediterranean, by Lisac and Muir (2000) showed the latter production system to have lower capital requirement and better returns on investment. Simpler cage systems are therefore likely to have even more favourable financial performance.

# Chapter 4 - The size and nature of markets and trade for aquaculture products in Ghana

## 4.1 General introduction

The need to increase annual domestic fish production and efforts by the government at attaining this through increased aquaculture production has been established in preceding chapters. Efforts so far have concentrated on enhancing production with little consideration given to marketing. Recent developments geared further in the area of production have included the signing of a memorandum of understanding by the Ministry of Fisheries with two Chinese fisheries companies to secure a US$ 40 million loan from the Chinese government to begin a 2000ha fish farming project on River Pra at Shama in the Western Region (http://www.ghana.gov.gh/ghana/ministry_contract_loan_fish_farming.jsp - accessed 19/06/08). A potential strongpoint of aquaculture is that production can be market oriented as opposed to basing markets on the variabilities of production, as in capture fisheries (Pillay and Kutty, 2005). Proper understanding of consumer demands, attitudes, and preferences can therefore be a major asset in planning a viable aquaculture production programme, thus the need for a market survey.

A market is literally defined as a place where goods and services are sold, in effect, a location. It can also be defined by time such as the seasonal markets or by a level or generic sense as in the retail and wholesale market. In marketing, the term market refers to the group of customers or organizations that is interested in or has demand for the product, has the resources to purchase the product, and is permitted by law and regulations to acquire the product (www.netmba.com – accessed 13/02/08).

The primary objective of every market is to sell goods that satisfy customer needs at whatever level these are expressed. The demand of any product is however influenced by price of the product, prices of related goods, consumers' tastes and preferences, population numbers, income levels of consumers, and future expectations. Understanding demographic characteristics, consumer characteristics and consumer attitudes toward the product can be used by the industry to expand markets into other geographic areas or to increase consumption in traditional market areas (Engle, 1998).

### 4.1.1 Marketing in aquaculture

Marketing is thought to play a key role in any successful aquaculture development. The success of aquaculture depends not only on increased production, but also on the existence of a well organized and efficient marketing system. Gilbert (1989) placed the importance of marketing in aquaculture on a par with production, financing, cash flow and other profit determining factors in aquaculture enterprises.

Marketing unfortunately is often an area disregarded by fish farmers with most producers being production oriented rather than market oriented (Gilbert, 1989). Williams (2000) noted that without adequate attention to marketing strategy, even the most efficient fish production may not be financially profitable. Those who are successful in this business are those that are market oriented, have diverse markets, have spent much time talking to potential customers before beginning to design their production operation and are committed to their customers (Engle and Quagrainie, 2006). Good marketing in aquaculture is far more than just finding customers for what farms have decided to produce. It starts with customers, both final end user and trade customers, and from analysis of their needs works back to decisions about what should be produced when it should be produced and what the customer should be offered (Shaw, 1990).

### 4.1.2 Fish consumption and consumer preferences in Ghana

General fish consumption patterns in Ghana have been studied to varying extents by Essuman (1992); Heinbuch (1994) and Seini et al. (2004). According to the studies, consumption patterns were defined by incomes of consumers, location of consumers, ethnicity, availability and prices of other animal protein sources such as meat and meat product, eggs and milk. Essuman (1992) from his study found that the higher a consumer's income the more the quantity of fish demanded, the species preferred and the size of fish preferred, whilst the poor and rural population in Ghana are said to buy smaller sizes of fish because they are what they can afford. He also indicated that certain processed forms of fish were preferred by some ethnic groups than others and cited the example of fermented fish as much more preferred in southern Ghana, particularly among the Akans (the largest ethnic group in Ghana) than in the north among the indigenous tribes. Seini et al. (2004) from their study found in relation to location that coastal dwellers or people living on the fringes of large water bodies ate relatively more fish than their inland counter parts.

About 80% of total fish supply is cured in various ways, with smoking being the most widely practised method, applicable to virtually all species of fish available in the country. Thus between 70-80% of the domestic marine and freshwater catches are consumed in smoked form (FAO and UNDP, 2001). Other forms of pre-sale preservation are drying, frying and salting.

### 4.1.3 Fish trade and marketing in Ghana

Trading in fish is an important industry in Ghana providing full or partial employment for an estimated 10% of the population in both rural and urban communities. The volume of trade is dominated by the artisanal fishery sector which accounts for 80% of domestic fish supply. Landings from this sector are dominated (93%) by small and medium sized pelagic fishes and demersal fishes (Perry and Sumaila, 2007). As already mentioned in Chapter 2 (Section 2.4, Page 63), it is a very segregated activity with males dominating the production sector whilst females dominate the processing and marketing sectors. A large proportion of the fish traded is sold smoked. Fresh fish is thought not to attract a large market in many places as a result of poor cold storage facilities (Aryeetey, 2002). Although estimated annual turn over of the sector is not immediately available, there are indications that this runs into millions of Ghana Cedis as the local value of smoked fish exports to the United States, Canada and Europe in 2001 were estimated to range from $ 7.3 million to $ 9.4 million (Diei-Ouadi and Mensah, 2005).

### 4.1.4 Fish sale outlets: structure and infrastructure

There are six main forms of fish sale outlets in Ghana. These are the regular markets, fish landing sites, fish markets, frozen foods stores, vendors and farm gate or pond side.

*Regular markets*

These are markets dealing in a wide range of merchandise but which often have sections allotted to fish sellers, either central markets serving entire districts or regions or local markets serving communities. Urban markets are opened for business daily whilst those in the rural areas or serving small urban communities operate once or twice a week on particular days or at regular intervals of days. Traders at these markets form associations as per product sold. Examples of such associations are the fish sellers association, or even riverine fish sellers association. Each group has its leaders but above all these leaders is the market "queen" who oversees all operations in the market. Ghana has a decentralised form of government and these markets are built and managed at the local level by the district assemblies or the municipal authorities. Operators in these markets pay daily tolls to the municipal authorities. Infrastructure wise, the central markets are fairly well equipped with portable water supply, electricity, chilled storage and ice supply (normally by private operators), and washing facilities with several stores, stalls, and sheds. Some local markets in the cities and urban areas have similar facilities but smaller in size whilst others and those in the rural areas are poorly equipped with some rural markets being just a cluster of sheds. Levels of trade in fish at the central markets are intermediate, wholesale, and retail. Trading at the local markets is primarily retail.

*Fish landing sites*

These are sites adjacent to inland water bodies or the beaches where fishermen land their catch. The description here however focuses primarily on fresh water landing sites. Levels of trading (wholesale, intermediate wholesale or retail) at a site are very much determined by the volume of fish landings. About 310 of such sites have been identified along the Volta lake, prominent among these are Yeji, Dambai Brumben, Ekye Amenfrom, Tapa Abotoase, Kwame krom, Kpando Torkor, Dezemeni, Tapa Abotoase, Torurroano and Akateng and Akokomasisi landing sites where an estimated 75000t of fish were landed in 2002 (Directorate of Fisheries, 2003). Important landing sites in other parts of the country include Galilea along the Weija reservoir in the Greater Accra region, Obonu adjacent to Lake Bosomtwi, Barekese next to the Barekese dam and Owabi dam all in the Ashanti region. Fish sold here are either live or fresh except on market days at certain landing sites especially those along the Volta Lake when processed fish is also available.

Most landing sites are poorly equipped with no receptacles for landed fish. Trading is generally in the open sky or under thatch shelters. Landed fish are sold to wholesalers directly from boats or canoes. These are then sold to intermediate wholesalers and retailers from the floor on polyethylene sheets. There are no chilled or frozen storage facilities. Fresh fish dealers come along with ice blocks sometimes bought from the vicinity. There are no potable water or washing facilities. Trading starts very early in the morning and ends by midday. There are plans by the government to install blast freezers and ice making machines at eight landing sites, including Dzemeni and Kpando Torkor along the Volta (http://www.ghana.gov.gh/?q=ghana/ministry_provide_refrigeration_fish_landing_sites.jsp - accessed 7/05/08).

*Fish markets*

These are markets that deal in both fresh and processed (smoked, salted dried/fermented and fried) fish. With the exception of the wholesale and retail outlets located in central and local markets, and fish landing sites where the number of traders can run into a few hundreds, the sizes and number of traders are quite small often ranging from 10 to about 50 traders maximum. Level of trading in the smaller units is primarily retail.

*Frozen food stores*

Commonly referred to as “cold stores” in Ghana, these deal primarily in frozen marine fishes, frozen meat and meat products. These are about the most organised fish sale outlet with adequate frozen preservation and storage facilities. The bulk of foods sold by these outlets are imported. The sizes of the outlets vary ranging from very small retail units operated from domestic chest freezers and run from the operator’s home or a small shop to large industrial establishments operating from large commercial walk in freezers and employing several people. It is the only outlet where the prices of fish are posted and sold per unit weight.

The main difference between wholesalers and intermediate wholesalers in this outlet is that the wholesalers are the main importers, importing[4] fish from Mauritania, Senegal and Namibia, and meat and meat products from the USA, Canada, Argentina and Brazil. Fish from the wholesalers are sold in cartoons of 20 and 30kg weights.

*Vendors*

This group of dealers are either roaming or stationary. Roaming vendors go from place to place selling their fish whilst stationary vendors are permanently located under a stall or under the shade of a tree often along a busy road. There were two types of roaming vendors; small retailers who go round communities carrying fish on their heads to sell or

[4] Information obtained from operators during data collection

larger retailers who have pre-arranged “contracts” with food joint operators such as hotels, restaurants and tilapia joints for regular supply of fish. Prices of fish sold by the vendors varied widely, depending on the location and the bargaining power of the buyer.

*Farm gate*

The final fish sale outlet fish is the farm gate. These are sale outlets for farmed fish often located on a pond side. The level of trade at this outlet varies with the level of operation. The commercial farms gates as observed on one commercial farm and also reported by Blow and Leonard (2007) for another commercial farm largely sell to wholesalers who go on to sell to retailers and intermediate wholesalers. The subsistence farms on the other hand sell largely to retailers as they are often in relatively small quantities. Quantity of fish sold at this outlet is over a 1000 mt, - estimate based on total aquaculture production in 2006.

### 4.1.5 Objectives

The objectives of this chapter were therefore to determine the size and nature of the domestic markets for tilapia (*Orechromis niloticus)*, to determine consumer preferences and attitudes to the fish, and from this, to set out the likely implications for expanding aquaculture production, and the potential returns available to producers.

The work was carried out by collecting primary data from the Greater Accra, Eastern, Volta and Ashanti regions. The Greater Accra region (GAR) was selected because it is a coastal town with access to both fresh and frozen marine fishes. Living standards are about the highest in the county, and it has a good representation of different ethnic groups. The Eastern and Ashanti regions are both located inland somewhere mid-section of the country but with the latter being further inland. Both regions are dominated by the Akan ethnic group. Living standards are lower than in GAR. The Volta region, another coastal region was selected because of its direct access to both marine fish and freshwater fish from the Volta Lake. Living standards are the lowest of the four regions and it is dominated by the Ewe ethnic group.

This chapter determines the species preferred by households, reasons for choice and what the buying factors are and general views and preferences for captured and cultured tilapia. The mode and operation of dealers in the tilapia wholesale and retail sectors are also looked at, as well as an estimation of the size of trade and main constraints faced by dealers and operators.

## 4.2 Methodology

### 4.2.1 The study area

The study as just above mentioned in the objectives was undertaken in four regions of Ghana; the Greater Accra, Eastern, Ashanti and the Volta Regions all of which are located in the southern and mid sections of the country. Specific towns selected within the Greater Accra Region for the household and food services operators were the Accra and Tema Metropolitan Areas; Eastern region – Koforidua municipal area, Kpong, Akwatia, and Somanya; Ashanti region – Kumasi Metropolitan Area and Ejisu; and the Volta Region – Ho, Hohoe, Kpando and Dzemeni (Figure 1). With the exception of the regional capitals (Accra, Koforidua, Kumasi and Ho), selection of the other locations was in a way influenced by the other surveys being conducted i.e. the fish farm and fish market surveys which were being done concurrently. These were therefore areas where any of the other surveys could be conducted at the same time.

## Characteristics of the regions

*The Greater Accra Region*

The Greater Accra Region, which contains the capital city of Accra, is the smallest of the ten regions of the Ghana, occupying just about 1.4% of the total land area. The region is the second most populated, after the Ashanti Region, with a population of 2,905,726 representing 15.4% of country's total population and a population density of 895.5 persons per km$^2$, the highest in the country.

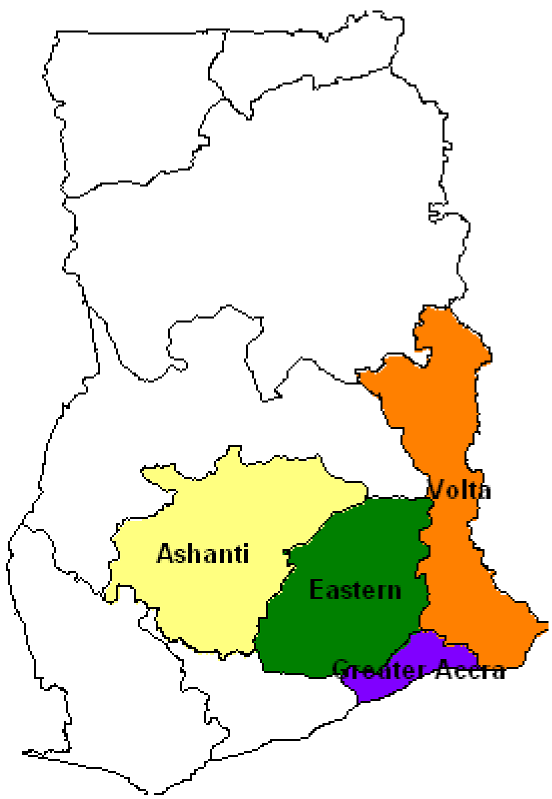



Figure 4.1 Map of Ghana showing the study areas

The major ethnic groups of the region according to the 2000 census were the Akans (39.8%), Ga-Dangmes (29.7%) and Ewes (18%) (Ghana Statistical Service, 2002).

The Greater Accra Region also has the highest national literacy rate as well as the largest concentration of professional and technical workers. The Accra and Tema Metropolitan Areas, where the surveys for this region were conducted have literacy rates of 85.1 and 79.8% respectively (Ghana Statistical Service, 2002).

The region has relatively high levels of employment, with 70.4% of people in the region being economically active. Of this, 42.0% are engaged in sales and service occupations, and 10.8% are professional, technical and related workers (Ghana Statistical Services, 2002). More than half of the economically active population in this region are self employed. Unlike the other regions, agriculture, animal husbandry and forestry workers, fishermen and hunters, do not feature prominently, at only 9.1% compared with 49.1% for the country as a whole. The region has a coastline length of 225km and marine fishing and related works is a major occupation of the immediate coastal dwellers.

*The Eastern Region*

The Eastern Region is the sixth largest region of the country with an area of 19,323 $km^2$, representing 8.1% of the total land area of Ghana. It has a total population of 2,106,696. It is the third most populous region, after the Ashanti and Greater Accra. The region has an average population density of 109 per $km^2$, about an eighth of the levels in the Greater Accra Region.

There are four major ethnic groups in the region, the Akans (52.1%), Ga-Dangmes (18.9%), the Ewes (15.9%) and the Guans (7.2%).

Compared with the national average of 57.9%, 63.6% of the population in the region, are literate. Close to half of the literate population (47%) have however only attained

Middle School or Junior Secondary School level education with just about 3 % having tertiary level education.

Seventy-five percent of the people in this region are economically active. Of these 54.8% are involved in agriculture and related work, 19.3% involved in sales and services, 14.0% involved in production, transport and equipment work (14.0%) and just about 6.9% involved in professional and technical work.

*The Ashanti Region*

The Ashanti Region is the third largest region in terms of size. With land coverage of 24,389 square kilometres, representing 10.2% of the total land area of Ghana, it is the most populous and one of the most rapidly growing regions in the country. Ashanti region has a population of about 3,612,950 (Ghana Statistical Service, 2002), about 19.1% of the national total with a population density of 148.1 persons per square kilometre, the third largest after the Greater Accra and Central Regions. The dominant ethnic group is the Akans at 77.9% of the local population. Other groups include the Mole- Dagbon (9.0%), the Ewe (3.2%), the Grusi (2.4%), the Mande-Busanga (1.8%) and the Ga- Dangme (1.4%).

The literacy level here is about 65%. The major occupation in all the districts is Agriculture/Animal Husbandry/Forestry, except in the Kumasi metropolis, where sales workers predominate. The main economic activity of the people in the region is agriculture with 44.5% of the economically active population engaged in it.

*The Volta Region*

The Volta region lies to the east of country. It covers a land area of about 20,570 $Km^2$ which represents 8.6% of the land area of Ghana. The Volta Lake is a prominent feature in this region. The region has a population of 1,635,421 and has a relatively low population density of 79.5 individuals/$Km^2$. Although the region is ethnically diverse, the main ethnic groups are the Ewe (68.5%), Guan (9.2%), Akan (8.5%) and Gurma (6.5%).

Literacy rate in this region, compared to the three other regions in the study area is relatively low. Only about 57.9% of the adult population in the region is classified as literate.

About 74.5% of the adult population in this region are economically active. Of this, more than two-thirds are self-employed. Agriculture, animal husbandry, fishing and hunting sectors constitute the largest occupational groups in all the districts.

### 4.2.2 Data collection

Three survey areas were defined, with the aim of connecting the main infrastructures and wholesaling capacity dealing in tilapia, with food services and domestic consumption. The entire data were obtained from primary sources. The data collection team is as described in Chapter 2 (Methodology – section on data collection). The consumer data collection was entirely random. Respondents were approached in the streets, in their homes, in their offices, etc. With the dealer data, the focus was only on those dealing in tilapia. With the exception of a few household consumers and food service operators who asked to submit the questionnaires later, all the other were completed immediately with the respondents.

## Dealer survey

The questionnaire for the dealers was designed to gather information on their preferences for tilapia in relation to size, price and quality; to estimate quantities of the fish dealt in per annum, sources of the fish, average distance covered to obtain the fish, levels of operation, general trends in the sector and to collate their views on farmed fish. The questionnaire was administered to the dealers at all the fish sale outlets mentioned above i.e. the fish landing sites, fish markets, fish farms, local markets etc.

One hundred and thirty-three (133) wholesale and retail dealers were interviewed. The number of dealers interviewed per location is presented in Table 4.1. There was no information on the total number of tilapia dealers in each location or per region, therefore their representative levels could not be defined. Of the 133 tilapia dealers interviewed, most lived and conducted their businesses in the same region. In the Greater Accra region, however 11% of dealers travelled from other locations to conduct their business, about one-third from the Eastern Region and two-thirds from the Volta Region. Average distances to Accra are about 100 and 220 km respectively.

Table 4.1 Number of dealers interviewed per location

| Location | Number of dealers |
|---|---|
| Greater Accra Region | 76 |
| Eastern Region | 25 |
| Ashanti Region | 17 |
| Volta Region | 15 |
| Total | 133 |

## Food service operators

A number of restaurants and tilapia joints (food outlets whose main menu is grilled tilapia which is often served with “banku” a local dish made from fermented corn dough) were visited and questionnaires again administered to them. Another category of food service, chop bars, low cost restaurants dealing mainly in traditional Ghanaian foods were also surveyed. Sampling was at random and as in the case of the dealers, the questionnaires were designed to collect information on preferred sizes, quantity and quality of tilapia preferred, the source of the fish, frequency of purchase, quantity of tilapia purchased per annum, the forms in which the fish were sold and finally their views on farmed fish. The number of food service operators in the four regions is presented in Table 4.2.

Table 4.2 Number of food service operators interviewed in each region

| Location | No. of respondents |
|---|---|
| Greater Accra Region | 49 |
| Eastern Region | 12 |
| Ashanti Region | 3 |
| Volta Region | 10 |
| Total | 74 |

### Consumers

The questionnaire for the consumer survey was designed to collect information about consumer demographics, preferred sources of protein, most preferred fish species, frequency of fish consumption, attitudes and views on farmed fish. Although sampling was at random, a number of men approached with the questionnaire, either declined or passed them on to their wives because according to them shopping for food stuff was the duty of women. Responses were therefore heavily weighted towards women.

The first section of the questionnaire focused on the socio-economic characteristics of the respondent and the respondent's household. This was then followed by a series of general questions about fish and fish consumption habits and preferences, then specific questions relating to tilapia.

The results were then used to develop a demographic profile of people in Ghana who were likely to buy tilapia and hence, areas where tilapia farms are likely to thrive because of good demand for the product. The number of households interviewed in the four regions is presented in Table 4.3.

Table 4.3 Number of households interviewed in each of the four regions

| Region | No. of households |
|---|---|
| Greater Accra | 112 |
| Eastern | 65 |
| Ashanti | 95 |
| Volta | 101 |
| Total | 373 |

### 4.2.3 Data analysis

All data collected for each of the categories were coded and entered into separate files in SPSS 14 for Windows, Microsoft Office Excel 2003 and Minitab 13 for Windows. With the data being mainly categorical, cross-tabulations and other non parametric methods were employed in the analysis.

Based on the tilapia consumption patterns described by the household consumers, the respondents were classified in three categories – regular tilapia consumers, occasional consumers and non-consumers. The regular consumers were made up of households who purchased tilapia regularly, at least once a month. The non-regular consumers were households who purchased tilapia once awhile and finally the non-consumers who were households who for one reason or another did not like it and did not consume it.

### Estimation of the size of tilapia trade

Besides the cold stores and at some pond sides, fish is generally not sold per unit weight. At landing sites, small-sized fish were measured in containers or baskets of about 5l capacity and then sold. Bigger fish were hand sorted by the seller according to size and dealers had to negotiate for prices making it impossible for traders to indicate the exact weight of fish bought on occasion. They could however give an estimate of the amounts spent. The quantities of fish dealt in by traders were therefore estimated from the average amounts spent on each trading trip and an approximate per kg prices of fish. The latter were obtained by sitting with the traders whilst they purchased the fish and once that was done, the amounts paid were noted as well as the quantities, which were measured with a weighing scale carried along to all the markets visited.

## 4.3 Results

### 4.3.1 Wholesaler and retailers (dealers)

### Profile of dealers

Of the 133 tilapia dealers interviewed, 15% were wholesalers, 5.3% were intermediate wholesalers and 79.6% were retailers (Table 4.4). About 7% of dealers had been in the trade for more than 30 years whiles the majority (43.6%) began their operations between the period 2000 and 2006. The profile of entry into the business showed a steady increase in the number of entrants since 1976 (Table 4.5). Estimated mean and total monthly quantities of tilapia purchased by dealers at different levels of trading are presented in Table 4.5). The estimates were obtained using the procedure described in methodology under data analysis. Mean volume of trade by wholesalers per month was 2071kg whilst mean volumes dealt in by intermediate wholesalers and retailers were

342 kg and 286kg respectively. All the dealers did not necessarily deal in just tilapia - close to 20% traded in other riverine fishes such as *Chrysichthys, Clarias* and *Heterotis* species.

Total number of tilapia dealers across the country was not assessed during the survey. The number of fish traders and processors along the Volta Lake the main source of freshwater fish in Ghana (85%) has however being estimated at 20,000 (National Fisheries Association of Ghana - http://www.nafagfish.org/fisheries.htm). Tilapia is estimated to account for 30% of fish landed from the lake. Assuming a similar proportion of the traders deal in tilapia, tilapia traders nationwide could be estimated at around 6,000. This however excluded traders at the regular markets who do not travel to fish landing sites for their consignments.

Table 4.4 Profile of dealers

| Level of trade | Number of traders | % of dealers | Mean monthly purchases (kg) | Sum of monthly purchases (kg) |
|---|---|---|---|---|
| Wholesale | 20 | 15.1 | 2071 ± 293.2 | 33,183 |
| Intermediate wholesale | 7 | 5.3 | 342 ± 58 | 2,050 |
| Retail | 106 | 79.6 | 286 ± 26 | 24,900 |
| Total | 133 | 100 | | 60,133 |

Table 4.5: Periods within which the dealers began their businesses

| Year business started | Number of traders | % of traders |
|---|---|---|
| 1970 - 1975 | 7 | 6.4 |
| 1976 – 1980 | 4 | 3.7 |
| 1981 – 1985 | 5 | 4.6 |
| 1986 – 1990 | 10 | 9.2 |
| 1991 – 1995 | 14 | 12.8 |
| 1996 – 2000 | 30 | 27.5 |
| 2000 - 2005 | 39 | 35.8 |
| Total | | 100.0 |

## Sources of tilapia

Fish landing sites along the Volta River and Lake were named by the dealers as being their sources of tilapia. The most common places named were Kpando Torkor, Dzemeni, Akosombo, Yeji, Afram Plains, Dambai and Kpong. Others were Galilea, located along the Weija reservoir, by dealers in the Greater Accra Region and Lake Bosomtwe and Barekese dam by dealers in the Ashanti Region. The only fish farms named in the Greater Accra Region and to a small extent in the Eastern and Volta Regions was Tropo Farms located on the outskirts of the Greater Accra Region and Crystal Lake (by only one retailer in the Greater Accra Region) a cage culture commercial farm located in the Eastern region, but there are indications (Blow and Leonard, 2007) that harvested fish from this farm is also largely sold in the Greater Accra Region.

Total quantities of fish obtained from wild-capture and culture sources by region are given in (Table 4.6). More than 60% of tilapia sold in the Greater Accra region was from culture. It is the only the region among the four where a large proportion of fresh tilapia traded is from culture. The Volta region was second with 13.2% of quantities sold coming from culture. None of the dealers in the Ashanti region reported selling tilapia from culture. Close to 95% of traders buying cultured fish in all the three regions indicated buying it from Tropo farms, one of the largest commercial fish farms in the country. The other 5% obtained it from Crystal Lake. Dealers attributed their preference for fish from Tropo farms to the relatively large (250 – 350g) and consistent sizes, consistency in supply and the relatively lower price per unit compared to those from wild-capture (see Table 4.9 below).

More than half of dealers (57.7%) bought and sold fish in the same region they resided whilst the rest (42.3%) obtained the fish from regions others than where they reside (Table 4.7). More than 30% of traders in the Greater Accra and Ashanti region travelled to various fish landing sites other than those in their regions to buy fish. These included areas such as Yeji in the Brong-Ahafo region and Buipe in the Northern region all of which are landing sites along the Volta Lake. Estimated distance travelled by such traders to buy fish ranged from less than 50km to 499 km.

Table 4.6: Estimates of quantities of tilapia bought by traders interviewed in the four regions

| Region | Estimated monthly purchases (kg) | Quantity from culture (kg) | % of region's total | Quantity from wild-capture (kg) | % of region's total |
|---|---|---|---|---|---|
| Greater Accra | 41,710 | 25,297 | 60.9 | 16,413 | 39.1 |
| Eastern | 10,832 | 270 | 2.5 | 10,562 | 97.5 |
| Ashanti | 4967 | - | - | 4967 | 100.0 |
| Volta | 4,539 | 600 | 13.2 | 3939 | 86.8 |

Table 4.7 Table showing the location of traders (regions where they reside) and regions where they buy tilapia from. The figures are percentages (%)

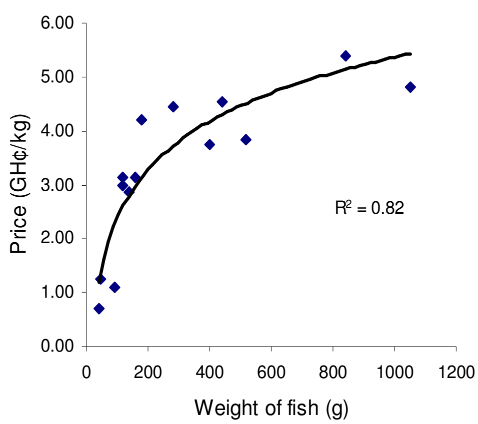
| Region of residence | Regions where traders buy their fish | | | | | |
|---|---|---|---|---|---|---|
| | Greater Accra | Eastern | Ashanti | Volta | Several sources | Total |
| Greater Accra (%) | 54.4 | 5.9 | - | 8.8 | 30.9 | 100 |
| Eastern (%) | 10.3 | 37.9 | - | 48.3 | 3.4 | 100.0 |
| Ashanti (%) | - | - | 61.1 | - | 38.9 | 100.0 |
| Volta (%) | 4.5 | - | - | 90.9 | 3.3 | 100.0 |
| % of Total | 29.9 | 10.9 | 8.0 | 29.2 | 21.9 | 100.0 |

**Fish pricing**

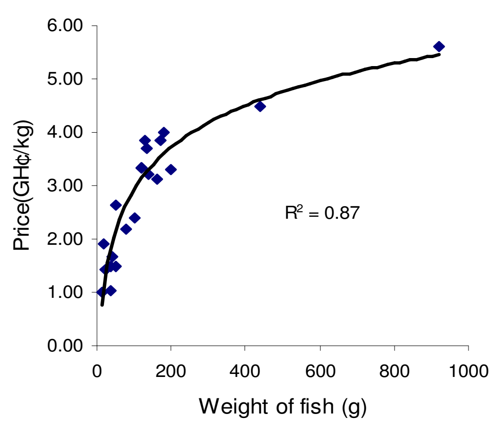
Apart from the cold stores and the farm-gate locations no prices were posted, and dealers charged different prices to different customers. A retail customer who intended to buy fish would normally be quoted a price by the seller and the buyer would bargain for a lower price. If an agreement is reached, the customer will buy the fish otherwise he or she would walk away. Retail prices also varied with the location of the fish sellers. Prices of fish sold along major roads and in high income areas were found to be the most expensive with prices ranging from GH¢ 6.00 (US$ 6.40/kg) to about GH¢ 7.50 (US$ 8.00/kg), much higher than those in the markets and the fish landing sites visited. According to the dealers, size, freshness and quality of the fish also influenced the price, the larger the fish the higher the price per kilogram (Table 4.8). Freshly brought in fish were stated to be more expensive than fish that have stayed overnight. Differences in price were not obtained but similar observations had also been made by Heinbuch (1994).

At the wholesale-retail level, the pattern of pricing also depended on many factors, making it difficult to obtain consistent perspectives. According to the traders interviewed the prices of fish varied considerably depending on the season, location, freshness, quality and size. The most influencing factor among these may be the season as a trader in Accra indicated an 80g sized tilapia purchased at GH¢ 2.2/kg at the time of the survey (October) could have obtained at about half the price (GH¢ 1.25) /kg at peak season (July). Prices obtained by traders also depended on their bargaining powers. Figure 4.2 shows price profiles for tilapia in four landing sites across the study area. Although the fish were only hand sorted and priced according to size without any form of scientific measurement, very strong correlations with coefficients of determination ($r^2$) of 0.8 (Figure 4.2) were found between the price/kg and the size category of the fish. Wholesale prices of captured tilapia quoted by traders at all sites except the Ashanti region were relatively similar ranging from GH¢ 3.12 to GH¢ 3.78 (Table 4.8). A reason for the lower prices in the Ashanti region may be due to the relatively smaller sizes of tilapia being traded in which had an average size of 170g compared to 233g, 266g and 290g in the Greater Accra, Volta and Eastern regions respectively.

Mean farm gate prices of cultured fish ranged from GH¢ 1.40 to GH¢ 2.18 (Table 4.8). Prices of cultured fish did not necessarily vary consistently with size as observed with captured fish. The Volta region for instance had the lowest prices/kg of GH¢ 1.33 despite the fact that mean size of cultured fish was higher than that of Eastern region where mean price/kg was GH¢ 1.53 (Table 4.8). The location may have had an influence as many towns in the Volta region have relatively more access to fresh tilapia from the Volta Lake because of the numerous landing sites along the lake as mentioned earlier. In the Ashanti region, the fish farmers association's guide price for cultured fish at the time of data collection in 2006 was GH¢ 2.00 which reflected in the mean price obtained for the region.




Dzemeni – Volta Region




Galilea – Greater Accra

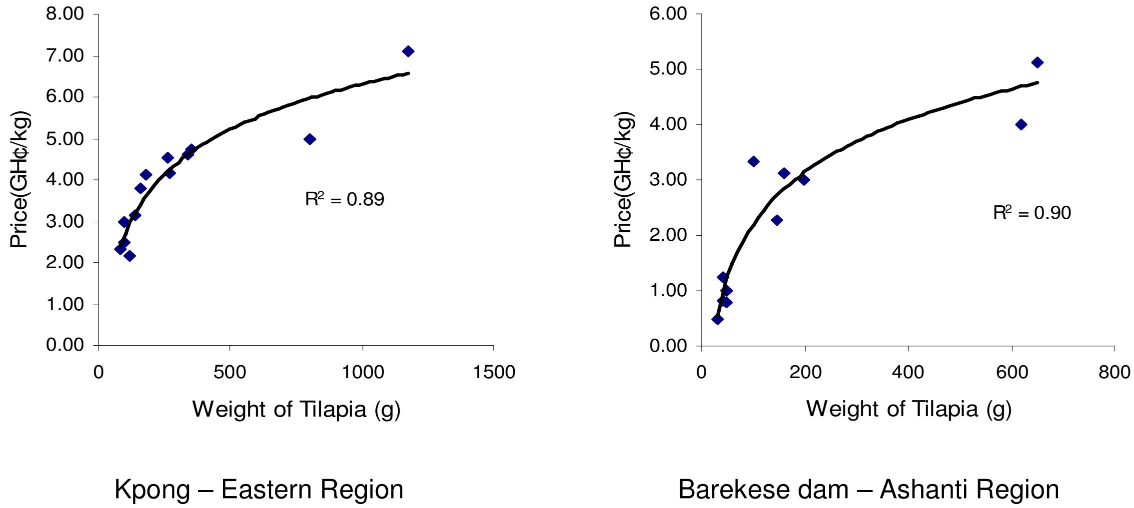



Figure 4.2 Per kilogram wholesale prices of captured tilapia in relation to fish size at four freshwater fish landing sites in the surveyed areas.

Table 4.8 Mean wholesale prices of captured and cultured tilapia in the four regions

| Region | Wild-Capture fish | | | Cultured fish | | |
|---|---|---|---|---|---|---|
| | Sample No. | Average fish size(g) | (GH¢/kg) | Sample No. | Average fish size(g) | (GH¢/kg) |
| Greater Accra | 25 | 233 ± 69 | 3.36 ± 0.27 | 7 | 202 ± 28 | 2.18 ± 0.76 |
| Eastern | 15 | 287 ± 66 | 3.78 ± 0.29 | 15 | 161 ± 15 | 1.53 ± 0.36 |
| Ashanti | 13 | 170 ± 41 | 2.26 ± 0.41 | 13 | 258 ± 32 | 2.00 ± 0.09 |
| Volta | 16 | 266 ± 56 | 3.12 ± 0.35 | 32 | 184 ± 33 | 1.33 ± 0.53 |

Very few retailers (about 9%) provided both buying and selling prices of their products. Gross profits/kg of these traders ranged from GH¢1.50 to GH¢ 3.80 for dealers in culture fish (dealers 1 – 6) (Table 4.9) and GH¢ 0.30 to GH¢1.0 for those dealing in captured fish (dealers 7 to 12 – Table 4.9). Key information missed in this instance was to have found out from the traders how the retail prices were fixed. What was obvious though in this study was the 470% differences in gross profit between dealers trading in cultured fish and those dealing in tilapia from the wild. All the cultured fish dealers featured in this Table 4 obtained their fish from a single commercial farm – Tropo farms.

Table 4.9 Buying and selling prices of tilapia obtained from retailers

| Retailer | Fish size (g) | Source | Buying price (GH¢/kg) | Selling price (GH¢/kg) | Gross profit (GH¢/kg) |
|---|---|---|---|---|---|
| 1 | 300 | cultured | 2.80 | 5.50 | 2.70 |
| 2 | 300 | cultured | 2.80 | 6.00 | 3.20 |
| 3 | 250 | cultured | 2.50 | 5.00 | 2.50 |
| 4 | 250 | cultured | 2.50 | 4.00 | 1.50 |
| 5 | 300 | cultured | 2.80 | 6.60 | 3.80 |
| 6 | 300 | cultured | 2.80 | 5.00 | 2.20 |
| Mean gross profit/kg cultured fish | | | | | 2.65 |
| 7 | 35 | Wild | 1.00 | 1.40 | 0.40 |
| 8 | 100 | Wild | 1.00 | 2.00 | 1.00 |
| 9 | 120 | wild | 2.60 | 3.26 | 0.66 |
| 10 | 60 | wild | 1.50 | 2.00 | 0.50 |
| 11 | 140 | wild | 2.60 | 3.12 | 0.53 |
| 12 | 150 | wild | 3.20 | 3.50 | 0.30 |
| Mean gross profit/kg from captured fish | | | | | 0.56 |

## Product form and purchasing factors

More than 83% of the dealers interviewed bought their fish fresh. Of this 79% sold it fresh, 5% fried, 2% grilled, another 2% salted and dried, 4% smoked and the rest (8%) sold it in various processed forms. Of the 17% that bought processed tilapia, the huge majority (92.7%) bought salted dried tilapia, 5% smoked tilapia and 2.3% other processed forms such as fried or fermented.

Three main factors were found to influence purchasing decisions. These were size, freshness (quality) and price. The most important factor according to 68% of respondents in all areas visited was size. This may be because they supplied fish to clients, most of whom were restaurants, hotels and tilapia joints operators, who had specific size requirements, the most preferred size being at least 200g which is probably considered a single plate portion. Dealers for whom size was the priority only approached producers or wholesalers if sizes of fish were right. Only 12% specifically dealt in tilapia weighing less than 200g, which were usually sold to consumers fresh, fried, salted or dried. About 20% had no preference for size. These were all large wholesale dealers at the landing sites who went on to sell the fish to intermediate wholesale dealers and retailers. The primary buying factors for dealers in this group were freshness and quality. The second consideration was the freshness of the fish. However, this was not the case for traders in the Greater Accra Region, for whom price was the second most important factor (Figure 4.3).

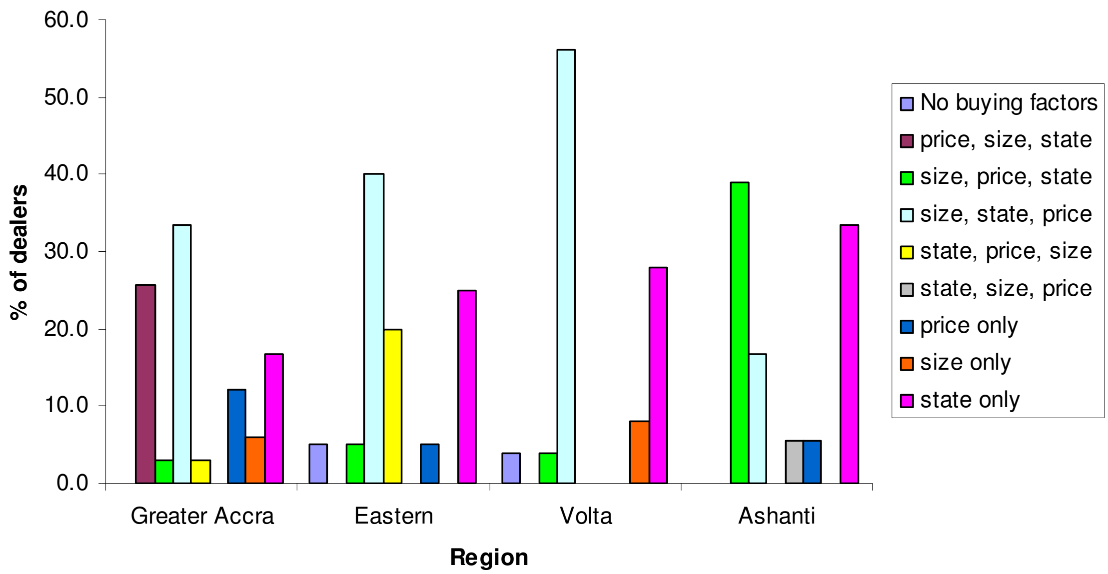



Figure 4.3 Factors considered by dealers in buying tilapia

This did not however imply that their clients were ready to buy fish irrespective of the quality, as low quality fish according to the dealers was either rejected or obtained at a lower price. How much lower was however not enquired from the traders. High ranking of price by about 26% of dealers in the Greater Accra Region may be attributed to the high operational cost – they complained about additional costs incurred (besides those incurred in preserving the fish fresh via chilling) in transporting fish from fish landing site like Kpando Torkor to Accra (a distance of about 220km).

## Substitutes for tilapia

Substitutes named for tilapia were described by 46% of dealers, the remainder believing that there could be no substitutes for tilapia because of its unique taste. The most common riverine species named as substitutes were catfish (*Chrysichthys nigrodigitatus)* and Widehead catfish (*Clarotes laticeps)* and the most common marine fish named as substitute was Red Pandora (*Pagellus bellottii*). Red Pandora is one of the commonest fish found in the coldstores besides mackerel species. Price-wise retailed fresh tilapia is relatively more expensive than these suggested substitutes (Table 4.14) below. Trading in tilapia according to the dealers was their “specialised” area and indicated they may only try trading other fish when tilapia was not available. There was therefore not a sense of competition as to which to trade - tilapia or the substitutes.

## Perceptions about farmed fish

In relation to farmed fish, only 38.2% of traders indicated buying cultured fish on a regular basis (Table 4.10). Of this, 90.4% were from the Greater Accra region, 3.8% from the Eastern, 1.9% from the Volta region and 3.8% from the Ashanti region. The rest indicated not dealing in cultured fish or had tried it and failed because of poor sales and were no longer interested in dealing in it. Less than 15% indicated buying cultured tilapia during the lean season for captured tilapia.

Table 4.10 Percentage of traders who sell tilapia and those who do no

| Region | Regular cultured fish dealers (%) | Non-dealers/Occasional dealer (%) |
|---|---|---|
| Greater Accra | 69.1 | 30.9 |
| Eastern | 6.9 | 93.1 |
| Ashanti | 11.1 | 88.9 |
| Volta | 4.8 | 95.2 |
| Total | 38.2 | 61.8 |

A number of reasons were given by those who dealt regularly in cultured tilapia. These were reliable supplies, availability, consistency in preferred sizes, and price – they were cheaper than those from wild-capture as seen from Table 4.9 above. For example a 300g cultured tilapia was being sold wholesale for GH¢ 2.80/kg while similar sized fish from capture based on the price profile in Figure 2 above will go for GH¢ 3.80/kg a price difference of about GH¢ 1.00 (US$ 1.06) and the huge difference in gross profit of GH¢ 0.56/kg of capture fish compared with 2.65/kg for cultured fish. They all however suggested that captured tilapia was tastier than cultured tilapia.

For those not interested in dealing in cultured tilapia, reasons given were that it was less tasty or bland, fatty, and had a different flavour from captured tilapia. It was also stated to have softer tissues and ripped more easily when grilled or fried. They related the difference in tissue texture to that of broiler chicken and a layer. The dealers also complained about cultured fish having a shorter shelf life. According to them the appearance changes and begins to decay within 24 hours after purchase, while captured tilapia stored the same way could stay several days without change in appearance. The final reason was that cultured tilapia looked bigger than it weighed. Views expressed by all those who claimed to have tried selling cultured fish and failed were the same, irrespective of location and that quite makes their claims worth considering in any later related study. A common ground though amongst these dissatisfied traders is the fact that they bought the fish from subsistence fish pond farmers rather than from commercial producers. Despite this, some expressed willingness to try cage or pen cultured fish since according to them the fish will be coming from “familiar waters” and will probably not be different from captured ones.

### 4.3.2 Food service outlets

### Profile of operators

Of the 90 outlets interviewed, 83% had tilapia on their menu, serving it grilled, boiled or fried. Of these 47.3 % were restaurants, 21.6 % were tilapia joints and 31.1 % were chop bars. Periods within which operators started their business are as shown in figure which suggested growing number of operators (Figure 4.4). Regional distribution of the operators is given in (Figure 4.5). 66.2% of the outlets were in the Greater Accra region.

Monthly purchase per operators was 325kg (median = 80), range of 10 – 3750Kg and sum total of 16608kg. The Greater Accra Region accounted for 85.7% of the mean monthly purchases (Table 4.11)

Table 4.11 Mean monthly quantities of tilapia bought per sector

| Region | Restaurant (Kg) | Tilapia joints (Kg) | Chopbar (Kg) |
|---|---|---|---|
| Greater Accra | 412 | 475 | 362 |
| Eastern | 73 | -* | - |
| Ashanti | 20 | - | 90 |
| Volta | 25 | - | - |

* None of the traders provided that information

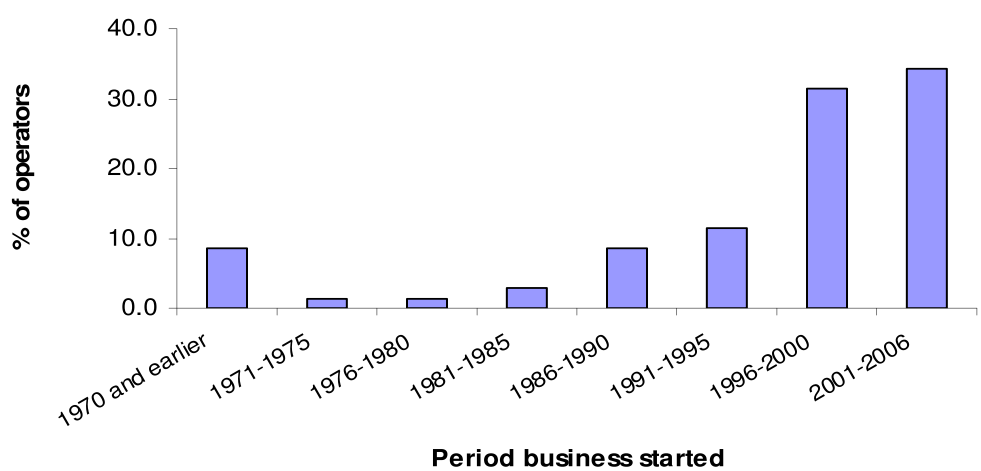



Figure 4.4 Periods within which operators started their businesses

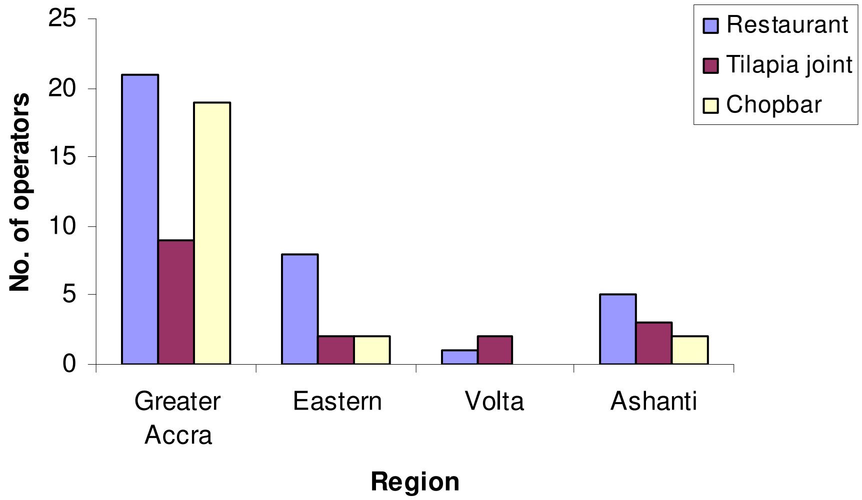



Figure 4.5 Regional distribution of food service operators visited

The main suppliers of tilapia to 58.1% of operators interviewed were intermediate wholesalers or roaming vendors. Of the remaining 41.9%, 87.1% obtained their fish directly from fish landing sites and 12.9% from fish farms. Overall 63.5% indicated their sources were captured tilapia from various landing sites around the Volta Lake (Figure 4.6). For those buying from others, this information was passed on to them. Others origins mentioned were fish farms (6.8%), regular markets (21.6%) and frozen foods stores (8.1%). Sixty-seven percent of those buying from frozen food stores were in the Ashanti region, the rest (33%) located in the Eastern region (Figure 4.7). As mentioned above all the tilapia sold by the large wholesale frozen foods stores in the Ashanti region were imported from Thailand. Operators who purchased fish from the regular markets did not have any idea what the sources were but assumed they were captured and not cultured fish.

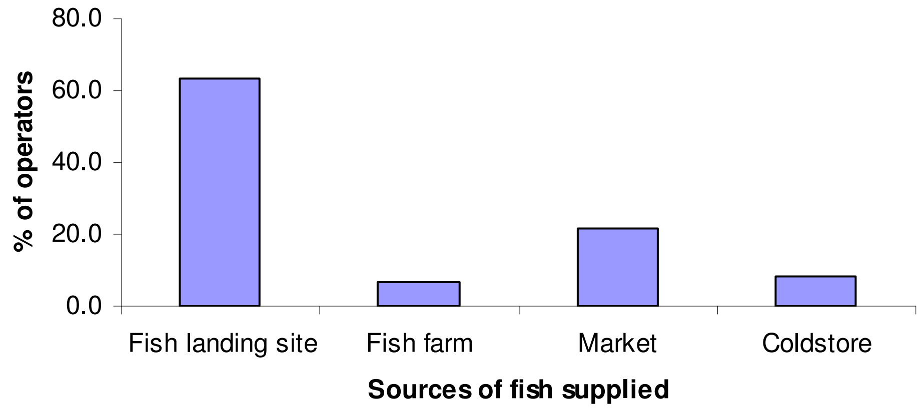



Figure 4.6 Sources of tilapia used by food service outlets

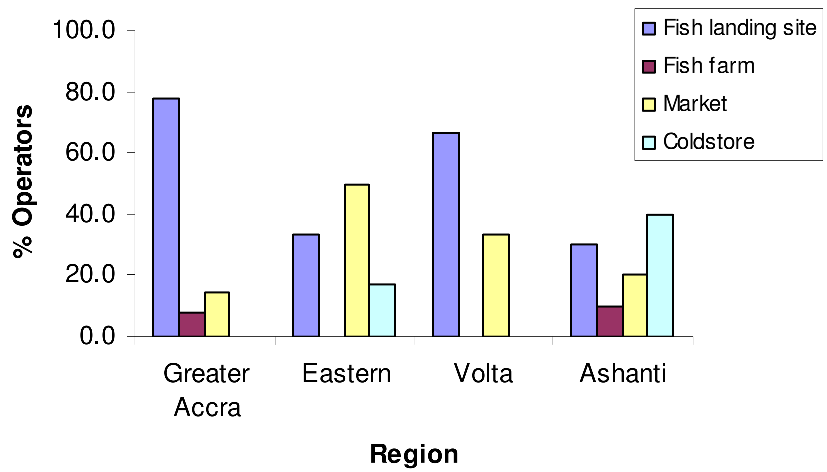



Figure 4.7 Sources of tilapia used by food joint operators by region

At the regional level, food service operators in the Greater Accra and Volta regions obtained large parts of their supplies from the landing sites and none of these obtained supplies from coldstores (Figure 4.7).

## Preferences and attitudes

In terms of size, 73% of operators preferred tilapia weighing at least 200g. The rest had no preference. In relation to supplies, about 65% indicated that they always had sufficient supply of tilapia every time from dealers, 24.3% mentioned they were not getting sufficient supply at all and 8.1% only had sufficient supplies sometimes. Using the chi square test, no significant associations were found between the size of fish preferred by operators and the sufficiency of supply ($X^2 = 2.723$; df = 2; $p > 0.05$).

### Buying factors

Like the dealers, three main factors - size, state and price were considered by food service outlets in buying tilapia. The size of fish was again the most important factor for most operators (68.9%). This was not surprising since dealer purchases are closely connected to the preferences of these operators. Freshness (21.6%) and price (6.8%) were relatively less important. Priority given to size, according to the operators, did not imply that freshness was compromised but was attributed to the nature of their business where bigger fish are preferred by customers. Grilled tilapia according to Manu (2004) has become a delicacy for the affluent in society and that was helping drive demand. He indicated the price of grilled tilapia was 300% higher that of the fresh fish.

Table 4.12 Factors considered by food service outlets in buying tilapia

| Buying Factors | % of Operators | | |
|---|---|---|---|
| | First Priority | Second Priority | Least/Not considered |
| Size | 68.9 | 1.4 | 29.7 |
| State (freshness) | 21.6 | 40.5 | 37.8 |
| Price | 6.8 | 29.7 | 62.2 |

### Substitute species

Suggestions from operators for possible substitutes for tilapia were diverse. About 73% of respondents agreed there could be substitutes for tilapia. The most common species listed by 71.5% restaurant operators who agreed there could be substitutes were marine species; Red Pandora (*Pagellus bellottii)* (44.4%), Red snapper (*Lutjanus* *fulgens*) (12.0%), Mackerel (*Trachurus spp*) (8.0%), Typical Catfish (*Chrysichthys spp*) (4.4%) and 32.0% listed more than one substitute which included Pink dentex (*Dentex gibbosus)*, blue spotted sea bream (*Sparus caeruleostictus)* and croaker (*Pseudotolithus brachygnathus*. Chop bar operators (65.2%) who agreed there could be substitutes, listed chub mackerel and horse mackerel (31.3%), Red Pandora (12.6%), *Chrysichthys* species (18.2%) and others (56.2%) which included herrings (*Engraulis encrasicolus)* and Wahoo (*Acanthocybium solandri*). Seventy-five percent of tilapia joints operators agreed there could be substitutes with the most common named species being *Chrysichthys* species (18.2%), Red Pandora (6.3%), Mackerel (9.1%) and others (72.7%) made up of combinations of several species such as herrings, tuna and mackerel. The advantage of a number of the species listed as substitutes over tilapia is that they are relatively cheaper (Table 4.14) and more accessible than tilapia but apart from the Greater Accra region they can hardly be obtained fresh. They are sold frozen and can easily be obtained from any of the coldstores.

### 4.3.3 Consumer preferences and attitudes

### Profile and characteristics

A total of 373 households were interviewed in the four regions. The total number of respondents in each region and the gender distribution are presented in Table 4.13. There were a total of 112 respondents in the Greater Accra Region, 68 in the Eastern Region, 97 in the Ashanti Region and 101 in the Volta Region. Seventy-nine percent of the respondents were females.

Table 4.13 Number and percentages of males and females interviewed in the four regions in the household consumer survey

| Region | Total | Female (%) | Male (%) |
|---|---|---|---|
| Greater Accra | 112 | 75.9 | 24.1 |
| Eastern | 65 | 70.8 | 29.2 |
| Ashanti | 95 | 72.6 | 27.4 |
| Volta | 101 | 74.2 | 24.8 |
| Total | 373 | 74.8 | 25.2 |

The ethnic distributions of the respondents in the regions are presented in (Figure 4.9). All the four major ethnic groups in the country i.e. the Akans, Ewes, Guans and Ga-dangmes were represented in all regions but in varying proportions. The Akans were quite well represented in all regions except in the Volta Region (Figure 4.9). Respondents from the Volta region were primarily Ewes. The Ga-dangmes and the other minority ethnic groups featured most prominently in the Greater Accra and Eastern Regions. Their numbers in the other regions were quite insignificant.

There are over sixty ethnic groups in Ghana, the Akans accounting for a little over 52%, followed by the Ewes, about 12.4%, the Ga-Dangmes at about 10%, the Dagombas about 3.8% and the Guans about 3.2% (Ghana Statistical Service, 2002). The Ewes and the Ga-dangmes were therefore over represented in the data collected.

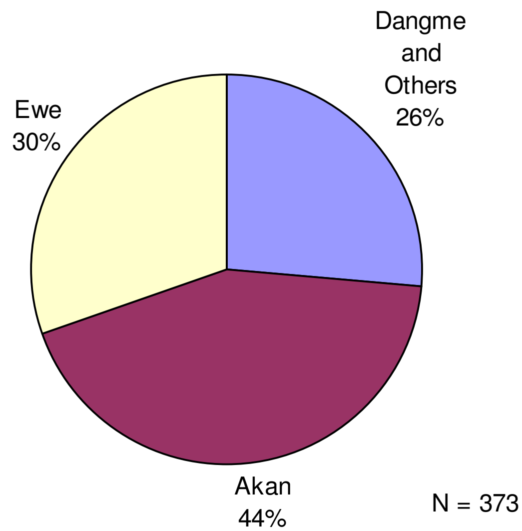



*Figure 4.8 Ethnicity of households interviewed*

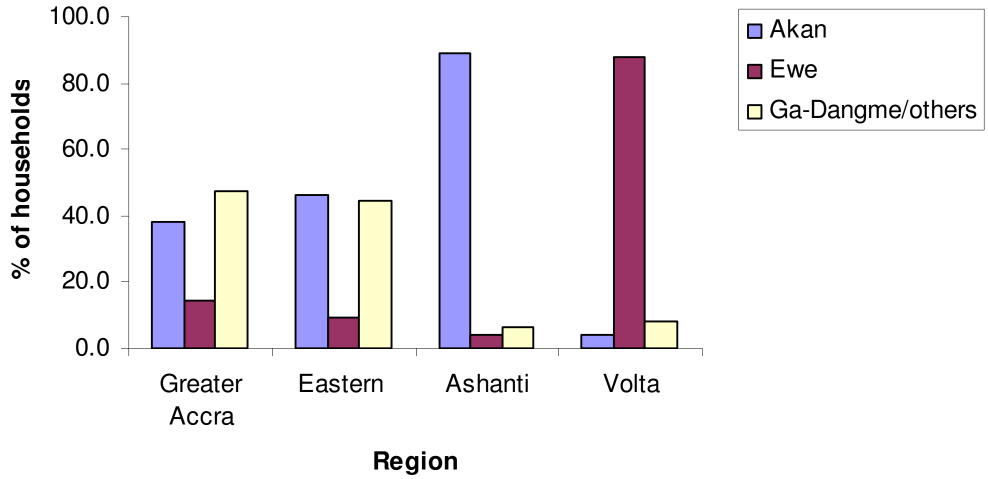



Figure 4.9 Regional distribution of ethnic groups

The respondents were initially placed in six levels of educational attainment; post-graduates, graduates, post-secondary (for any qualification beyond the secondary school level but below a first degree), secondary or technical school level, then Middle School or the Junior Secondary School level (MLSC/JSS) and finally those with no formal education. However, due to the small number of respondents in some categories, groups were merged and reclassified into: tertiary, for educational levels first degree and above; secondary for all educational qualifications ranging from secondary to below first degree, and finally MLSC/JSS and lower representing Middle School and Junior Secondary School levels and below. Percentages in each category are presented in Figure 4.10 , and a breakdown at regional level shown in Figure 4.11. The overall educational level attained by more than half of the respondents was the Middle School Leaving Certificate Level which was in line with the 2000 census report (Ghana Statistical Services, 2002).

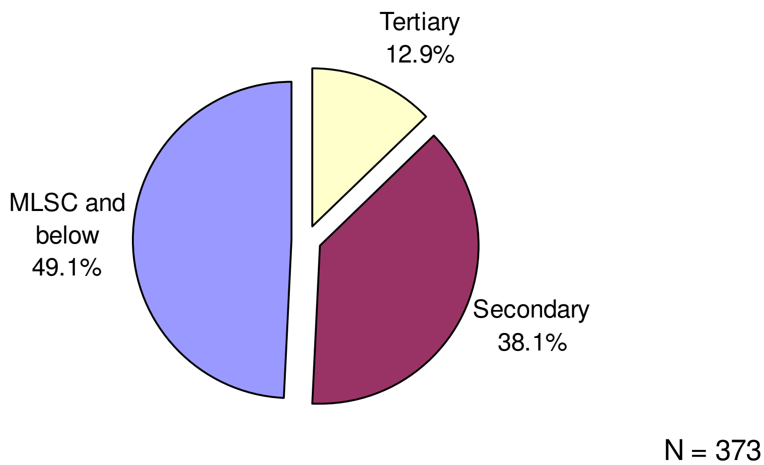



Figure 4.10 Educational levels of the household respondent

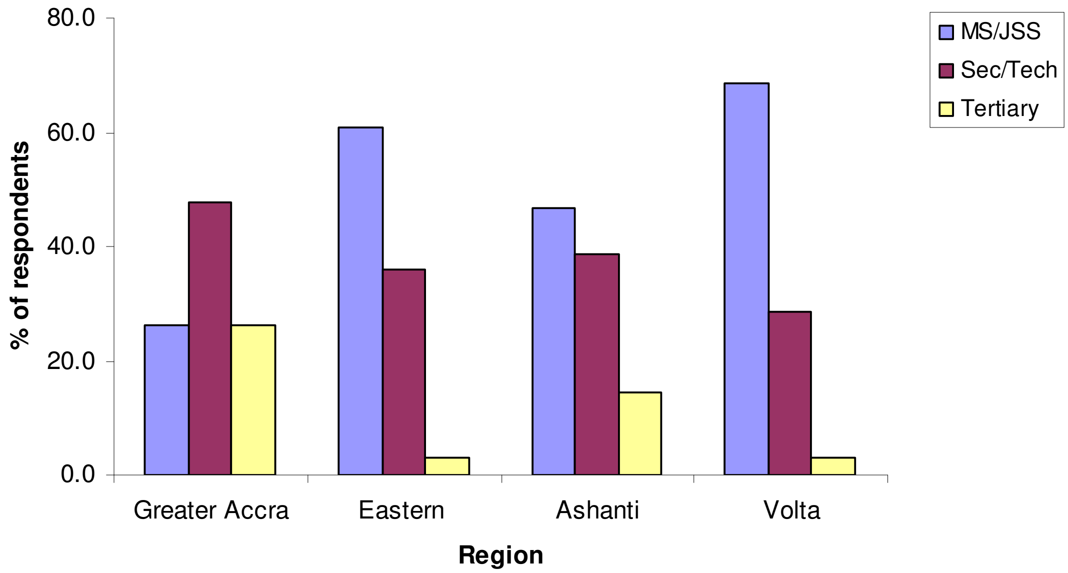



Figure 4.11 Educational levels of respondents by region

## Sources of protein

Four main sources of protein were identified by respondents - fish, meat (beef, pork, lamb and mutton) poultry products and “bushmeat” (meat from the wild – including grass cutters, wild fowls, antelopes, etc.). The most preferred protein source in all four locations was fish, accounting for at least 60% of households' protein intake (Figure 4.12). Marine fish species such as herring and chub mackerel were among the cheapest of sources whilst smoked and fresh tilapia were amongst the expensive ones. Its prices were only comparable to the smoked form of Red Pandora. The most expensive source of the protein from the list was grasscutter which are mostly obtained from the wild.

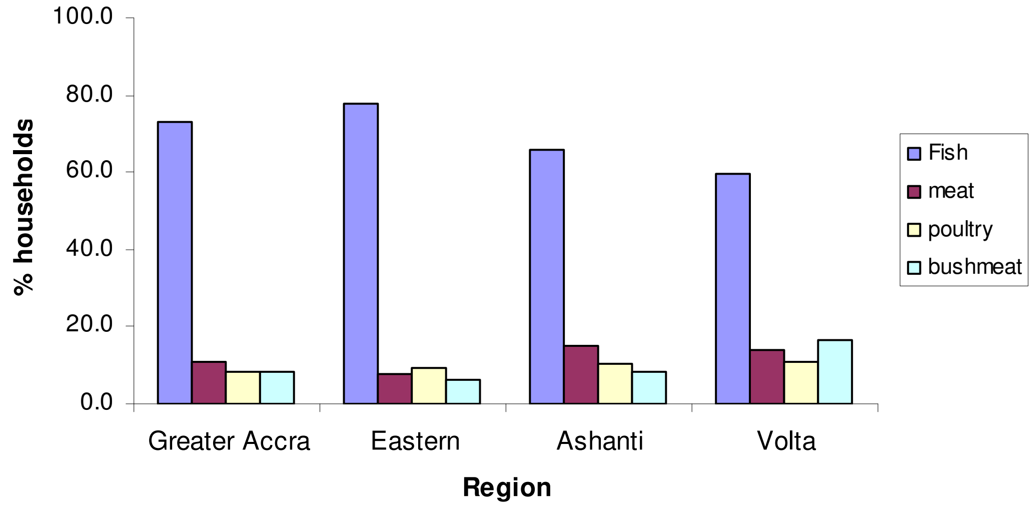



Figure 4.12 Household protein consumption preferences by region

Table 4.14 Price ranges of typical protein sources

| Product | State | Price(GH¢/kg) |
|---|---|---|
| Poultry | | |
| Layers (thighs) | Frozen | 1.70 - 2.00 |
| Broilers (thighs) | Frozen | 1.40 - 1.70 |
| Turkey (drum sticks) | Frozen | 1.80 - 2.00 |
| Gizzard | Frozen | 1.50 - 1.80 |
| Eggs (crate of 30) | Fresh | 2.40 - 3.00 |
| Meat | | |
| Mutton | Fresh | 2.60 - 2.80 |
| Beef (local) | Fresh | 2.50 - 2.60 |
| Beef (imported) | Frozen | 2.20 - 2.50 |
| Fish | | |
| Red pandora | Smoked | 6.00 - 8.30 |
| Red pandora | Frozen | 2.50 – 3.00 |
| Horse mackerel | Smoked | 1.50 - 2.10 |
| Chub mackerel | Frozen | 1.20 – 1.50 |
| Herring | Frozen | 0.90 – 1.00 |
| Tuna | Smoked | 2.00 – 3.00 |
| Tilapia | Smoked | 6.00 - 8.40 |
| Tilapia | Fresh | 4.00 – 10.00 |
| Tilapia | Salted | 1.10 – 5.30 |
| Typical catfish | Fresh | 2.20 – 2.40 |
| Synodontis | Fresh | 1.70 – 2.10 |
| Bushmeat and others | | |
| snail | Live | 3.80 - 4.50 |
| Grass cutter | Smoked | 9.00 – 11.00 |

## General fish preferences

Based on the number of counts obtained per species per region, the ten most preferred fish species by households for each region were computed (Figures 4.13 to 4.16). Eight out of the ten most preferred species by households in the Greater Accra Region were marine species, five out of ten in the Eastern Region and six out of ten in the Ashanti and Volta Regions. A comparison of the preferences by region using Krushal Wallis test of variance, a non-parametric alternative to one-way ANOVA, showed significant variations among all the regions except between the Greater Accra Region and the Ashanti Regions.

Seven of the ten most preferred species were common to all locations. These were Red Pandora (*Pagellus bellottii*), Tuna (*Thunnus obesus*), Chub mackerel (*Scomber japonicus*), Tilapia (*Oreochromis niloticus*), Atlantic Horse Mackerel (*Trachurus trachurus*), Typical catfish (*Chrysichthys nigrodicitatus*) and Herring (*Engraulis encrasicolus*). All of these were marine species except for tilapia and Typical catfish.

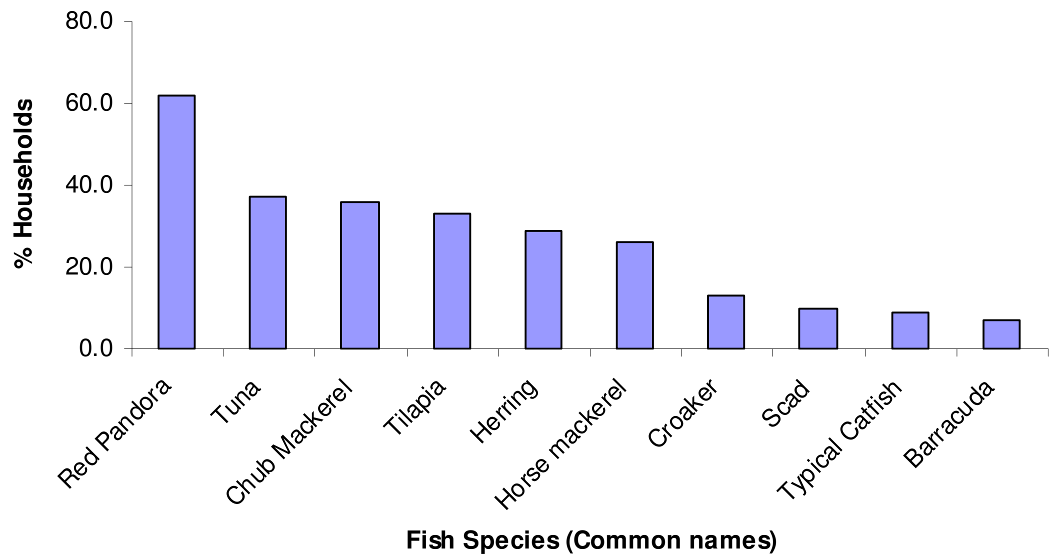



Figure 4.13 Ten most preferred fish species in the Greater Accra Region

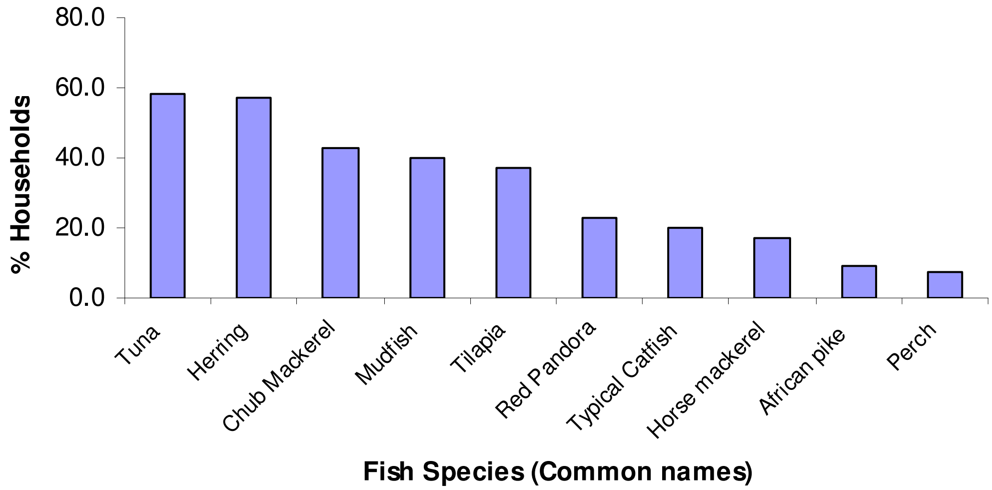



Figure 4.14 Ten most preferred species of fish by households in the Eastern Region

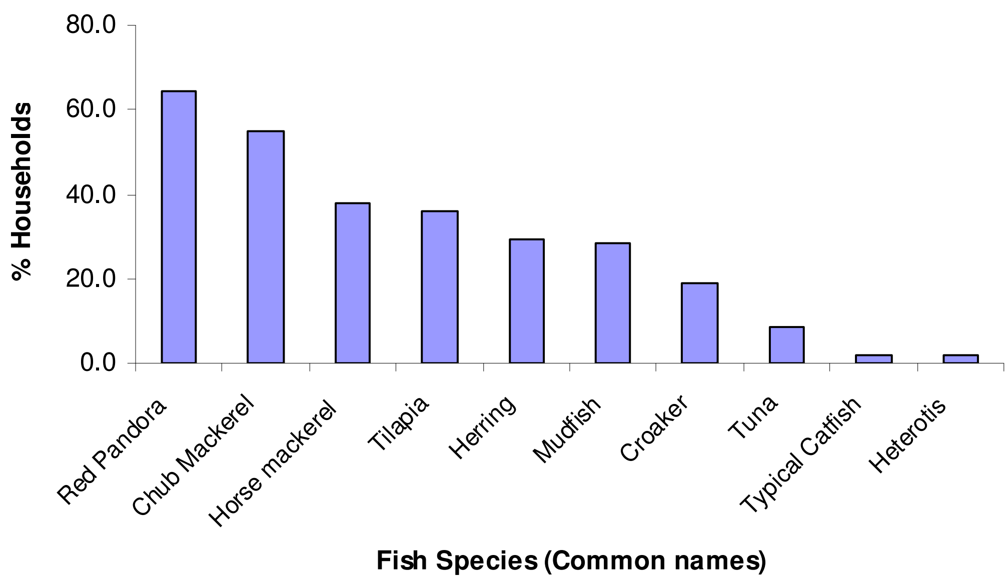



Figure 4.15 Ten most preferred species of fish by households in the Ashanti Region

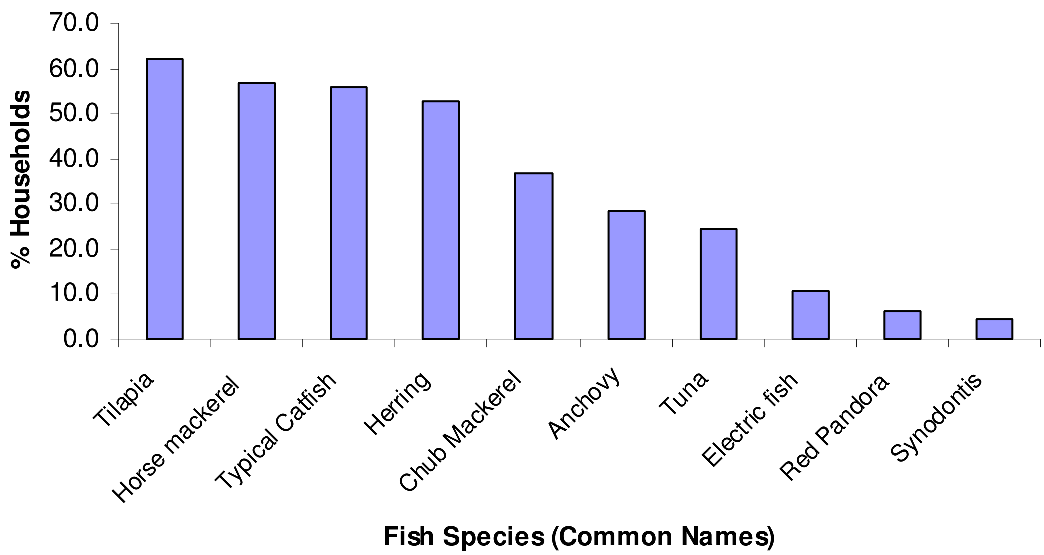



Figure 4.16 Ten most preferred species of fish by households in the Volta Region

Widehead catfish (*Clarotes laticeps*) was common to only the Ashanti and regions whilst Cassava fish (*Psuedotolithus brachygnathus*) was common to only the Greater Accra and Ashanti Regions respectively. Eight other species were unique to specific regions (Table 2). A total of seventeen species were listed among the ten regularly eaten species in the four locations. Nine of these were of marine origin and eight were freshwater species.

Using the ranking from SPSS version 14, preferred fish species for each region were ranked in relation to their frequencies such that the species with the least frequency is given the lowest score of 1. Similarities or associations between the ranking was determined for the seven species common to all the four locations using Spearman's rank correlation coefficient The results are shown in Table 4.15 below.

Table 4.15 Relationships between preferred fish species rankings by region.

| | | | Greater Accra | Eastern Region | Ashanti Region | Volta Region |
|---|---|---|---|---|---|---|
| Spearman's rho | Greater Accra Region | Correlation Coefficient | 1.000 | -.008 | 0.73(**) | -0.85(**) |
| | | Sig. (2-tailed) | - | >0.05 | <0.001 | <0.001 |
| | | N | 232 | 232 | 232 | 232 |
| | Eastern Region | Correlation Coefficient | -0.01 | 1.000 | -0.57(**) | -0.04 |
| | | Sig. (2-tailed) | .907 | - | <0.001 | >0.05 |
| | | N | 232 | 232 | 232 | 232 |
| | Ashanti Region | Correlation Coefficient | 0.73(**) | -0.57(**) | 1.000 | -0.51(**) |
| | | Sig. (2-tailed) | <0.001 | <0.001 | - | <0.001 |
| | | N | 232 | 232 | 232 | 232 |
| | Volta Region | Correlation Coefficient | -0.85(**) | -0.04 | -0.51(**) | 1.000 |
| | | Sig. (2-tailed) | <0.001 | >0.05 | <0.001 | - |
| | | N | 232 | 232 | 232 | 232 |

** Correlation is significant at the 0.001 level (2-tailed).

There was a positive and significant correlation between fish species preferred in the Greater Accra and the Ashanti Regions ($r^2 = 0.53$; n = 7; p<0.001) implying that fish consumption preferences in the two regions were similar. A strong, significant but negative correlation was also observed between preferences in the Greater Accra and Volta Regions, implying that species most preferred in Greater Accra Region were least preferred in the Volta Region. No significant correlations were found between household fish preferences in the Greater Accra and the Eastern Regions. Preferences in the Ashanti Region had significant relationships with all three other regions, positively with the Greater Accra Region, but negatively with the Eastern and Volta Regions. The strengths of the later associations were however quite weak ($r^2 = 0.32$; p<0.001 and 0.26; p<0.001 respectively).There was no significant correlation between rankings for the fish preferred in Volta and Eastern Regions.

## Fish sale outlets for consumers

Seven types of fish sale outlet were used by consumers; regular markets, cold stores, fish markets, fish landing sites, “roaming” fish vendors, farm gates and to a very small extent supermarkets. Regular markets were the most used, by 77.2% of households and the sole outlet for 43% of households. This may be attributed to the fact that fish could be obtained from this type of outlet in any form, processed or unprocessed and may also be because they are a regular shopping place for all other food items. The cold stores were the second most used with 28.3% of households buying from there and the sole outlet for only 8% (Table 4.16). Most households purchased fish from more than one outlet. The most common combination was the market and the cold store. The supermarkets were the least used.

Table 4.16 Retail outlets and percentage (%) of households patronising it

| Region | Market | Frozen Foods Store | Fish market | Fish landing site | Fish Vendors | Fish Farm | Supermarket |
|---|---|---|---|---|---|---|---|
| Greater Accra | 70.3 | 30.6 | 10.8 | 15.3 | 18.0 | - | 2.7 |
| Eastern | 81.0 | 5.2 | 3.4 | 8.3 | 8.6 | 13.8 | 1.7 |
| Ashanti | 78.5 | 41.9 | 1.1 | 1.1 | 4.3 | 4.3 | 2.2 |
| Volta | 80.8 | 26.7 | 17.5 | 17.5 | 9.2 | 4.2 | - |
| Over all | 77.2 | 28.3 | 11.5 | 2.8 | 10.5 | 4.5 | 1.6 |

Compared to the other regions, relatively fewer households in the Greater Accra region obtained fish regularly from the markets. Consumers in the Eastern region used the frozen food stores the least while close to half (41.9%) of households in the Ashanti region bought fish regularly from this type of outlet. The third most used fish sale outlet in the Greater Accra region were the vendors (18.0%) which was at least twice that of any of the other regions. None of the household interviewed in the Greater Accra region mentioned buying fish from fish farms compared to 13.8% in the Eastern region.

## Forms of fish preferred by households

Seven processed and unprocessed forms of fish were available at retail outlets; fresh, frozen, smoked, salted, dried and fried fish. All forms except live fish were available in regular markets. Frozen fish, besides being in cold stores were also available in regular markets and supermarkets. Fresh, smoked and salted fish were, in addition to the regular market, also available from the fish market or sometimes the fish landing sites on their market day. Live fish were only available at the landing sites. The results from the survey showed that most households purchased their fish smoked, fresh or frozen (Figure 4.17). Across the regions, the percentages of households' fish preferences for processed and unprocessed fish were not very different (Figure 4.18). The smoked form was the most preferred form followed by fresh fish and frozen fish in descending order of magnitude.

### Reasons for choice of fish

The foremost reason for choice of fish by a large number (46%) of households interviewed was taste (Figure 4.19). Fourteen percent also preferred their fish because they felt it was healthy (less or no fat) and nutritious. About 13% preferred it because it was the fish readily available within the locality; only 8.0% preferred it because of the price i.e. cheaper in relation to other fish or forms of protein Ease of processing was not an issue with most households interviewed. Only 1% considered it. This is probably because most retailers will degut the fish and remove the scales at the request of the buyer. About 7% for health reasons stated that they had to eat those particular species they bought regularly.

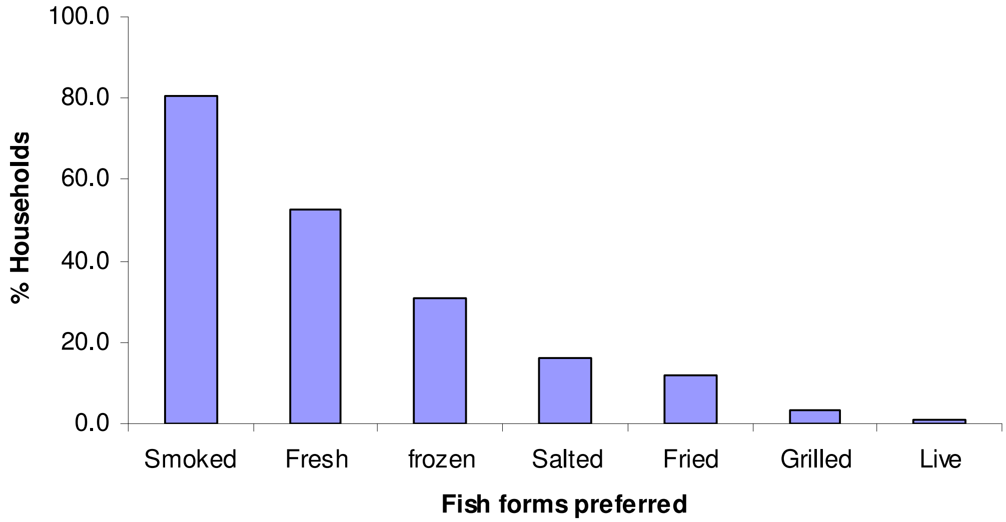



Figure 4.17 Processed and unprocessed fish forms preferred by households

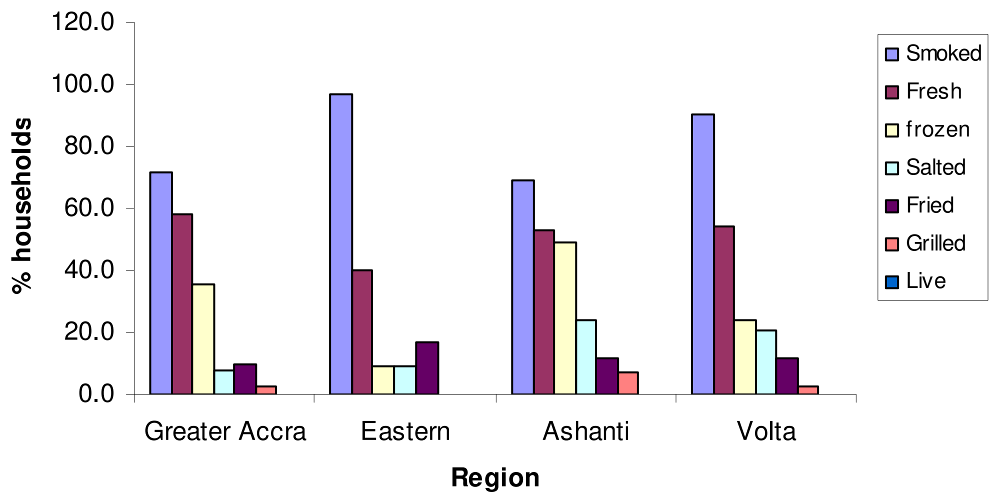



Figure 4.18 Processed and unprocessed fish forms preferred by households by region

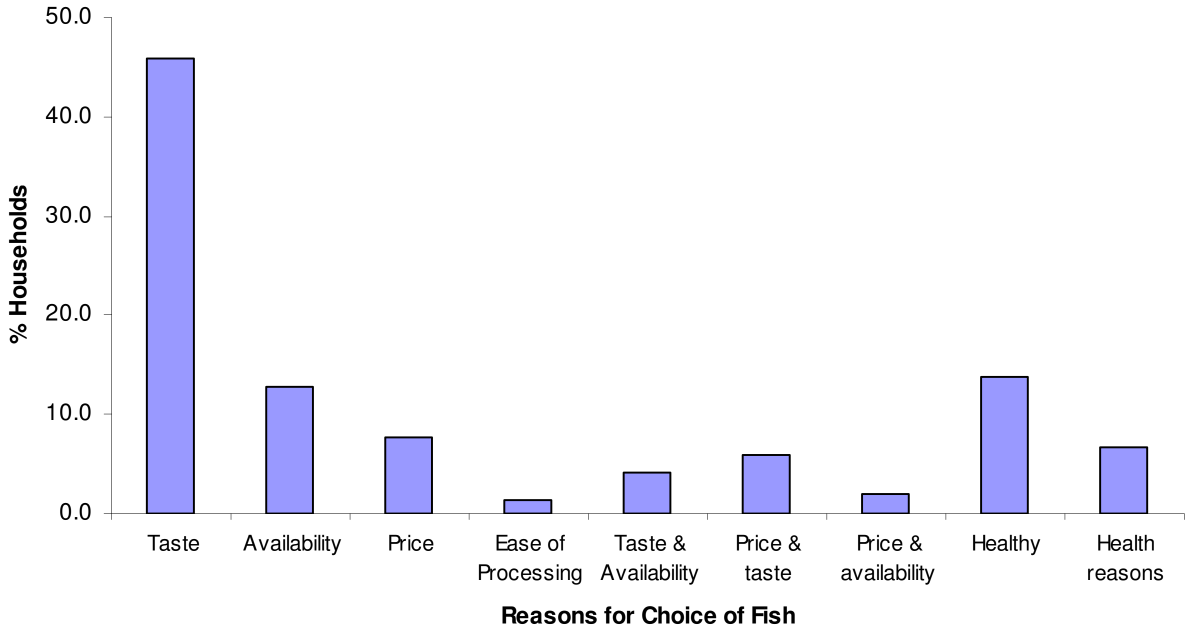



Figure 4.19 Reasons for which consumers preferred their choice of fish

## Household preferences and attitudes for tilapia

Tilapia was the fourth most preferred fish in the Greater Accra and Ashanti Regions, fifth in the Eastern Region and the most preferred in the Volta Region. Based on their reported rates of tilapia consumption, households were divided into three categories; regular, occasional and non-consumers. Regular consumers were those who bought tilapia regularly (minimum once a month) and tilapia was often part of a meal, occasional consumers were those which liked tilapia but only bought occasionally (minimum about once a quarter but less than once a month), and non-consumers did not buy tilapia at all. The percentages in each category at all locations are given in Figure 4.20 and Figure 4.21. Of the entire data, 41.7% of respondents were regular consumers, 47.7% were occasional consumers and 10.4% were non-consumers (Figure 4.20). Regional details of tilapia consumption patterns are given in Figure 4.20. The Volta region had the largest number of regularly consuming households at 62.8%.

The Greater Accra region had the least at 28.8% of households but the largest number of occasional consumers at 63.1% while the Ashanti region had the largest relative percentage of non-consumers at 19.8%. Based on a chi-square test, significant differences in consumption patterns by households only existed between the Volta region where more than 60.0% of households were regular consumers and the three other regions ($\chi^2 = 43.2$, df = 6, $p < 0.001$) where the percentage of regular consumers ranged from about 30 to 37%.

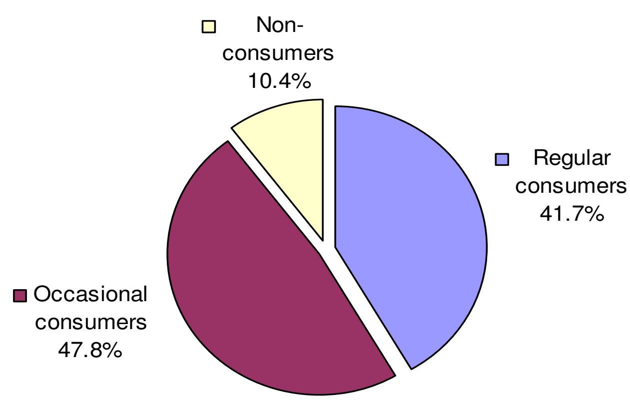



Figure 4.20 Tilapia consumption patterns across the study area

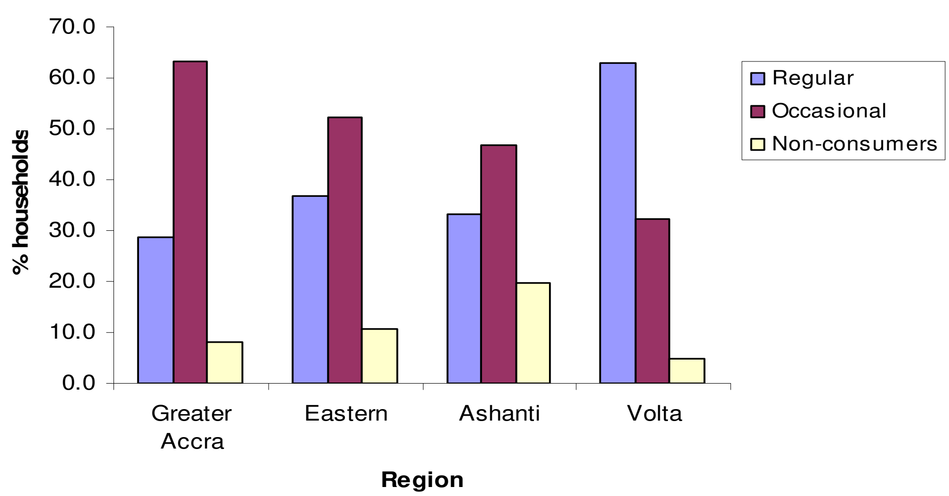



Figure 4.21 Tilapia consumption patterns by region

### Reasons for regular consumers' preference for tilapia

Several reasons were given by households for whom tilapia was a regular choice. About 35.5% preferred it mainly because of the taste, 18.4% preferred it because it is an indigenous species and readily available in the form they preferred to buy it (i.e. fresh), 12.7% had it regularly because it was healthy and nutritious and 12.1% for health reasons – i.e. consumers who were limited in their choice of protein and had taken to tilapia (Figure 4.22). Others preferred the fish for two or more of the reasons stated above. Only 2.4% of regular consumers preferred tilapia because it was cheaper than other fish and fish products in their locality and these were mostly respondents in the Volta region. A regional analysis revealed a slightly different trend for consumers in the Volta region. For them the fish being indigenous was the primary reason, not the taste (Figure 4.23). The Volta Lake is a major feature of this region and is the main source of fresh water fish in Ghana, of which tilapia is said to account for 30% of the catch (Apawudza, 2005). In effect marine fish dominated areas like Accra, tilapia is reasonably well preferred and chosen because of flavour, in inland fishery dominated areas (eg Volta) – tilapia is strongly preferred, with familiarity the key factor and in other areas like the Eastern and Ashanti regions flavour again is the key reason for choice.

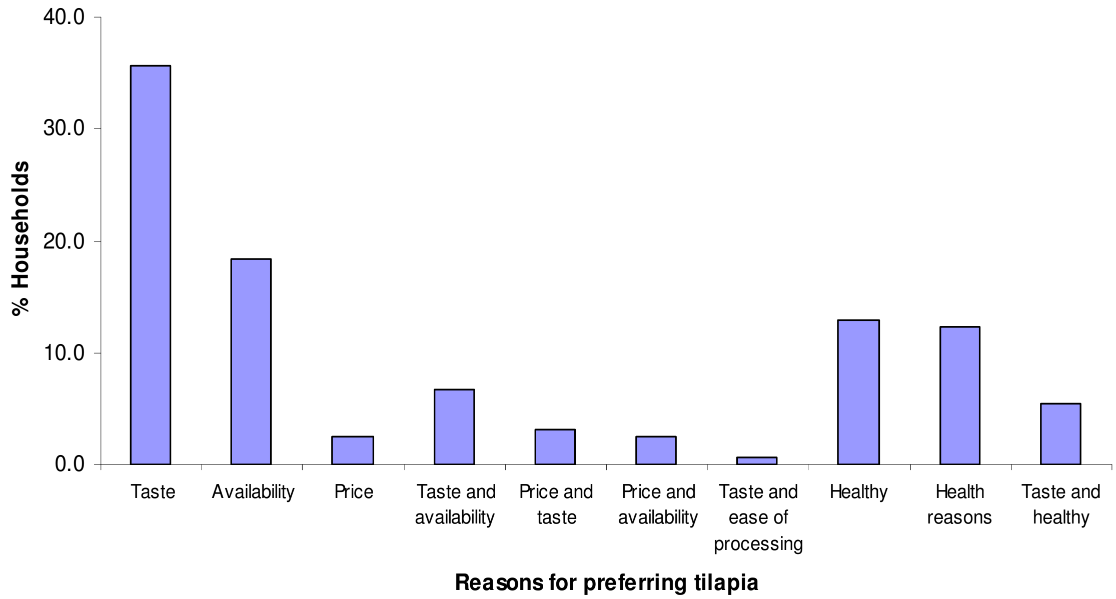



Figure 4.22 Reasons for households' preference for tilapia (entire data)

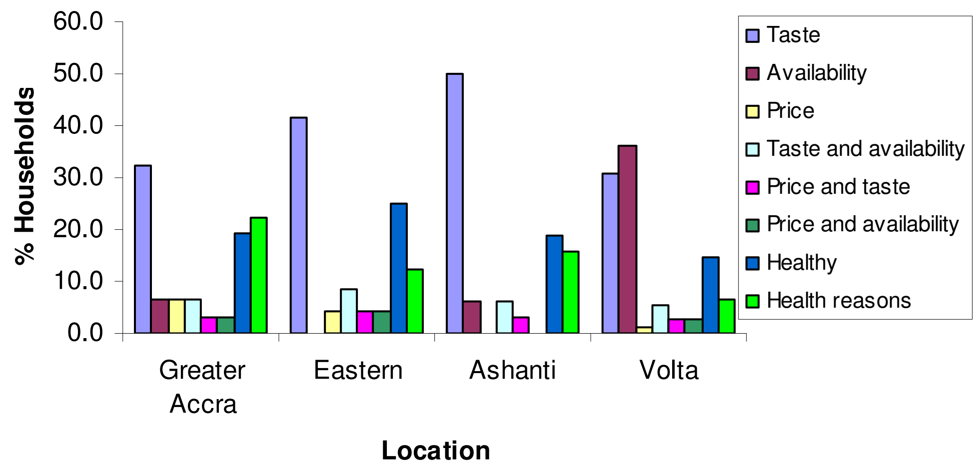



Figure 4.23 Reasons for households preference for tilapia – by region

## Occasional consumers

Forty-two percent of households interviewed were classified as occasional tilapia consumers. A large number were located in the Greater Accra Region, followed in descending order by the Ashanti, Volta and Eastern Regions (Figure 4.24). The primary reason for restricting consumption of tilapia was the price. Fifty-seven percent felt that the price was more than they could afford or high when compared to other equally tasty fish species or to other protein sources (Table 4.14). The other single deterring factor was unavailability either in the form preferred, mostly fresh, or in the preferred size. Other reasons were either that a member of the household did not like it, or that purchases are only occasional as a change from what is consumed regularly (Figure 4.24). Between 2.5 to 5.3% of the occasional consumers indicated not taking it regularly because it was very bony.

### Non-consumers

Only 10% of households interviewed did not consume tilapia. Volta Region had the fewest non-consumers, at only 5%, followed by Greater Accra and the Eastern Regions at 8 and 11% respectively. The Ashanti Region had the largest number, at close to 20% of households (Figure 4.25). One of the main reasons given by about 25 to 40% of non-consumers in the Greater Accra, Ashanti and Volta regions was that the fish was tasteless (Figure 4.25). Another reason given was the bony nature of the fish, noted in all four regions by about 17 to 25% of households. The price of the fish was also a major reason for non-consumption in the Eastern, Ashanti and Volta regions. Very few households did not like it because of the flavour. Among the fish preferred by these households are Red Pandora and Atlantic horse mackerel.

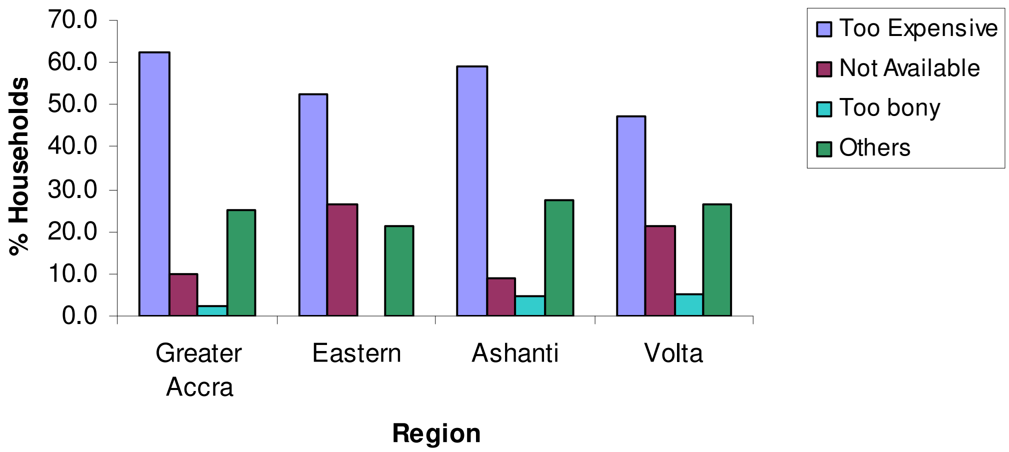



Figure 4.24 Reasons for occasional consumption of tilapia – by location

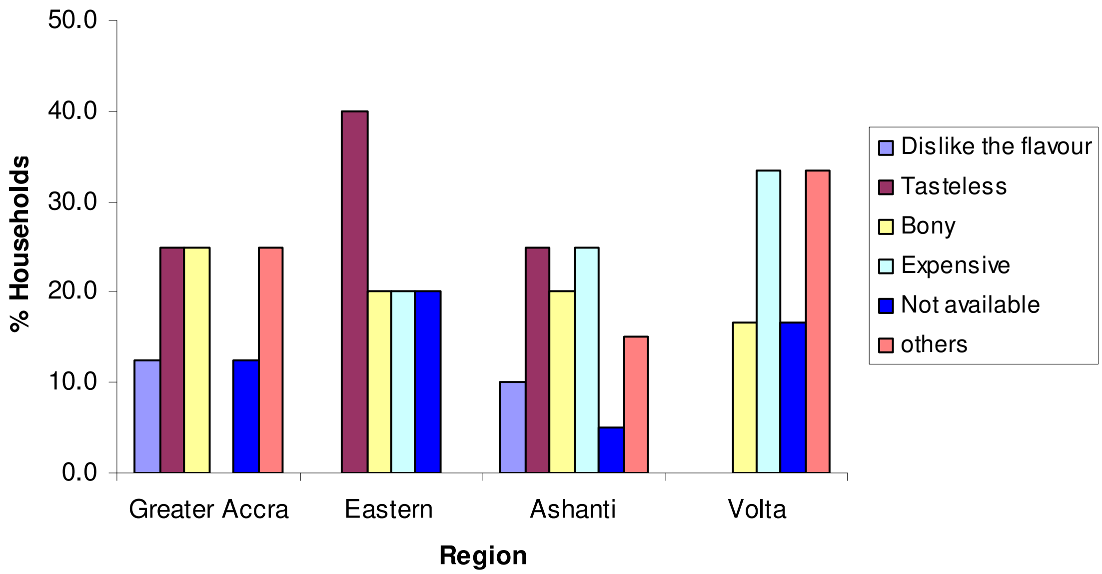



Figure 4.25 Reasons for non-consumption of tilapia

## Preferred product forms and estimated quantities

Unlike other fish, the most preferred form of tilapia by households was the fresh state (Figure 4.26), followed by smoked tilapia and the salted and sun dried form. Frozen product was the least favoured. This may be attributed to the general view among dealers and consumers alike that the fish tends to lose its taste when kept frozen. Other product forms available were fried and grilled tilapia. Grilled tilapia, served mainly by restaurants and tilapia joints had relatively low patronage because of the price per unit, which (Manu, 2004) estimated to be about three times the price of the fresh fish.

Tilapia weighing at least 200g was the size most preferred by both regular and occasional consumers (Table 4.17). When asked about approximate quantity of the tilapia consumed per month, 79.4% of the regular consumers indicated buying about a kilogram per month and 20.5 indicated buying more than a kilogram each month. Up to 32.0% of regular consumers in the Volta region indicated buying more than 1kg per month compared to 20.6%, 9.3% and 18.3% for the Greater Accra, Eastern and Ashanti regions respectively. These were however perceived quantities since as noted earlier most sales outlets apart from the cold stores and some farm gate sellers did not sell fish per unit weight. The true quantities are likely to be different.

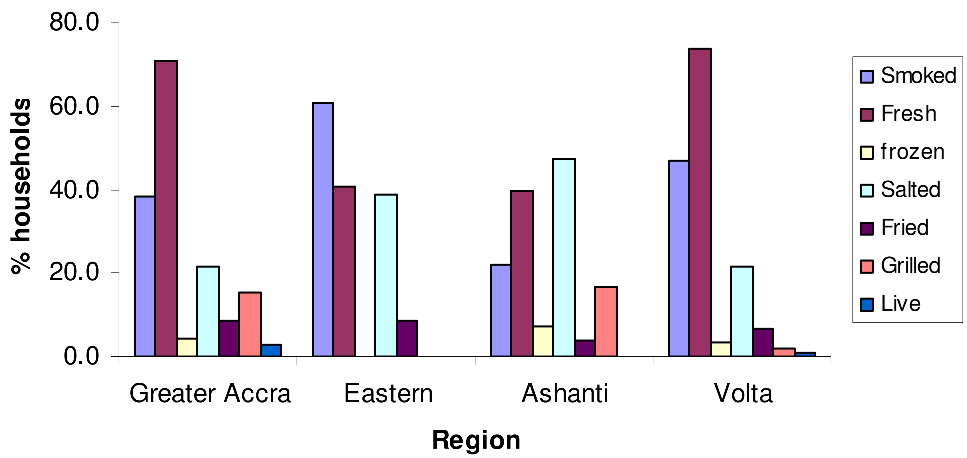



Figure 4.26 Tilapia product forms preferred by consumers by region

Table 4.17 Sizes of tilapia preferred by consumers and approximate quantities bought per month

| Region | Preferred size (%) | | Estimated quantity consumer per month (%) | |
|---|---|---|---|---|
| | < 200g | ≥ 200g | < 1kg | >1kg |
| Greater Accra | 21.5 | 78.5 | 79.4 | 20.6 |
| Eastern | 21.1 | 78.9 | 90.7 | 9.3 |
| Volta | 11.8 | 88.2 | 68.0 | 32.0 |
| Ashanti | 21.6 | 78.4 | 81.7 | 18.3 |
| Over all | 19.5 | 80.5 | 79.4 | 20.6 |

## Relationships between consumption pattern and demographic variables

There were no significant relationships between tilapia consumption and professions or income of respondents, levels of education and the number of people per household. Significant though not strong relationship ($r^2 = 0.21$) however existed between consumption and ethnicity of household members. The main difference existed between the Ewes, and all others. The Ewes turned out to be the largest consumers of tilapia accounting for about 46% of the regular consumers and least among the occasional and non-consumers (Figure 4.27), a trend which could be attributed to relative ease of access to the fish by virtue of their location to the main source of tilapia in Ghana – the Volta Lake and possibly lower retail prices in relation to income which as seen from Figure 4.23 the price along with taste was the main reason consumers preferred the fish in this region.

Using multinomial regression analysis, a regression model was developed to determine the extent to which the two variables (ethnicity and level of education) predicted tilapia consumption. The two were entered as independent variables with tilapia consumption as the dependent variables. From the results, the effect of ethnicity on the consumption pattern was not significant.

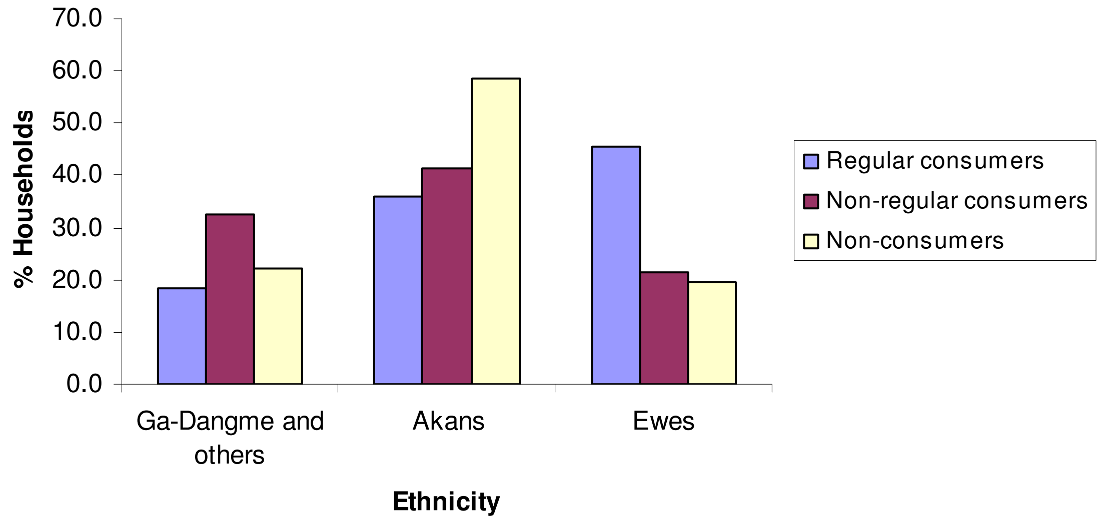



Figure 4.27 Tilapia consumption patterns among ethnic groups

### Estimated quantities of tilapia consumed in the study areas

The quantities of tilapia consumed per month by regular consumers were estimated from amounts respondents indicated spending monthly on tilapia and the average retail price per kg tilapia estimated GH¢ 4/kg which is the mean of the retail prices given in Table 4.9 above. For occasional consumers, tilapia purchasing was assumed to be quarterly. From these assumptions mean quantities of tilapia purchased by regular consumers per month was estimated at 3.1kg for households in the Greater Accra region, 1.8kg for households in the Eastern region, 1.6kg for Ashanti region and 2.4kg for households in the Volta region (below). Total quantities purchased per annum per region were finally calculated by the percentage number of households in the region likely to be regular consumers which was based on the results of the survey. Similar calculations were made to obtain annual quantities of tilapia consumed by for the occasional consumers (Table 4.19). Using the same argument but on a national basis and assuming that the overall pattern for the combined data is a reflection of national trend, annual tilapia consumption in Ghana could be estimated at 71,444mt. The Volta Lake is the main source of freshwater accounting for 85% of inland fish capture fish production. Annual fish landing from the lake in 2002 was estimated at 75 000mt of which 30% is said to be tilapia (Apawudza, 2005). This thus suggests an annual shortage in tilapia supply of about 46,000 mt.

Table 4.18 Estimated annual quantities of tilapia consumed by regular consumers per region

| Region | Quantities Kg/month | Household per region[5] | % regular consumers | Quantity/year mt |
|---|---|---|---|---|
| Greater Accra | 3.1 | 800,497 | 28.8 | 8576 |
| Eastern | 1.8 | 506,722 | 36.9 | 4039 |
| Ashanti | 1.6 | 849,145 | 33.3 | 5429 |
| Volta | 2.4 | 426,422 | 62.8 | 7712 |
| Total | | | | 25,756 |

Table 4.19 Annual quantities of tilapia consumed by occasional consumers

| Region | Quantities Kg/quarter | Household per region | % occasional consumers | Quantity/year mt |
|---|---|---|---|---|
| Greater Accra | 2.4 | 800,497 | 63.1 | 4849 |
| Eastern | 1.7 | 506,722 | 52.3 | 1802 |
| Ashanti | 1.4 | 849,145 | 46.9 | 2230 |
| Volta | 1.9 | 426,422 | 32.3 | 1047 |
| Total | | | | 9,928 |

## 4.4 Discussion

The study focused on consumption of tilapia, within a wide range of species and product form choices. Among these is catfish, considered a strong alternative/complementary culture species to tilapia. Tilapia was particularly interesting to consider because it is the most commonly cultured fish in the country and may be likely to form an important part of intended future expansion of aquaculture production.

[5] Number of households per region were estimated from the 2000 population and housing data census. The numbers were projected to reflect 2006 household numbers using the average population growth rates for each regions.

One of the main limitations of the present study was the area and representativeness of sampling. In particular it was unable to cover the northern parts of the country which according to Essuman (1992) and Heinbuch (1994) has different market features from those of the south. The survey also concentrated mostly in the regional capitals which are all urban areas and may therefore not reflect consumption patterns of rural dwellers in these regions. Nonetheless, the data obtained covers many of the more populated locations, with definable levels of fish consumption, and can provide important reflections on market characteristics and potential at the national level.

Trading in tilapia and other freshwater species in the study areas was well established. The main sales outlets across the four regions were fish landing sites but in the Greater Accra Region fish from culture was a major source of supply as well supplying more than half of tilapia sold by the dealers interviewed. Landing facilities, market infrastructure and outlets at various levels of trade were however poorly developed at the sites visited, resulting in unhygienic handling of fish during and after harvest, and a potential loss of quality and value. Post-harvest handling is very important as fish is particularly very susceptible to pathogenic contamination (Abila, 2003). The only exceptions were probably the cold stores but they dealt mostly in marine fish, and product quality there also depends on prior handling, freezing and distribution conditions. Wholesale trade in tilapia at the few farm gates visited was carried out more hygienically as harvested fish once weighed were chilled immediately in reusable insulated foam boxes or baskets lined with jute sacks.

Cultured fish dealers at the intermediate and retail levels however complained about fish from farm gates have a shorter shelf life and deteriorating faster than those from the fish landing sites. This problem was thought to be attributable to poor preservation. Icing was the most common method used in preserving the fish. However, cool storage if done improperly could lead to reduced quality and shelf life of tilapia and increasing health risks El-Sayed (2006). Apawudza (2005) in a study exploring opportunities for fresh fish marketing from Yeji, a major landing site along the Volta Lake, found that packing the fish in layers separated by layers of ice in the proportion of 1:1 by weight was able to maintain the fish fresh for more than 72 hours. This is vital information that could be passed on to fish dealers at the wholesale level, as they supply dealers lower in the market chain. However, access to ice supplies and its costs may also be constraints. The issue of shorter shelf life of culture fish could also be attributed to post harvest handling. An observation made during the survey was that traders buying cultured fish had a lot more fish to handle at a time than at the landing sites where fish from the various fishermen came in, in smaller quantities and at different times and traders gutted the live fish right away allowing the blood out before preserving in ice. At the farm gate, traders chilled the live fish right after being sold to them without gutting and only gutted and re-preserved the fish after obtaining the quantities required. This was commonly observed to take some time between an hour to about two hours depending on how quickly the fish are harvested. Rigor mortis in tilapia according to Jarding et al. (2000) could occur within 1-1.5h after harvesting and is faster for fish stored on ice than those stored at ambient temperature. They also found from their study, which was on a commercial fish farm in Zimbabwe, that the unprocessed fish could stay in rigor mortis for at least one week leading to decreased shelf life compared to fish processed pre-rigor.

A profile of dealers showed increasing numbers were entering the trade, though a few have been dealing in fish since the early 1970s. More than half of existing traders started the business within the last ten years, which was attributed to potential growth in the sector and their perceptions of financial opportunities in carrying out the business. There was little evidence of concentration in smaller numbers of larger dealers, suggesting a high level of competition and as yet a relatively unstructured market.

From the consumer survey, tilapia was a widely accepted fish and its consumption cuts across social and economic backgrounds with up 87% of household in the four regions considering themselves consumers. Of the four regions, the Greater Accra Region had the highest market potential for tilapia with an estimated annual requirement of more than 13,000mt. Based on estimates of tilapia production from capture fisheries, and estimates of potential consumer demand nationwide, national shortfall in supply was estimated to be around 40,000mt. This could to some extent account for its relatively high price currently, as potential demand is outstripping supply. Most households in the Greater Accra and Volta regions indicated preferring the fish fresh while those in the Ashanti and Eastern regions preferred it smoked or salted.

Despite its wide acceptance, of the 87% consuming households, close to 55% considered themselves only occasional consumers which implied they only bought the fish once a while (assumed to be once every quarter/three months). Prominent among the deterring factors was the price, which they considered very expensive.

A deterring factor to the farmed form of the fish was however the perceived differences in quality expressed by some dealers in relation to the soft nature of the tissue, the flavour, the taste and the relatively short shelf life when compared to the wild-caught tilapia. Possible reasons for the shorter shelf life are as discussed above. Issues relating to texture, flavour, oil contents and hue were also expressed by Haard (1992) in comparing aquaculture products with wild-caught products. He found that aquaculture products in general tended to provide flesh that was softer in texture, a less strong flavour, often of different hue and with higher but more uniform oil content. These issues are however ones that can be dealt with by the farmer by the introduction of better husbandry practices. Flavour for instance arises from the complex of compounds in the tissue and, within a species, which are controlled by the environment and the feed ingredients (Lindsay, 1990). Wild-caught fish and shrimp are said to have stronger natural flavours than their cultured counterparts because of the greater diversity of their diets. Replacing natural feeds with the blander cereal- and legume-based artificial diets can enhance this lack of diversity (Bremner, 2003). Textural characteristics have also been attributed to harvest stresses and post-harvest practices, changing seasons and maturation and changes in pH (Bremner, 2003; Kubota et al.  1999). Preserving the fish appropriately after harvest may curb these.

Poor handling and holding conditions, inadequate processing and use of inappropriate processing methods can also seriously affect the quality of tilapia and increase post harvest losses. Crowding of fish in a net during harvest is also known to lead to rises in blood cortisol, increase in metabolic rate and utilisation of glycogen with a resulting increase in lactate levels and a decrease in tissue pH (Bremner, 2003). pH is the major determinant of the texture of the flesh, with inherent buffering capacity of amino acids and peptides playing a role in its control. Low pH normally results in firm textured flesh, but too rapid a reduction in pH tends to cause a soft texture even at a low pH. Thus the biological conditions, as reflected in glycogen levels and buffering capacity, dictate the flesh texture within the species. Provision of a good aeration during harvest can help to relieve this situation (Robb, 2001), but a range of improved handling and post-harvest practices may be appropriate.

In comparing gross profit of dealers of cultured tilapia to those of captured tilapia, that of the former were about four times as high as the latter because although the cultured fish dealers obtained their fish at relatively cheaper wholesale price, they maintained the retail price similar to those from wild-capture, thus making much higher gross profit. This was one of the main reasons given by dealers preferring cultured fish, though it is unlikely that these differentials would remain over the longer term. With a growing population, the demand for tilapia and fish in general can be expected to increase, and with the stagnation in general fish production from both marine and fresh water sources, production from aquaculture can be expected to play a key role in reducing the supply deficit and hence the retail prices, currently high because of demand.

Among the finding of this study was the fact that current production of tilapia is widely accepted by most households in Ghana and potential demand currently far outstrips supply. Preference for fish among household consumers was influenced to an extent by source availability, quality, flavour perceptions, price, nutrition and health concerns. It was however invariant to income, education and household size. Another finding was that demand for cultured fish lies very much in the general quality of fish produced particularly in relation to consistency of size, the price and reliability of supplies. Fish farmers attempting to address this apparently large market opportunity will need to bear these in mind.

# Chapter 5 - A GIS approach to defining aquaculture development

## 5.1 Introduction

A key issue in aquaculture development is that of defining its potential location and scale. This conventionally involves site selection, and more generically, the definition of conditions and strategic locations where the sector might more favourably develop. Site selection for aquaculture planning is complicated involving the identification of areas that are economically, socially and environmentally available, and offer the prospect to be commercially viable (McLeod et al.  2002). It is a key factor in any aquaculture business, determining investment and running cost, affecting both success and sustainability and resolving conflicts between different activities making rational use of space (Perez et al., 2005; Lawson, 1995; Pillay and Kutty, 2005). Although site selection depends on the culture system to be adopted and the species to be cultured, there are factors such as agro-climatic conditions, access to markets, suitable communications, protection from disasters, availability of skilled and unskilled labour, public utilities, security etc. which affect all systems. Ideal sites may thus not always be available, and conflicts over land and water use may have to be resolved. With an adequate database however, Geographic Information Systems (GIS), organising and presenting spatial data in a way that allows effective environmental management planning, can serve as a powerful analytic and decision-making tool (Aguilar-Manjarrez and Ross, 1995).

GIS has been defined by Burrough (1986) as ‘‘a specific information system applied to geographic data and is mainly referred to as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data for solving complex planning and management problems''. It is a tool for collection, storage, analysis and presentation of spatial data, essentially computer based mapping. A simple GIS can play a role in assessing the development patterns of aquaculture systems and, as a low cost tool for broader social environmental analysis in an information poor country (Bush, 2003).

A major benefit of a GIS is that it can collect, store, relate and present information at different spatial scales. This means that information can be either detailed and locally specific or general and wide scale (Bush and Kosy, 2007). It also offers advantages over conventional methods because of the speed and accuracy with which it can handle large spatial datasets, allowing decision-makers to make more informed decisions because multiple scenarios can be evaluated or spatial analyses conducted that would otherwise prove to be too manageable (Salam, 2000).

### 5.1.1 Application of GIS in aquaculture

The first application of GIS in the aquaculture sector dates back to the 1980s (Perez et al. 2005) and it has since proved useful in assessing impacts on aquatic resources and environments for development projects involving land and water use. It has been used in predicting development prospects for different species in various environments (Aguilar-Manjarrez and Nath, 1998; Salam et al. 2005), in modelling of effluent discharges by aquaculture operations (Perez, et al. 2002), in site selection, zoning and land-suitability classification (Hossain et al. 2007; Kapetsky et al. 1987) as well as in socio economic issues such as relating aquaculture production potential with poverty (van Brakel, 2006). Although these examples suggest that GIS tools are receiving attention within the aquaculture community, its deployment for spatial decision support in this domain is thought to be very slow (Nath et al. 2000) and this has been attributed to a number of constraints including a lack of appreciation of the technology, limited understanding of GIS principles and associated methodology, and inadequate organizational commitment to ensure continuity of these spatial decision support tools. Another issue may also lie in the fact that in many cases it remains to be validated in terms of efficiency, decision-making quality, and effectiveness in incorporating social and technical processes (Muir, 2005)

### 5.1.2 Potential application in Ghana

As earlier noted, aquaculture production in Ghana has been based largely in earthen ponds where rainfall, groundwater and perennial streams are the main sources of water. There have however being growing interests in cage culture (Abban, pers comm. 2008) with the introduction of two commercial cage farms (Tropo farms and Crystal lake) in the Volta lake and another at Akuse (Pewage farms) in an irrigation dam (Plate 5.1).

Plate 5.1: A cage farm in an irrigation dam at Akuse

The first ever assessment of the country's fish farming opportunities was undertaken in 1988 by Kapetsky et al. (1991). Its objective was to identify the districts with the best prospects for farming *Oreochromis niloticus* and *Clarias gariepinus* in ponds with manure and rice as the main inputs. The southern parts of the country were identified as having the best opportunities. Among the recommendations to refine the study was the need to incorporate other types of crops for which by-products could be used for fish farming. Other assessments involving Ghana were those undertaken in 1994 by Kapetsky (1994) which covered 32 African countries and that by Aguilar-Manjarrez and Nath (1998) covering the entire sub-Saharan African region. Results from the first study suggested that 40% of the country was 'optimum' for two crops per year with 30% being optimum for one crop and suitable for the other. The third study found 80% of the country to be at least suitable and the rest marginally suitable. Recommendations by Kapetsky (1994) to improve the outcome of his study were to use higher-resolution data (his data ranged from 1:1,000,000 to 1:5,000,000) and to include constrained areas such as national parks and reserves. Aguilar-Manjarrez and Nath (1998) among others recommended the differentiation of cropland classes to assist in identifying suitable crops for fish culture.

### 5.1.3 Objectives

In view of the importance currently placed on aquaculture in Ghana and its efforts to address the annual shortfall in domestic fish production, the strategic potential, based on land/resource suitability is essential to define. This can also provide important information enabling potential developers/investors to identify suitable zones to ensure secure and sustained returns and benefits (Hossain and Lin, 2001) and may also help in controlling environmental impact, avoiding adverse social and environmental interactions (Hossain et al. 2007). At this stage, while Ghana appears to have excellent potential for aquaculture, very little of this has been realised. It is important therefore to clarify specifications and criteria to ensure that projections offer as realistic as possible an overview of target opportunities.

The objective of this chapter is therefore to use a GIS approach to update and reassess the potential for aquaculture development in Ghana in the light of the expected expansion in the sector, incorporating recommendations from the previous studies. It is focused on fresh water aquaculture, considered to be the primary area of sectoral development at this stage, with a particular but not exclusive focus on tilapia. It incorporates primary definers of water, climate, soils and feed/fertiliser sources, together with more specific issues such as market access and other social and economic factors.

## 5.2 Methodology

### 5.2.1 Overview

The suitability of areas for aquaculture development in Ghana was assessed by establishing which factors and constraints were important, and how they would impact. A factor is defined as a criterion that adds to or detracts from the suitability of the specific alternative under consideration, whilst a constraint serves to limit alternatives under consideration (Eastman, 2001). Examples of constraints considered in this study are forest reserves, game reserves, road networks, river courses and large water bodies (in relation to pond construction). Factors considered basic for aquaculture development were; water availability and quality, terrain and soil suitability, infrastructure in the form of roads, support in the form of extension services and supply of fingerlings, availability of inputs (manure, agriculture by-products and other feed types) and markets.

The factors were classified in four suitability rankings i.e. very suitable (VS), suitable (S) fairly suitable (FS) and unsuitable (US). The VS level provides a situation in which minimum time or investment is likely to be required in order to develop fish farming, an S classification implies that modest time and investment are required, FS implies that significant interventions may be required before fish farming operations can be conducted whilst US implies that the time or cost, or both, are too great to be worthwhile for fish farming (Aguilar-Manjarrez and Nath, 1998).

### 5.2.2 Data collection

Data were from secondary sources, primarily from the Ghana Country At a Glance (G-CAG) database. The Arcview database was developed in 1999 as an additional resource to the Environmental Information System Development (EISD) component of the Ghana Environmental Resource Management Project (GERMP) (Martensson et al. 1999) which was partly built on data generated by the various EISD institutions which comprised the Ghana Environmental Protection Agency (EPA), Department of Feeder Roads (DFR) of the Ministry of Roads and Highways, Forestry Department (FD) of Forestry Commission, Lands Commission (LC), Meteorological Services Department (MSD), and the Population Impact Project (PIP) and Remote Sensing Application Unit (RSAU) both of the Department of Geography and Resource Development of the

University of Ghana, also the Soil Research (CSIR/SRI) and Water Research Institutes of the Council for Scientific and Industrial Research (CSIR/WRI) and the Survey Department of Ghana (SD) as well as relevant data sets from other sources.

Fifty-one geographical, referenced and harmonised data sets covering 12 geographical themes are presented in the database. The themes are; national and international boundaries, conservation areas, climate information - temperature, rainfall, and evapotranspiration (ETP), geology, hydrology, land cover, land ownership, soils, topography, infrastructure, transportation and population information (Table 5.1). A large part of the information presented in the database was derived nationally from mapped/surveyed/compiled data layers in an original equivalent to 1:250 000 paper map scale databases put together by the above listed institutions.

Other sources of data were the Shuttle Radar Topography Mission (SRTM) website (www.strm.org) for the digital elevation models used in the slope sub-model, the Ghana Statistical Services 2000 population and housing census report and the Ghana Districts web pages (www.ghanadistrict.com) for updated information on district populations and growth rates (Ghana Statistical Service, 2002)

Data for water quality assessment were collated from volumes 1, 2 and 3 of the Ghana raw water quality assessment report prepared by the WRI for the Water Resources Commission of Ghana in 2003 (CSIR/WRI 2003). Volume 1 covered the south-western river system, volume 2 the Volta system and volume 3 the coastal drainage system. Additional information on roads networks and densities were obtained from recent online reports published by the Ministry of Roads and Transport, Ghana (www.mrt.gov.gh/statistics/DFR/Dfr_Road_Density.pdf - accessed 18/04/08).

Table 5.1 Summary features of major data themes

| Name of Theme | Main Custodian institution(s) | Primary data format | Data set(s) in final G-CAG database | Data format in final G-CAG database |
|---|---|---|---|---|
| Boundaries | Lands Commission | ARC/INFO polygons | National<br>Land surface<br>Region<br>District<br>Map tiles (50' and 250' map series) | Polygon/Line |
| Climate data | Meteorological Services Department | Point data as ASCII | ETP-year;<br>Rainfall – year and monthly<br>Temperature, year and monthly | Polygon<br>Polygon<br>Polygon |
| Conservation areas | Forestry Department<br>Ghana Wildlife Department | ARC/INFO polygons 1:250000<br>Paper maps of varying scales | Forest reserves<br>Forest resources<br>Wildlife Reserves | Polygon<br>Polygon<br>Polygon |
| Demography | Population Impact Project / University of Ghana | Tabular data, Excel format | Town pop<br>District pop<br>Region pop<br>Population density<br>Population time series 1984-2005 for selected features | All point data associated to the towns and administrative boundaries (polygons) |
| Geology | RSAU / Environmental Protection Agency | Paper map 1:1 000 000 | Geological formations | Polygon |
| Hydrology | Water Research Institute | Paper map 1:1 000 000 | Principal river basins<br>Rivers<br>Water bodies | Polygon<br>Line<br>Polygon |
| Land cover | RSAU / University of Ghana | ARC/INFO polygons 1:250,000 | Land cover | Polygon |
| Land ownership | Lands Commission | ARC/INFO polygons 1:250,000 | State land<br>Stool Land | Polygon<br>Polygon |
| Soil data | Soil Research | ARC/INFO polygons 1:250,000 | Soil type | Polygon |
| Topography | SRTM | 90m X 90m satellite imagery | Contour lines<br>Elevation zones | Polygon |
| Transportation | Survey Department | ARC/INFO Lines | Roads<br>Railroad | Line<br>Line |
| Settlement | Survey Department<br>Department of Feeder Roads | ARC/INFO polygons | District capitals<br>Regional capitals | Polygon<br>Points |

Source: (Martensson et al. 1999)

### 5.2.3 GIS software and systems used

The primary software tools used were IDRISI Andes and Cartalinx. IDRISI Andes is an integrated GIS and Image Processing system providing over 250 modules for the analysis and display of digital spatial information. It is raster based but with vector capabilities (http://www.clarklabs.org/products/index.cfm - accessed 26/03/08). CartaLinx is used to create coverages consisting of spatial definitions of features in vector format, and associated attribute values files, data which are typically exported to a GIS. The Economic and Social Research Institute (ESRI) Arcview 3.2 was used primarily for conversion of data files from Arcview to Shapefile format before importing into IDRISI Andes.

### 5.2.4 Data handling and conversion

The G-CAG database was generated in Arcview and presented in both Latlong and Transverse Mercator (UTM - grid in feet) formats. The Latlong format was intended for use with international databases whilst the UTM format was compatible with the Ghana National Grid system. The data with the Latlong reference system was used, primarily because images from other databases such the SRTM had to be incorporated in the model. The thematic maps were converted to IDRISI vector layers, by converting them to Arcview Shapefile and then imported to IDRISI Andes using the module SHAPERIDR. In IDRISI Andes, the shape files were then converted to IDRISI raster images with a 50 m resolution using the modules PROJECT followed by RASTER/VECTOR. The number of rows and column needed to obtain the 50m resolution were determined using the formulae given in Equation 5.1and Equation 5.2 (Eastman, 2001).

Number of rows = $\frac{Y_{max} - Y_{min}}{50}$ Equation 5.1

Number of Columns = $\frac{X_{max} - X_{min}}{50}$ Equation 5.2

Where $Y_{max}$ and $Y_{min}$ are respectively the maximum and minimum y coordinates of the country boundaries and $X_{max}$ and $X_{min}$ are respectively the maximum and minimum x coordinates.

### 5.2.5 GIS data development – land and water

**Water availability and quality**

Water is the most important natural resource in any aquaculture development. The estimation of the quantity of water required in a farm and the ways and means to meet the needs are the essential factors to be considered in the choice of a site (Kutty and Delince, 1987). The main sources of water for freshwater aquaculture in Ghana are perennial rivers and streams, ground water and runoff from rainfall. As seen earlier in Table 2.10 (Chapter 2, page 30) , only 12% of subsistence fish farmers depended solely on rainfall runoff, 45% on surface waters such as perennial rivers and streams, 40% on ground water – mainly springs and the rest on dams and reservoirs, used mostly by the commercial producers, for both pond and cage production systems.

Primary data on rivers according to the G-CAG database report were obtained from the World Resources Institute (WRI) African Data Sampler (ADS), based on the Digital Chart of the World (DCW) data set. The drainage channels were printed and checked by the Water Research Institute (WRI), reshaped and corrected where necessary.

Drainage basins were then drawn on the same base map by WRI and digitised by the RSAU.

Data for all water bodies except for the Volta Lake were obtained from the RSAU land cover mapping data. The lake data were derived by computing the extent of the water surface at a theoretical maximum water level of 280 feet, an approach agreed upon by the Land Information Project Operations Committee (LIPOC) organisations; a sub-committee of the G-CAG project made up of the EPA, LC, SRI, MSD, RSAU and SD (Martensson et al. 1999).

Precipitation and evapotranspiration (ETP) data were obtained from the G-CAG database, the first collated from 50 national meteorological stations from 1961 to 1990, together with data from 15 stations in surrounding countries to ensure that interpolation of climate surfaces would be accurate within national border areas (Martensson et al. 1999). ETP data sets were obtained from 38 stations across the country. Monthly measurements from these stations (maximum daily temperature (ºC), minimum daily temperature (ºC), mean daily relative humidity (%), wind speed measurement ($ms^{-1}$), bright sunshine hours per day (hours), elevation (m), latitude (deg), number of days in year), also from 1961 to 1990 were interpolated using the Penman-Monteith equation to yield an annual ETP surface (Boateng et al. 2001).

*Rivers and groundwater*

Availability of water from rivers was estimated from the river density which was calculated as the length of river per unit area. The river density was determined per district. This was done by clipping the perennial rivers image with the district boundaries from the district layer using CATALINX. After clipping, data was transferred to MS Excel where the total lengths (km) of the rivers per unit area of each district ($km^2$) were calculated. Densities were finally imported into IDRISI, saved as an attributed layer file which was then assigned to the district IDs. River density was used, instead of distance from the river, because it was meant to represent areas was with possibilities of groundwater as well since aquifers are said to be closely linked to rivers systems to which they contribute baseflow from seepages and springs (Rippon and Wynessa, 1994).

*Water bodies*

The use of water bodies was considered primarily for the development of cage culture. These included the Volta Lake, Weija reservoir, Owabi and Barekese dams and the irrigation reservoirs which are listed in Table 5.2.

*Estimation of effective rainfall*

Annual rainfall requirement was estimated using the equation

Water requirement = (Precipitation [mm] x 1.1) - (Potential evapotranspiration [mm] x 1.3) – Seepage (960mm). Equation 5.3

Where the coefficient of 1.1 accounts for the runoff from the pond side that is in excess of the rainfall that falls directly into the pond and 1.3 compensates for the higher evaporation from free surfaces such as small open ponds (Aguilar-Manjarrez and Nath, 1998).

Table 5.2 Public and irrigation schemes in Ghana

| Name of dam | Region | Surface area (ha) | Volume (million $m^3$) |
|---|---|---|---|
| Ashaiman | Greater Accra Region | - | 6,2 |
| Weija | Greater Accra Region | 3361.5 | 116.7 |
| Dawhenya | Greater Accra Region | 300.0 | 5.8 |
| Kpong (Right bank) | Greater Accra Region | | - |
| Aveyime | Volta Region | | - |
| Afife | Volta Region | - | 29.45 |
| Kpando Torkor | Volta Region | | - |
| Amate | Eastern Region | | - |
| Dedeso | Eastern Region | | - |
| Inchaban | Central Region | | 1.8 |
| Okyereko | Central Region | 83.0 | 2.8 |
| Mankessim | Central Region | 192.0 | 5.67 |
| Inchaban | Western Region | | 1.8 |
| Akomadan | Ashanti Region | | - |
| Anum valley | Ashanti Region | | - |
| Tanoso | Ashanti Region | | 340.00 |
| Barekese | Ashanti Region | | 3.4 |
| Subinja | Brong-Ahafo Region | | - |
| Bontanga | Northern Region | 770.0 | 2.53 |
| Golinga | Northern Region | | - |
| Ligba | Northern Region | | - |
| Tono | Upper East Region | 1860.0 | 92.0 |
| Vea | Upper East Region | 405.0 | 17.3 |
| TOTAL | | | |

Source: FAO Aquasat database
(http://www.fao.org/nr/water/aquastat/damsafrica/african_dams060908.xls)

The water sub-model for fish farming was obtained from the weighted overlay of effective rainfall, and perennial river density and annual precipitation. Annual precipitation was included primarily because groundwater is a major source of water for fish farming and it is naturally replenished by precipitation.

Table 5.3 Suitability classification for water sources

| Factor | Very Suitable | Suitable | Fairly Suitable | Unsuitable |
|---|---|---|---|---|
| Annual rainfall (mm) | > 1200 | 1000 - 1200 | 700 – 1000 | >700 |
| Effective rainfall (mm) | ≥ 0 | 1 to -2000 | -2000 to -3499 | < -3500 |
| Perennial river density ($km/km^2$) | ≥ 0.36 | 0.2 - 0.35 | 0.04 – 0.20 | < 0.04 |

## Water quality

The water quality was assessed from mean pH, temperature and dissolved oxygen concentrations of the major river basins, compiled from the raw water quality data assessments reports a study conducted under the "Ghana raw water criteria and guidelines" project. Suitability classifications (Salam, 2000) are as presented in Table 5.4.

Table 5.4 Suitability classification for water quality parameters

| Factor | Very Suitable | Suitable | Fairly Suitable | Unsuitable |
|---|---|---|---|---|
| pH | 6.0 – 8.0 | 5.0 – 6.0<br>8.0 – 9.0 | 4.0 – 6.0 | < 4.0<br>> 9.0 |
| DO (mgl-1) | 5.0 – 10.0 | 4.0 – 5.0 | 3.0 – 4.0 | < 3.0 |
| Temperature (ºC) | 25 - 32 | 22 - 25 | 18 - 22 | 0 - 18 |

## Soil texture and topography

A good understanding of soil and its characteristics is one of the most important of many factors which must be considered for successful freshwater fish culture (Coche and Laughlin, 1985). This is because the quality of soil has a great influence on productivity, construction and maintenance costs, and the quality of the overlying water (Aguilar-Manjarrez and Nath, 1998; Boyd, 1995; Pillay and Kutty, 2005). The ability of the pond to retain water is also greatly influenced by the characteristics of the soil.

Soil data was obtained as an Arcview vector files from SRI. Classification was based on the soil taxonomy system (Boateng et al. 2001) according to whom, the soil layer was extracted from thirty-five separate 1:250,000 scale maps, many defined on the basis of watershed boundaries. Included in the database were the soil unit information on topsoil textural class, presence of soil phases, available water holding capacity (AWC), 789 soil profiles and a listing of the three most dominant soil series of each soil association

(Boateng et al.  2001). The suitability of soils for aquaculture development was based on an integration of soil texture, soil pH and topography. The textural triangle method based on the USDA system of particle size classification was used to identify the textural classes suitable for aquaculture. The red shaded soil textural classes of the large triangle (sandy clay, sandy clay loam, clay loam and silty clay loam) are best for fish-pond construction (Coche and Laughlin, 1985).

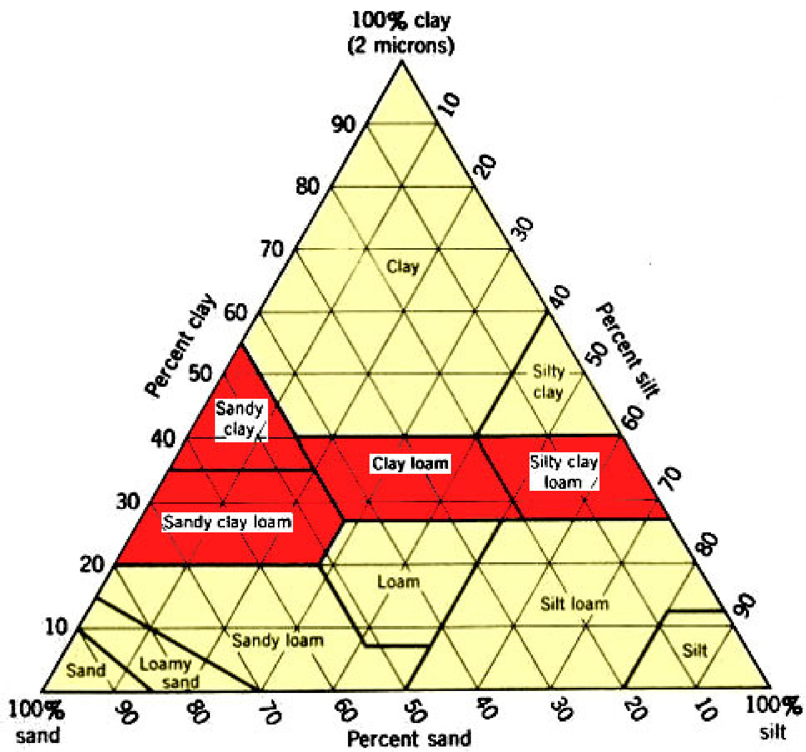



Figure 5.1 Soil texture triangle
(Source:ftp://ftp.fao.org/FI/CDrom/FAO_Training/FAO_Training/General/x6706e/Index.htm accessed: 6/04/08).

The suitability ratings of the three components are as given in Table 5.5. The textural rankings were based on the percentage of soil textures of an area suitable for pond construction. The suitability rankings of soil texture, soil pH and slope were as proposed by (Coche and Laughlin, 1985).

Table 5.5 Soil suitability rankings

| Factors | Very Suitable | Suitable | Fairly Suitable | Unsuitable |
|---|---|---|---|---|
| Soil texture (%) | > 80 | 50 - 80 | 20 - 50 | 0 - 20 |
| Soil pH | 6.5 - 8.5 | 5.5 - 6.5<br>8.5 - 9.5 | 4 - 5.5<br>9.5 - 11.0 | 1.0 – 4.0<br>11.0 – 14.0 |
| Terrain (%) | 0 - 2 | 2 - 5 | 5 - 8 | >8 |

## Infrastructure

Infrastructure was considered important particularly for the development of the commercial sector, which tends to sell its products beyond the farm location. Infrastructure thought to be important for aquaculture includes roads for transportation purposes and electricity particularly in intensive production systems. Information on road networks and density was available but not for electricity distribution. Road densities were however used to represent both facilities since besides being a measure of accessibility, road density is also an indicator of physical capital assets (Kristjanson et al. 2005).

Road densities - calculated as kilometres of road per district area - were obtained from a published online report by the Ministry of Transport titled ‘Relationship between population density, road’s density and poverty’ (Ministry of Transport, 2005). The rail density per district was obtained by clipping the rail line image with the district boundaries using CATALINX. The length of rail per unit district areas was then determined. The rail lines were mainly concentrated in the south. The suitability classifications (Text box 1) was a modification of that used by (Kapetsky, 1994). His classification was based on the number of 2' × 2' pixels containing a paved or motorable road per 10'× 10' grid (Text box 2). Values for the current classification was obtained by determining the ratio of pixels (area) with roads to that of the 10’ x 10’ area. For example a 10’ x 10’ grid with nine 2’ x 2’ pixels with road networks will culminate in a ratio of 0.36 (9 * (2’ * 2’): 100’ = 36:100 or 0.36).

Text box 1 Road density

| No. of 2’x 2’ pixels with motorable roads per 10’x10’ pixel | Interpretation |
|---|---|
| 9 – 22 | optimum |
| 5 – 8 | suitable |
| 1 – 4 | marginal |

Source: (Kapetsky, 1994)

Text box 2 Road density

| Value (Km/km$^2$) | Interpretation | Score |
|---|---|---|
| ≥ 0.36 | very suitable | 4 |
| 0.20 – 0.35 | suitable | 3 |
| 0.04 – 0.19 | fairly suitable | 2 |
| < 0.04 | unsuitable | 1 |

**Market potential**

Market potential was determined per district, based on district population density (individuals/km$^2$), an indication of potential farm gate sales for subsistence farming (Aguilar-Manjarrez. and Nath, 1998) and on urban market size (primarily for commercial farming) which was projected from district capital populations and proximity from these population centres (Kapetsky and Nath, 1997). In effect, district capitals were substituted for urban centres as they are in most cases the most populated towns. However this excluded other potentially large urban centres, a constraint in some cases. Proximity of all other areas in the district from the urban markets (district capitals) was determined using the DISTANCE module followed by a classification where the maximum distance was fixed at 499km which was the farthest distance travelled by dealers to buy tilapia (Chapter 4 - Sources of tilapia, Page 123). This distance was divided into four approximately equal parts to make up the various suitabilities (Table 5.6). In the classification of farm gate sales, areas with population density exceeding 310 individuals/km$^2$ were included as very suitable areas although such places had been classified as unsuitable in the previous study by (Aguilar-Manjarrez and Nath, 1998) because they were considered very likely to be build up areas which will not allow for pond construction. With urban markets district capitals with populations of less than 50,000 were considered unsuitable as its distribution is likely to be sparse.

Table 5.6 Suitability classification for farm gate and urban markets

| Factors | Very Suitable | Suitable | Moderately suitable | Unsuitable |
|---|---|---|---|---|
| Farm gate sales (individuals/km$^2$) | 150 - 310 | 25 - 150 | 1 – 25 | < 1 and >310 |
| Urban market (population) | > 1,000,000 | 250,000 – 1,000,000 | 50,000 – 250,000 | < 50,000 |
| Proximity classification (km) | 0 - 165 | 165 - 330 | 330 - 499 | > 500 |

## Inputs

Two main fish farming inputs were considered – feed and manure. Seed was not included here because fish farmers often depended on the Fisheries' extension officers, private hatcheries and research/educational institutions for its supply. It was therefore included in support services which is discussed in the next section. From the earlier survey (Chapter 2, Table 2.18) 66% of fish farmers in Ghana depended on agriculture by-products for feed, the most common of which were wheat bran, rice bran, maize bran, vegetables, fruits and other farm produce. Whiles most of these by-products are available locally, wheat bran is primarily available in urban markets because the crop is not indigenous to Ghana and the bran is produced by commercial mills located in Tema and Takoradi in the Greater Accra and Western regions respectively. Availability of inputs was therefore defined by the suitability of land for crops and the proximity of an area to an urban market for which urban centres were used as a surrogate. The suitability of croplands as surrogate for possible sources of inputs (Kapetsky, 1994) was defined similarly to that in the "Geospatial modelling for agro-ecological assessment and decision support for development planning in Ghana" report (Boateng et al. 2001). Classification was based on their crop suitability index, derived from annual attainable crop yields for a land area which in the report was also defined by agro-climatic and agro-edaphic conditions. The equation used for the suitability index (SI) is presented in Text box 3. The values ranged from < 1 to 100.

Manure availability was based on the densities of poultry, cattle or pig density at the district level. Data used here were obtained from the previous study by (Kapetsky et al. 1991) which is very old and was therefore used in more of a qualitative sense than quantitative.

Table 5.7 Input suitability classification

| Inputs | very suitable | suitable | fairly suitable | unsuitable |
|---|---|---|---|---|
| Cropland (Suitability Index) | 80 - 100 | 50 - 79 | 20 - 49 | < 20 |
| Distance to urban market (km) | 0 - 166 | 167 - 333 | 334 - 499 | > 499 |

Text box 3 Crop yield suitability index equation

SI = [ { (VS*0.9)+(S*0.7)+(MD*0.5)+(mS*0.3)+(NS*0.1)}-10]/80*100

Where VS, S, MD, mS and NS respectively stand for the number of very suitable, suitable, moderately suitable, marginally suitable and unsuitable crop yield pixels within a 1 $km^2$ ground area. The crop yields were defined by tonnage/$km^2$.

## Support

This is defined by the accessibility of farmers to aquaculture experts and extension officers for guidance, technical advice and access to quality fingerlings. Such assistance is provided by Fisheries Department regional offices, research institutions, universities and commercial farmers. Assistance provided include technical advice on siting and construction of ponds, stocking, supply of seedling, provision of harvesting equipment, assistance with harvesting and training in fish farming (Directorate of Fisheries, 2004). Support from research and other institutions is normally in the form of consultancy services, but unlike the Fisheries Department where farmers only pay for extension officer's travel costs, these are provided for a fee and are often accessed by relatively large scale producers. Institutions and commercial farms which may provide such support and their respective locations are listed in Text box 4. A few of the educational institutions listed such as UEW Agriculture College, Catholic University, Presbyterian University, Methodist University are not necessarily providing such services now but since they all have departments offering courses in agriculture they are thought to be in a position to offer some help to farmers. In the sub-model the Fisheries Department's regional officers are often located in the regional capital, and were thus represented on the image by the position of regional capitals. The suitabilities were defined by distance from the locations. These centres also represented sources of hatchery fingerlings which was considered a form of technical support though farmers have to pay for the fingerlings. Fingerlings could offer a particular advantage if available in quantity and at good price.

Text box 4 Supporting Institutions

| Institution | location | Region |
|---|---|---|
| WRI | Accra | GAR |
| ARDEC/WRI | Akosombo | ER |
| WRI field station | Tamale | NR |
| Nyankpala Agriculture Centre (UDS) | Navrongo | UE |
| Kwadaso Agriculture College | Kwadaso | AsR |
| UDS | Navrongo | UE |
| UG | Accra | GAR |
| UCC | Capecoast | CR |
| UEW Agriculture College | Mampong | ER |
| Catholic University | Fiapre | BAR |
| Presbyterian Uni | Agogo | AsR |
| Methodist Uni | Wenchi | BAR |
| Tropo farms | Asutuare | ER |
| Afife farms | Afife | VR |
| Nana Siaw farms | Ejisu | AsR |
| Crystal Lake | Dodze Asantekrom | ER |

### 5.2.6 Integration of primary criteria

Integration of factors to identify suitable areas for development of non-commercial and commercial pond culture was accomplished using IDRISI's Multi-Criteria Evaluation (MCE) choosing the weighted linear combination (WLC). The MCE has been designed to satisfy the fairness criterion and is considered very efficient in establishing weights of factors (Salam, 2000). Good results from MCE are however easier to obtain when the number of factors are not more than 10 (Ross, 1998) but where they exceed, the use of sub-models is recommended (Aguilar, 1996) because the accuracy and consistency ratio[6] (CR) may not be within limits (< 0.10) considered acceptable. Creation of sub-models involves putting together variables that group naturally such as water sources, water quality variables or soil and terrain.

Eight sub-models were developed; these were water availability, water quality, soil and terrain suitability, inputs, support, infrastructure, farm gate sales and urban markets. The water availability model for example was obtained from an integration of the possible sources of water; effective rainfall, river density and annual rainfall. Details factors and weight applied to the factors put together to develop the sub-model are presented in Figure 5.2.

The pair-wise comparison method developed by Saaty (1977) known as the Analytical Hierarchy Process (AHP) ranked from 1/9 (least important) to 9 (extremely important) (Table 5.8) was used to develop the set of relative weights for groups of factors in the multi-criteria evaluation. Relative importance of factors was decided based on information gathered from the field trips described in previous chapters, from key informants and from literature.

Table 5.8 Scale for relative importance of criteria

<table>
<tr><td>1/9</td><td>1/8</td><td>1/7</td><td>1/6</td><td>1/5</td><td>1/4</td><td>1/3</td><td>1/2</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td colspan="2">extremely</td><td colspan="2">Very strongly</td><td colspan="2">strongly</td><td colspan="2">moderately</td><td>equally</td><td colspan="3">moderately</td><td colspan="2">strongly</td><td colspan="2">Very strongly</td><td>extremely</td></tr>
</table>

Less important More important

### 5.2.7 Final integrated models

Weights applied to sub-models to obtain final integrated models for areas with potential for subsistence and commercial aquaculture are presented in Table 5.9 and Table 5.10

[6] Consistency ratio measures the degree of consistency in the pairwise comparisons.

respectively. Key differences in factor rankings for commercial and non-commercial farming were in the relative importance placed on urban markets and infrastructure where they were given higher weights in relation to commercial farming, since as explained earlier harvests from commercial farming will be expected to sell beyond the farm gate wherefore proximity to urban markets, and infrastructure becomes very important whereas in non-commercial farming farmers consume part of the harvest, use some as compensation for labour and sell the surplus locally. Water availability, water quality and soil quality and terrain models were given the highest importance in non-commercial farming as farmers in this category may not be in a position to incorporate "expensive" technologies.

Table 5.9 Pair-wise comparison matrix for assessing the relative importance of factors for non-commercial farming of tilapia.

| Factors | Water sources | Water quality | Soil quality | Inputs | Farm gate sales | Support | Weights |
|---|---|---|---|---|---|---|---|
| Water availability | 1 | | | | | | 0.41 |
| Water quality | 1/3 | 1 | | | | | 0.18 |
| Soil quality | 1/2 | 1 | 1 | | | | 0.21 |
| Inputs | 1/6 | 1/3 | 1/4 | 1 | | | 0.07 |
| Support | 1/6 | 1/4 | 1/3 | 1 | 1 | | 0.06 |
| Farm gate sales | 1/5 | 1/2 | 1/3 | 1/2 | 1 | 1 | 0.07 |

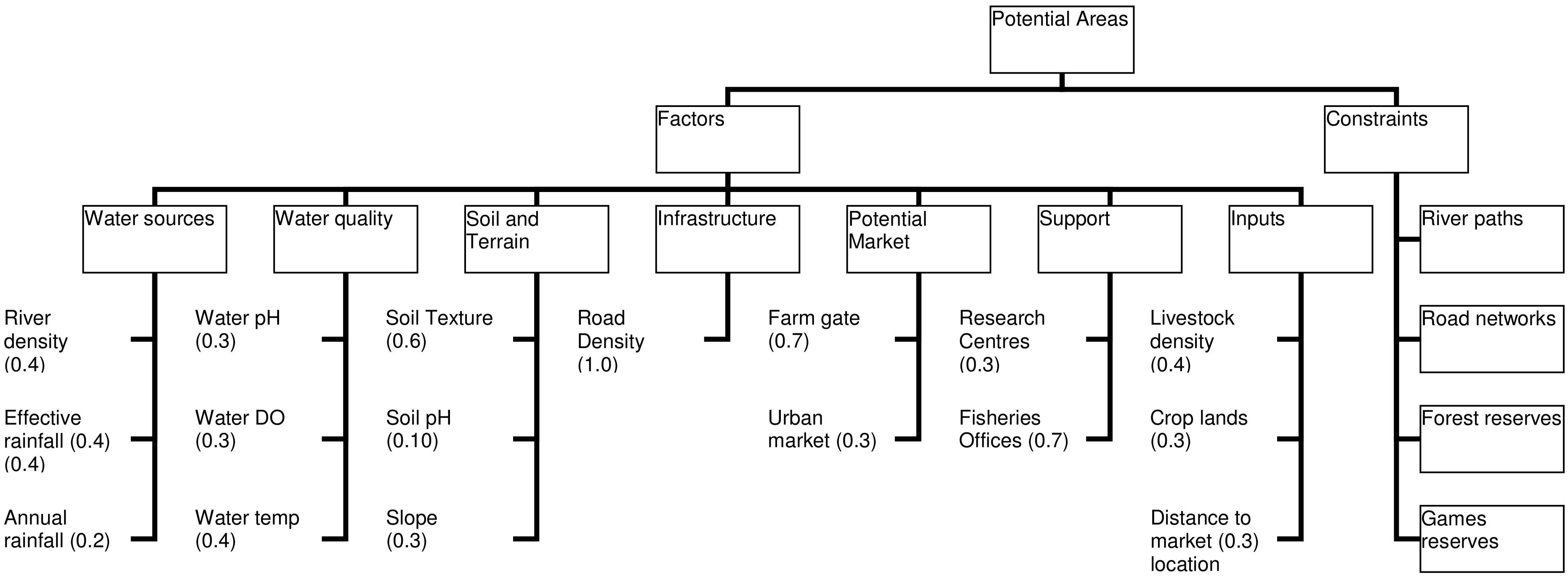
CR = 0.03

Table 5.10 Pair-wise comparison matrix for assessing the relative importance of factors for commercial farming of tilapia

| Factors | Water availability | Water quality | Soil quality | Urban market | Infra-structure | Inputs | Support | Weights |
|---|---|---|---|---|---|---|---|---|
| Water availability | 1 | | | | | | | 0.26 |
| Water quality | 1/2 | 1 | | | | | | 0.15 |
| Market | 1 | 3 | 1 | | | | | 0.25 |
| Infrastructure | 1/3 | 1/2 | 1/2 | 1 | | | | 0.08 |
| Soil quality | 1/3 | 1/2 | 1/3 | 1 | 1 | | | 0.12 |
| Inputs | 1/3 | 1/2 | 1/4 | 1 | 2 | 1 | | 0.08 |
| Support | 1/3 | 1/3 | 1/4 | 1/3 | 1/2 | 1/2 | 1 | 0.05 |

CR = 0.02

Figure 5.2 Summarised model for non-commercial farming showing the weights applied to each of the images put together to develop the respective sub-models



### 5.2.8 Potential for cage aquaculture development

In selection of sites for cage culture, three categories of criteria need to be addressed. These according to (Beveridge, 2004) are first, the physico-chemical conditions (temperature, salinity, oxygen, currents, pollution, algal bloom, exchange) which determine whether a species can thrive in an environment; the second criteria are factors that are needed in order to place a cage system successfully i.e. weather, shelter, depth, substrate; and the third issues relating to the establishment of the farm and profitability such as legal aspects, access, land-based facilities, security, economic and social considerations.

The current study which is basically, a preliminary for potential cage aquaculture development in Ghana, was set out to identify areas with potential primarily based on market potential, infrastructure, inputs (as defined for commercial farming) and support as defined above which relate primarily to the third criteria. These sub-models were taken through the decision making process similar to those undertaken in identifying areas suitable for pond aquaculture. Details of the weights applied are presented in Table 5.11. Market was given the highest weighting followed by infrastructure, inputs and support which were ranked close. List of the irrigation reservoirs are presented in Table 5.2 above.

Table 5.11 Pair-wise comparison matrix for assessing the relative importance of factors for commercial cage farming

| Factors | Urban market | Infrastructure | Inputs | Support | Weights |
|---|---|---|---|---|---|
| Urban market | 1 | | | | 0.40 |
| Infrastructure | 1 | 1 | | | 0.27 |
| Inputs | 1/2 | 1 | 1 | | 0.22 |
| Support | 1/5 | 1/2 | 1/2 | 1 | 0.10 |

Consistency ratio = 0.03

### 5.2.9 Verification of model

The final models were verified by comparing predicted sites with existing farm locations which were those from the fish farmer survey (Chapter 2, Table 2.2). The purpose of the verification was to confirm whether the existing farm locations match the suitability classifications or not and this is based on an assumption that all existing farms are located in areas which are either very suitable or suitable for aquaculture.

## 5.3 Results

Table 5.12 provides a summary of the results of the sub-models, indicating sizes of land and percentage of national total classified as very suitable, suitable, fairly suitable and unsuitable for each of the sub-models as well as the integrated models. The sub-models were water availability, water quality, soil quality and terrain, inputs, support, farm gate sales and urban market. The results of the integrated sub-model identifying areas suitable for non-commercial and commercial farming are presented as well as a final brief on the potential for cage culture.

### 5.3.1 Water availability and quality

Water quality in all river basins was found to be very suitable for fish farming (Figure 5.3). Mean basin water temperatures ranged from 26.7 to 28.9ºC. Mean dissolved oxygen concentrations were generally above 5mg/l which is considered the minimum for proper growth and development of fish (Alabaster and Lloyd, 1982). It is one of the limiting environmental factors affecting fish feeding, growth and metabolism (El-Sayed, 2006). Mean pH values ranged from 7.0 to 7.5 which were also within the very suitable range for the culture of tilapia (Salam, 2000).

Only 1.7% (4114 km$^2$) of the country's land area was found to be very suitable in terms of water availability, 81.6% was suitable, 16.7% was fairly suitable, and there were no unsuitable areas. The very suitable districts for water availability were the Kwaebibirem and New Juabeng districts in the Eastern region and the Adansi East and Asante Akim South districts in the Ashanti regions. The average river density for these districts was 0.17 while that for the fairly suitable districts was 0.05. Mean annual rainfall was also less in the fairly suitable areas which were primarily in districts in the Greater Accra; Accra Metropolitan area, Tema and Dangme west districts. In the Volta region, they were just two in the southern part of the region; Keta and Sogakope districts and in the central region the Awutu-Afutu-Senya district. All the districts in the Upper East and Upper West regions, were all fairly suitable accept for the Lawra district which was suitable (Figure 5.3).

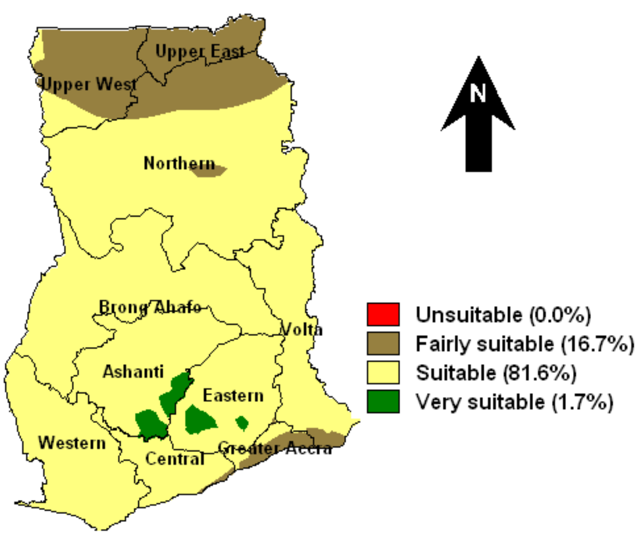



Figure 5.3 Water availability

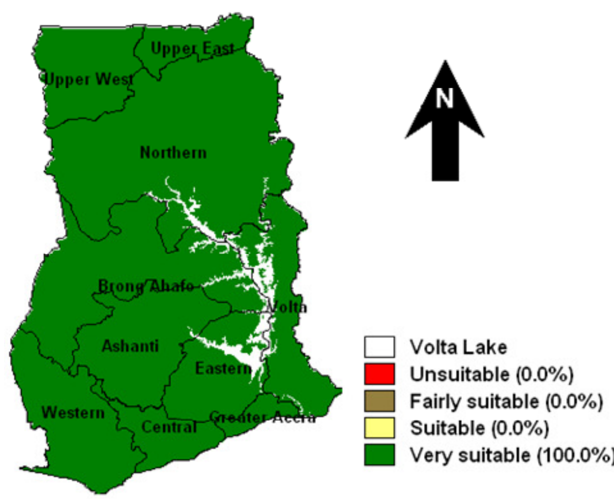



Figure 5.4 Water quality

Table 5.12 Areas ($km^2$) and percentage suitabilities of lands for the factors, sub-models and integrated models for subsistence and commercial farming

| Land characteristics | Very suitable | | Suitable | | Fairly suitable | | Unsuitable | |
|---|---|---|---|---|---|---|---|---|
| | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % |
| Water sources sub-model | | | | | | | | |
| Effective rainfall | -* | - | 184102 | 77.1 | 54769 | 22.9 | - | - |
| Perennial river density | 4661 | 2.0 | 126916 | 53.1 | 91357 | 38.2 | 15936 | 6.7 |
| Annual rainfall | 128257 | 53.7 | 70770 | 29.6 | 39842 | 16.7 | - | - |
| Over all | 4113 | 1.7 | 194856 | 81.6 | 39901 | 16.7 | 0.36 | 0.0 |
| Water quality sub-model | | | | | | | | |
| Water temperature | 238872 | 100 | - | - | - | - | - | - |
| pH | 238872 | 100 | - | - | - | - | - | - |
| DO | 194101 | 81.3 | 44770 | 18.7 | - | - | - | - |
| Over all | 238872 | 100 | - | - | - | - | - | - |
| Soil quality and terrain sub-model | | | | | | | | |
| Soil texture | 34546 | 14.4 | 41790 | 17.5 | 52610 | 22.0 | 110305 | 46.1 |
| Soil pH | 42555 | 17.8 | 156122 | 65.3 | 25140 | 10.5 | 15436 | 6.5 |
| slope | 62042 | 27.9 | 99634 | 44.8 | 29924 | 13.4 | 30901 | 13.9 |
| Over all | 21709 | 9.1 | 62516 | 26.1 | 130468 | 54.4 | 24876 | 10.4 |
| Infrastructure sub-model | | | | | | | | |
| Road density | 28106 | 11.8 | 70883 | 29.7 | 131712 | 55.1 | 8170 | 3.4 |
| Market sub-models | | | | | | | | |
| Farm-gate | 16482 | 6.9 | 146426 | 61.3 | 65185 | 27.3 | 10777 | 4.5 |
| Urban market and proximity | 480 | 0.2 | 35927 | 15.0 | 202463 | 84.8 | - | 0.0 |
| Inputs sub-model | | | | | | | | |
| Crop lands | 2790 | 1.2 | 47707 | 20.0 | 67887 | 28.4 | 120489 | 50.4 |
| Animal density | 2015 | 0.8 | 13266 | 5.5 | 141267 | 59.0 | 82904 | 34.6 |
| Proximity to urban market locations** | | | | | | | | |
| Over all | 260 | 0.1 | 41458 | 17.2 | 158858 | 66.0 | 40103 | 16.7 |
| Support sub-model | | | | | | | | |
| Proximity to institutions | 96760 | 40.5 | 98009 | 41.0 | 44101 | 18.5 | - | 0.0 |
| Integrated models | | | | | | | | |
| Final model - Subsistence | 3692 | 1.9 | 186880 | 97.4 | 1278 | 0.7 | - | - |
| Final model- Commercial | 314 | 0.2 | 161943 | 84.4 | 29597 | 0.15 | - | - |

* The area is less than $1km^2$ ** Physical locations

### 5.3.2 Soil quality and terrain

From the soil sub-model, 9% of the land area was identified to have very suitable soils for ponds, 26% was suitable, 54.6% fairly suitable and 10.4% unsuitable (Figure 5.5). Districts with the best soils and terrain are listed in Text box 4 (in brackets are the regions). Very suitable soils were largely concentrated in the middle belt of country and parts of the northern regions. The main limiting factor was soil texture; close to 50% of the land area was classified as unsuitable as against soil pH and slope where at least 70% of the land area was suitable (Figure 5.5). Nevertheless, there are ways of controlling or manipulate this though they too could exhibit spatial variations, e.g. by bringing in quantities of a suitable soil, by liming, by adding organic materials, by lining ponds with plastic sheeting, by puddling, by adding fertilizer or even by constructing alternative production systems (Meaden and Kapetsky, 1991). These techniques are however also usually more expensive and are less likely to be financially supportable unless other conditions are specifically positive.

Text box 4 Districts with very suitable soil quality

Sene (Brong Ahafo)
Atebubu (Brong Ahafo)
Kintampo (Brong Ahafo)
Wenchi (Brong Ahafo)
Kete-Krachi (Volta)
Nanumba (Northern)
Bibiani/Anwiaso/Bekwai (Western)
Kwaebibirem (Eastern)
West Gonja (Northern)
Sissala (Upper West)
Nkwanta(Volta)
Wassa Amenfi(Western)
Sefwi Wiaso(Western)
East Akim (Eastern)

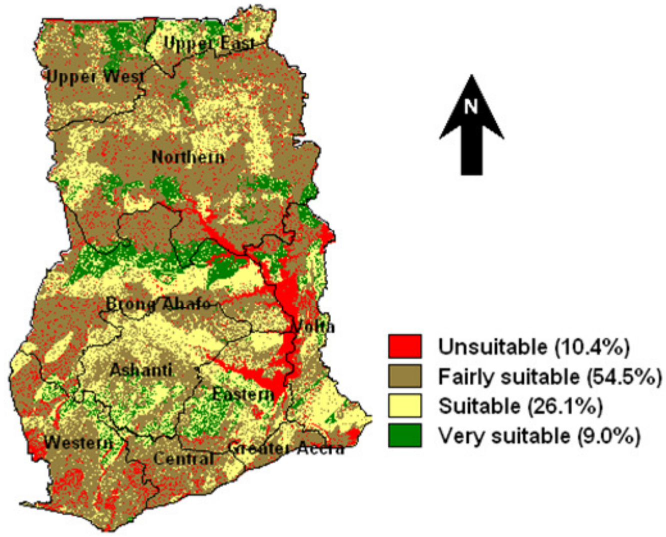



Figure 5.5 Soil quality and terrain suitability

### 5.3.3 Market potential and farm gate sales

Areas with good potential for pond side sales were relatively wide spread (Figure 5.6). Unsuitable areas were largely the very sparely populated districts with total population of less than 50,000. Market potential for commercial aquaculture production was best in the Accra and Kumasi metropolitan areas where about a sixth of the country's population reside. The coastal areas as well as parts of the middle belt were suitable. The Tamale metropolitan area was the only districts among the districts in the three northern regions was found to be suitable. The rest of the districts and much of the middle belt were only fairly suitable.

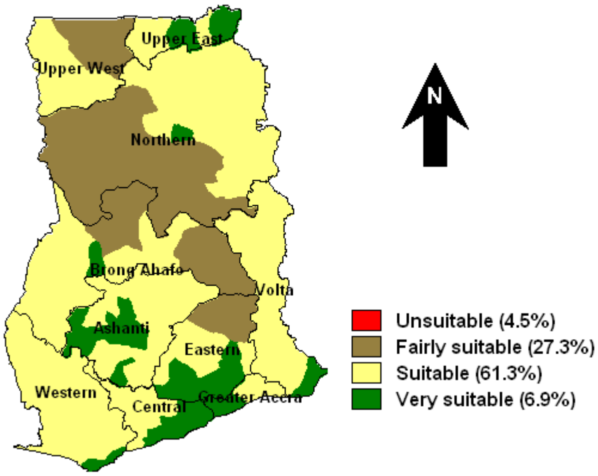



Figure 5.6 Potential farm gate sales

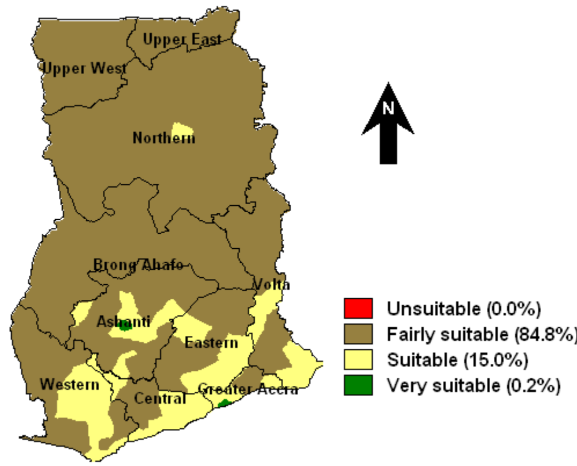



Figure 5.7 Urban market and proximity

### 5.3.4 Infrastructure

Infrastructure was much better in the southern and middle belts of the country. The very suitable locations were largely regions along the along the coastal zone and the Kumasi metropolitan area (Figure 5.8). The northern parts are generally fairly suitable with small pockets of suitable areas in and around the regional capitals. Overall 11.8% (28,107km$^2$) of the land areas was very suitable, 29.7% was suitable, 55.1% was fairly suitable and 3.4% was unsuitable (Figure 5.8).

### 5.3.5 Support

Areas with potential support for fish farming were wide spread across the country with over 40% of the land area being very suitable i.e. within 50 km of a research institution, an educational facility or a fisheries regional office or a commercial farm a number of which are also sources of hatchery fingerlings. Forty-one percent of the land area was suitable as it was within 100 km of at least one of these centres. No area was found to be unsuitable. Subsistence farms were not considered as suitable sources of fingerlings, although a number do supply fingerling to other colleague farmers, primarily because their fingerlings are inbred and have a high potential of stunting considerably reducing the usefulness of the population for commercial purposes (Welcomme, 1988).

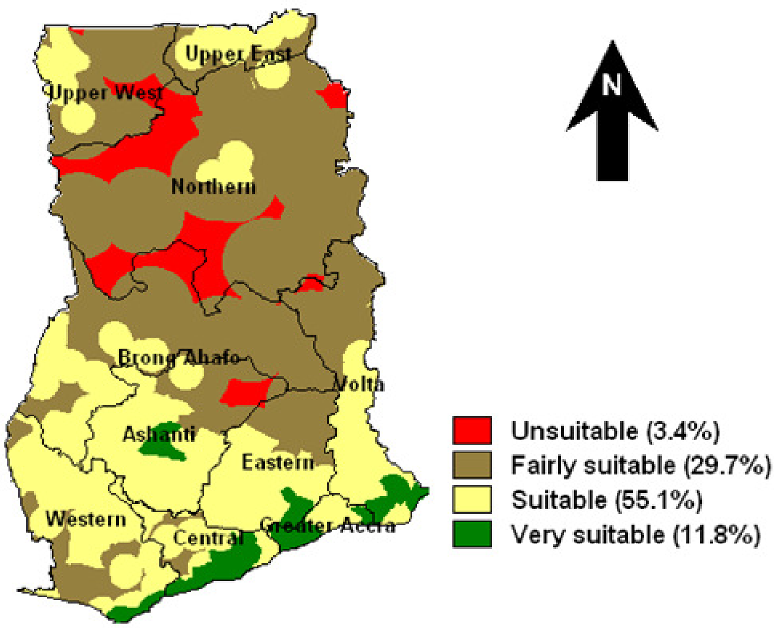



Figure 5.8 Infrastructure

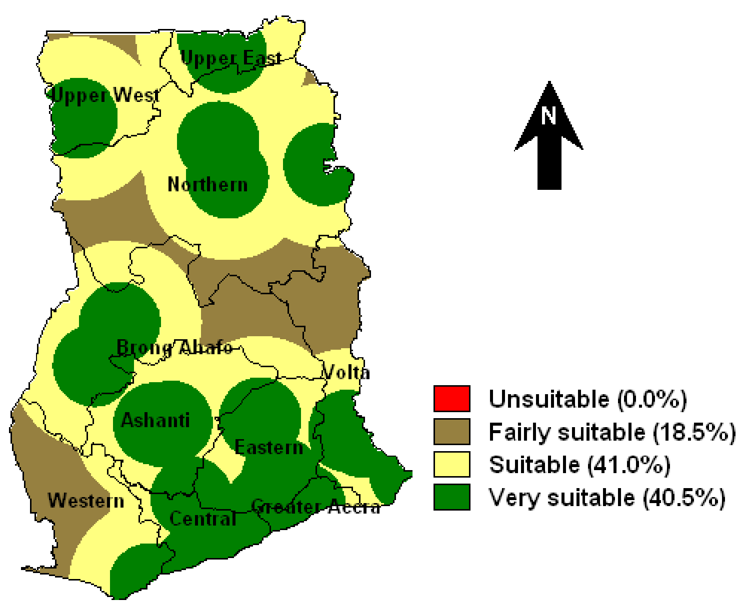



Figure 5.9 Support services

### 5.3.6 Inputs

Unlike the previous sub-models, different input models were developed for subsistence and commercial farming. For subsistence farming, more emphasis was placed on the relevance of agricultural by-products and availability of animal manure (assumed from animal densities) than on obtaining inputs from local markets while for commercial farming more emphasis been placed on inputs being obtained from markets rather than from agricultural by-products.

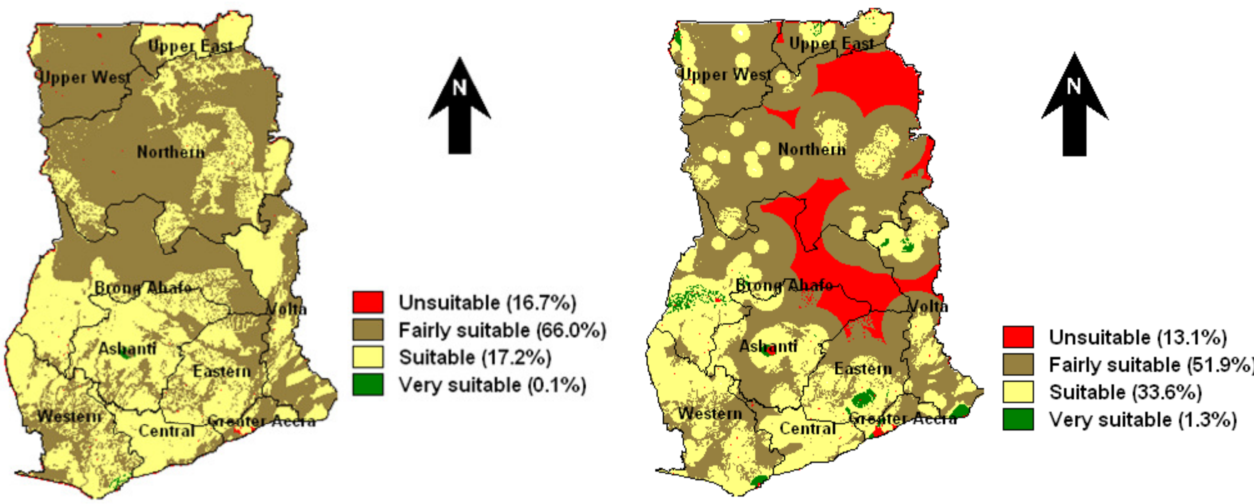



Figure 5.10 Inputs suitability classification: subsistence farming (left) and commercial farming (right)

Less than 1% of the land area was found to very suitable for inputs for subsistence farming. These were largely areas in the central parts of the Ashanti region and southern-eastern part of the western region. Large parts of the northern regions particularly the Upper West, western parts of the northern region and northern parts of the Brong-Ahafo region were only fairly suitable. Over all the southern and middle belts of the country were suitable for inputs for subsistence farming (Figure 5.10 above). The presence of agriculture according to Kapetsky and Nath (1997) is an important indicator of aquaculture potential as it also implies at least a minimum amount of infrastructure for development, such as a road transportation system, a local labour force and villages or towns for essential supplies.

### 5.3.7 Integrated models

About 80% (191,854 km$^2$) of the country's land area excluding the forest and game reserves (47,017 km$^2$) were found to be suitable for subsistence fish farming. Of this close to 2% (3692 km$^2$) was very suitable, 97.4% was suitable with less than 1% being fairly suitable (Figure 5.11). The very suitable areas for subsistence farming were largely in the Ashanti and Eastern regions. The precise districts were Kwaebibirem, Adansi East, Asante-Akim South, East Akim, Amansie East, Manya Krobo, Sekyere East, Fanteakwa, Bosomtwe-Atwima-Kwanwoma, and Akwapim North. These districts were areas where a number of the relevant variables overlapped each other.

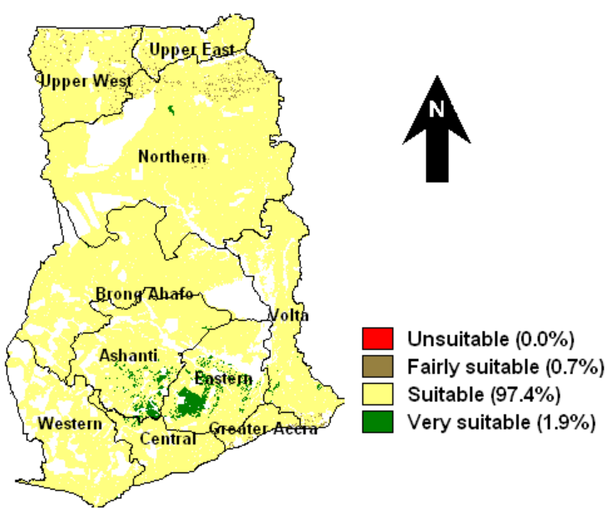



Figure 5.11 Suitability classification for subsistence farming

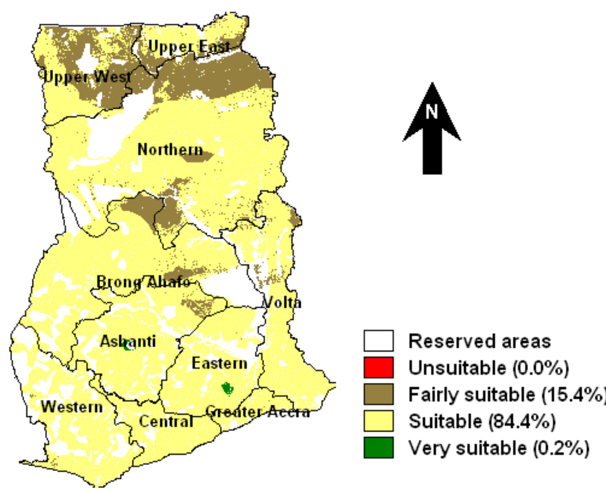



Figure 5.12 Suitability classification for commercial farming

With commercial fish farming, less than 1% (313.8 km$^2$) of the land area was very suitable (Figure 5.12). Eighty-four percent (169295 km$^2$) was suitable with 15.4%

(21352 $km^2$) being fairly suitable. The very suitable areas were again in the Ashanti region and Eastern regions. The Ashanti region currently has the largest number of fish farms in the country. Mean farm size in this region form the fish farm data collected (Chapter 2) was 0.7ha compared to the overall average on 0.36ha. The fairly suitable districts were largely areas in the north - the Northern, Upper East and Upper West regions which, from the fish farmer survey in Chapter 2, had the least number of ponds and had hardly seen any growth in pond culture in recent times. These areas according to Kapetsky (1991) are best suited for culture based fisheries because of the number of artificial water bodies in these areas. Constraints to commercial fish farming in these districts besides water (Figure 5.3) could also be attributed to the relatively poor urban market potential (Figure 5.7) and infrastructure (Figure 5.8). Except for the three northern regions, Upper East, Upper West and Northern region, most parts of the country which had areas that are fairly suitable most parts of the country were suitable for both commercial and non-commercial farming.

### 5.3.8 Verification of integrated models

The outcomes of the verification are presented in Figure 5.13 and Figure 5.14 for non-commercial and commercial farming respectively. The number of non-commercial fish farms in particular areas (from the survey data - Chapter 2) ranked from 1 to 5 farms, 6 to 10 farms, 11 to 20 farms and more than 20 farms are shown using different colour codes (Figure 5.13). Both commercial and non-commercial farms were largely located in the southern and mid sections of the country, in areas classified as either very suitable or suitable.

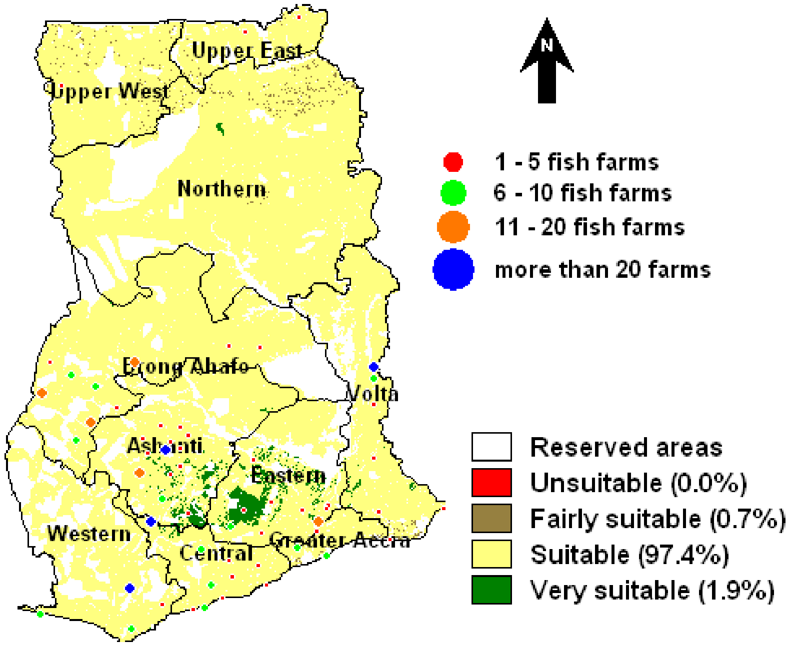



Figure 5.13 Verification of model for non-commercial farming: Concentration of farms in particular areas is depicted by the first set of colour codes. The second set is the suitability classification.

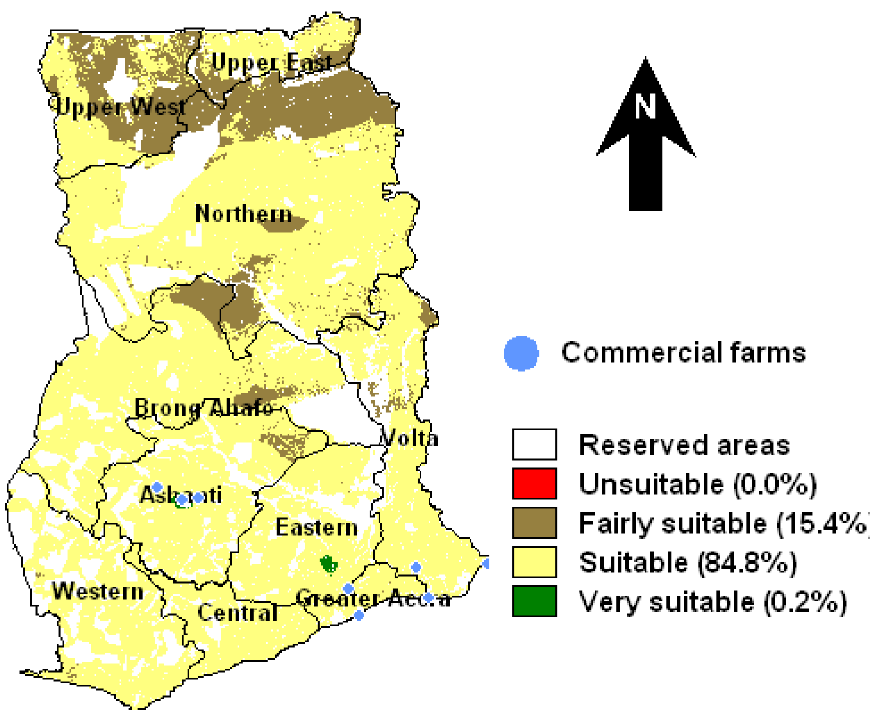



Figure 5.14 Verification of model for commercial farming: The blue spots indicate the location of existing commercial farms

### 5.3.9 Potential for cage culture development

From the model relatively fewer parts of the country were again identified as being very suitable for cage culture (Figure 5.15). These were sites in the Greater Accra, Western, Eastern and Ashanti regions. In the Ashanti region, the very suitable places were areas around the Kumasi Metropolitan area and the Bosomtwe/Atwima/Kwamwoma districts. The closest natural water body to these areas is Lake Bosomtwe. Other potential water bodies within the catchment of this area but not featured in Figure 5.15 are the Barekese and Owabi dams both of which are sources of domestic water supply to the surrounding communities. In the Greater Accra region the most suitable areas were the Accra Metropolitan area and the Tema district. Potential reservoirs within the catchment of these areas are the Weija reservoir with an estimated volume of 116.6 million $m^3$ which also is also a source of water supply to the western part of Accra, the Ashaiman and Dawhenya irrigation reservoirs with estimated volumes of 92.5 million $m^3$ and 5.8 million $m^3$ respectively. About a third of areas in the country were found to be suitable. These were again largely in the southern and middle parts of the country. With the exception of the north parts of the country and areas located north of the Volta Lake, most of the existing reservoirs and water bodies as depicted in Figure 5.15 are located in areas designated as suitable, making them potential sites for cage development.

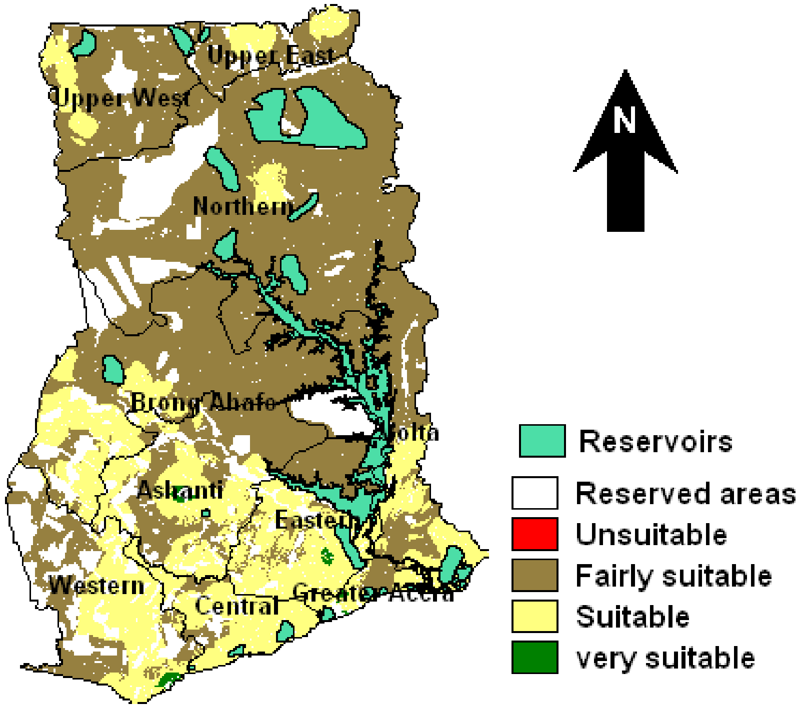



Figure 5.15 Areas with potential for cage culture

## 5.4 Discussion

Results from the study established the areas with potential for tilapia which could also apply to species such *Clarias* species and *Heterotis* which in Ghana are often in a mixed culture with tilapia (Chapter 2, Section 2.3.3).

Environmental conditions were generally ideal for tilapia production; the quality of water across the country based on mean dissolved oxygen concentrations, pH and temperature were very suitable which is very important as areas considered most suitable for tilapia culture are those with water of good quality i.e. well oxygenated, of favourable temperature, salinity and pH (Hossain et al. 2007). Water availability compared to water quality could be described as limiting as less than 2% of the total land areas could be classified very suitable. Over 80% of the country was however classified suitable. The main difference between areas classified as very suitable and those classified as suitable are that the former are at no risk of water shortage having sufficient water from rainfall, good access to river and potentially groundwater while the suitable areas were sufficient in only one of the sources. Areas identified as very suitable for subsistence and commercial farming were estimated at 3,696 $km^2$ and 313 $km^2$ respectively.

All things being equal, converting, for example, 10% of the area considered very suitable for non-commercial farming (369 $km^2$) to fish production based on a farm type 2 production model (chapter 2) with its estimated annual production of 0.44kg/$m^2$ (4,400 kg/ha), would produce 162,624 mt/year. Converting 10% of the area defined as very suitable for commercial fish production (31.4 $km^2$) based on the production level of commercial farm C of 4.5 kg/$m^2$ (chapter 2) would amount to an annual output of 141,300 mt/yr - production levels which to an extent will partly bridge the fish production deficit. The latter however may be more feasible as it will require the establishment of fewer farms. The former, based on the current average pond size of 200 $m^2$ will require the establishment of thousands of ponds unless the average pond size is increased substantially.

Results from this study to an extent differed from those of the previous studies. Kapetsky (1994) as mentioned above identified about 70% of the country's land area as being very suitable to suitable for subsistence level fish production with two crops/yr. Of this, 43% was considered to have optimum conditions for both crops with 57% having optimum conditions for one and suitable conditions for the second crop. Less than 10% of land area was identified to have two crops with fair growth. Results from Aguilar-Manjarrez and Nath (1998) identified 52% of the country to be very suitable for subsistence farming, 28% to be suitable and 30% to be fairly suitable. With commercial farming, 70% and 30% was classified as very suitable and suitable respectively which is quite contrary to outcome of current study where only 0.2% of the country's land area was identified as very suitable for commercial production and 84.4% as suitable for commercial production while about 97% was identified as suitable for non-commercial farming and 3% very suitable. In all the studies however there were no unsuitable sites.

Differences in the outcomes could be attributed to differences in resolutions of data employed with the current study employing the best resolutions so far ranging from 1:1,000,000 to 1:250,000. Another reason could also be difference in thresholds placed on each criterion. These according to Kapetsky (1994) strongly affects the result because the thresholds define the optimum, suitable and marginal areas.

While the GIS approach developed here has been useful in outlining national potential, it is subject to a number of conditions related to data quality and relevance, relative importance of key factors, and the weightings which might apply in balancing mixes of sub-optimal factors. Typically, very few locations are fully optimal in all factors, and choices need to be made to define which positive factors are needed to overcome other negative factors.

Thus another limiting factor was the urban market, which applied primarily to commercial farm development. This additional criterion may partly account for the difference observed in sizes of lands classified as very suitable for subsistence and commercial farming. Relatively larger parts of the country were however found to suitable; 94% for subsistence and 78% for commercial farming. There were generally no unsuitable sites.

Data for the study were largely from the G-CAG database and other secondary data sources. The reliability of these finding are therefore subject to the accuracy of the information used, and more detailed and recent local information may be needed.

The estimates of area with potential for fish farming development are also influenced by many factors. Among them are the use of surrogate factors, the selection of thresholds that describe various classes of suitability, and the use of nominal area estimate. The results were affected by the selection of thresholds for each of the factors and for the commercial and small-scale models, and its equivalent in the fish yield model. Another highly important yet often disregarded factor is the practical availability of land, linked with alternative use values and/or the legal, social or administrative constraints associated with land acquisition and/or usage.

The substitution of district capitals for urban centres omits several other potentially large urban markets. Urban market classification was also based on the assumption that fish consumption and purchasing power of the areas classified suitable are the same in all locations, which was not necessarily the case based on the market survey results reported in Chapter 4. Among the findings from that study was the fact that although tilapia is widely accepted and consumed by about 90% of households, the levels of consumption varied slightly across the regions with the Greater Accra having the biggest market while the Ashanti region which had a higher population had relatively fewer consumers. which were similar to findings of Heinbuch (1994) who also found fish consumption patterns in Ghana varied from one ecological zone to the other.

The identification of areas suitable for cage culture was primarily based on market potential, infrastructure, availability of inputs and technical support, reason being that the required data for a true classification study was not immediately available. A full assessment, as indicated in the methodology, will require information on the physico-chemical properties of the water as well as issues relating to siting which is strongly recommended for any future studies in this direction. Fish yield predictions in such environments for instance have been related to mean depth, surface area, electrical conductivity, chlorophyll-a, phosphorous concentration, primary productivity, the ratio of surface area to catchment area and the ratio of the catchment areas to the reservoir capacity (De Silva et al. 2001). Any future study regarding cage culture potential in Ghana for any water body will have to take these into consideration, and as with land-based production would have to consider the issues of accessibility permitting development in the water bodies concerned, and defining the acceptable levels.

# Chapter 6 - Conclusions

## 6.1 Introduction

The purpose of the study has been to provide an in-depth understanding of the mode, trends and operations of aquaculture development in Ghana with the aim of identifying the strengths and constraints of the sector, and which policy strategies are necessarily to ensure successful implementation of the rapid expansion envisaged. This rests against the backdrop of the Ghana government's current agenda of addressing an estimated 400,000mt shortfall in domestic fish supply through increased production via aquaculture with a target of achieving 50% (200,000mt) growth production in 5 years, while in fact the aquaculture sector has seen poor growth since its inception in the 1950s with the 2006 output of 1150mt (FAO data; www.fao.org/fi/statist/FISOFT/FISHPLUS.asp) estimated to be less than 1% of domestic fish supply.

This study has been carried out by looking at four key areas likely to be paramount to the implementation of any successful aquaculture business with particular reference to conditions in Ghana. The first stage was a thorough overview of the sector as it exists now, describing how it had evolved over the years, its current scale of activities, recent trends and directions and an understanding of the broad environment for the sector, and the obstacles and opportunities for its development. The second key area was a financial viability assessment of the sector based on the modes and levels of operation of existing farms, with the goal of identifying the most profitable locations, business types and technologies applied, of defining whether potential returns would support prospects for future investment, and of establishing the potential supply response to demand and price. A potential strongpoint of aquaculture is that production can be market oriented as opposed to basing markets on the variabilities of production, as in capture fisheries (Pillay and Kutty, 2005). The third aspect of the study therefore undertook an assessment of the market and trade for cultured fish with a focus on *Oreochromis niloticus*, the most cultured species in Ghana, and the likely target for primary expansion of aquaculture. This had the goal of identifying consumer preferences and attitudes to the fish, and from this, setting out the likely implications for expanding aquaculture production, possible price targets and hence (also via the production cost study) the potential returns available to producers. The possibility of then achieving the required national production would naturally depend on a range of factors including the cost, availability and quality of natural resources, environmental conditions, infrastructure and market access, and human resources. These factors are not uniformly distributed geographically and will therefore define areas of higher and lower potential based on the composite attributes of specific locations. Thus the need for the fourth and final area of the research which used a GIS approach to update and reassess the potential for aquaculture development in Ghana.

The aim of this final chapter is to review the key findings from each of the previous chapters, to assemble these together more comprehensively to define the practical potential and constraints for aquaculture at a strategic national level, and to develop conclusions and recommendations for sector development and policy support. Finally, a note is made of further research needs relevant to the work of this study.

## 6.2 Summary of key findings

### 6.2.1 Overview of fish farming in Ghana

Results from the survey showed a steady rise in the numbers of fish farms being established, right across the country except in the three northern regions; the Northern, Upper East and Upper West regions which have been considered to be more suitable for culture-based fisheries because of the number of artificial water bodies but very low annual rainfalls (Kapetsky et al. 1991). The regions with the highest growths in fish farms being established since the year 2000 were the Ashanti and Volta regions with mean annual growth rates of 26% and 24% respectively. Annual growth rates in the other regions ranged from 8% to 16% within the same period with a national average growth rate of growth rate of 16%. The main production systems were ponds (98%), pens (1%) and cages (<1%) with the pens and cages being more of recent developments, introduced after the 1995. The primary species cultured by about 90% of all the farmers was tilapia (*Oreochromis niloticus*), with 54% producing it in a mixed culture with Catfish (*Clarias gariepinus*, and *Heterobranchus spp.*), about 14% in a mixed culture with snakehead (*Channa striata*), grey mullet, *Heterotis* and a variety of other endemic species. Using a fish farm classification system by Ridler and Hishamunda (2001) based on objectives, mode and operations of farms, close to 97% of farms were classified non-commercial and less than 4% as commercial. All the commercial farms were established since around 1998. A comparison of farm sizes (comprising both commercial and non-commercial farms) established before 2000 and those established after 2000 showed no distinct variations, with mean and median sizes of earlier established farms being 0.35ha and 0.08ha respectively while the mean and median of farms established after 2000 were 0.37ha and 0.06ha respectively, indicating that although more fish farms were being established yearly, they are largely very small farms and whose total production may not be significant.

Farms were primarily owned by men at the non-commercial level while women featured more prominently in the commercial sector with about 40% of ownership. The trend as observed was attributed to the sectoral nature of the fish industry in Ghana where men are involved in the production/harvest sector while women handle the processing and marketing aspect (Akrofi, 2002). Increased involvement of women in production at the commercial level has however also been observed in the marine sector where commercially successful female fish traders are reported to be important creditors and financiers of canoes and equipment, and are increasingly owners and managers of fishing companies themselves (Overå, 1995).

The educational background of majority of the farmers (44.2%) was basic to middle school level. 13.2% had some form of vocational training and the rest (34.4%) had at least a secondary school level education. Those with no formal education were the least at 8.1%. This was considered important for the sector as the level of education of fish farmers is generally thought to affect the knowledge level, skill development, exposure to production technology and marketing practices, and adoption level of improved technology (Singh, 2003). This would suggest that there is at least the basis of education for many farmers, potentially facilitating access to information and skill development.

Equipment levels were in most cases very rudimentary, mainly basic farm tools until the advent of commercial fish farms towards the end of the 1990s introduced feed mills and aerators – though these were owned by less than 1% of the farmers.

General labour activities in the non-commercial sector were undertaken by farm owners and their families except in the areas of pond construction, and major pond maintenance where about 60% of the farmers depended on hired labour. Pond construction was largely done manually.

Funds for establishing non-commercial farms were primarily from the owners or their relations. Only a third of commercial farmers partly used bank loans to fund their projects.

Seed supplies were mainly from in pond production and wild sources. Feeds applied by non-commercial producers were largely cereal bran and agricultural by-products, with only a few (less than 2%) applying compound feeds. All the commercial producers on the other hand applied formulated feeds which they either produced themselves or obtained from the market. The average growing period for tilapia by non-commercial farmers was about 8½ months and 7 months for commercial farmers.

Based on the sizes of farms, types and levels of inputs applied by non-commercial farmers and using factor analysis followed by a cluster analysis, five farm types (labelled farm type 1, farm type 2, farm type 3, farm type 4 and farm type 5) were identified which gave a more specific and differentiated account of current culture practices, farm characteristics and outcomes of these practices, a summary of which is presented in Table 6.1.

Table 6.1 Summarized characteristics of the five farm groups

| Farm type | % of total no. of farms (n=312) | Mean farm size (ha) | Stocking density (fingerlings/$m^2$) | Feed quantity (kg/ha/yr) | Output (kg/ha/yr) |
|---|---|---|---|---|---|
| 1 | 24 | 0.11 | 4.6 | 8973.3 | 2248.0 |
| 2 | 47 | 0.02 | 4.7 | 14443.6 | 4423.0 |
| 3 | 17 | 0.66 | 0.8 | 5864.7 | 1436.0 |
| 4 | 4 | 0.47 | 3.2 | 8419.0 | 1787.0 |
| 5 | 8 | 0.25 | 2.6 | 9607.0 | 1518.0 |

Mean size of ponds in farm type 1 was 0.11ha with a median of 0.10ha, an indication of a normal spread of size ranges. Average stocking density for tilapia by these farms was 4.6/$m^2$. Mean quantities of feed applied per annum was 8,973.3 kg/ha/annum with fish yield per hectare per annum of 2,284 kg. Mean productivity of feed/kg tilapia was 0.25.

Farm type 2 had the largest number of farms with 47% of farmers falling within this category. Average pond size however the smallest at 0.03 ha (median = 0.02ha). Fish production by farms in this group was relatively intense with the highest mean stocking density of 4.7/$m^2$. Mean quantity of feed applied was 14,443.6kg/ha/yr higher than those of the other farms; feed productivity per kilogram tilapia was 0.31kg. Fish yield was the highest at 4,423kg/ha/annum. Farms grouped under type 3 were relatively larger and comprised 17% of existing farms. Mean farm size was 0.66ha (median of 0.56ha). Stocking density for tilapia and mean quantity of feed applied were lowest of all the groups at 0.81/$m^2$ and 5,864.7kg/ha/yr respectively. Mean fish yield was 1,436kg/ha/annum which was also the lowest of the five groups. 76.6% of farmer applied cereal bran, 2.1% applied cereal bran/fish meal, 2.1% applied compound feeds and 19.1% applied other feeds.

Farm type 4 had the fewest (4%) farms with mean pond size of 0.47ha (median 0.16ha) indicating a wide range in pond sizes but skewed towards the smaller sizes, the second largest after type 3. Mean tilapia stocking density was 3.2/$m^2$. Mean quantities of feed applied were 8,419.7kg/ha/annum with mean productivity of 0.21 kg of food per kg of fish. Yield was 1,787kg /ha/annum less than half that of farm type 2. Type 5 farms, were made up of small to medium sized units, accounting for 8% of farms. Mean pond size was 0.25 ha (median 0.18ha). Stocking density for tilapia was 2.6/$m^2$. Mean quantity of feed applied was 9,607kg/ha/annum with mean productivity of 0.16. Mean output was 1,518kg/ha/annum.

From these ranges, farm type 2 was thought to be the most promising with mean output per annum being at least twice that of the farm types.

The current sector's main strength as identified from the study was the growing interest in aquaculture with the continuous entry of new farmers. A worrying fact though is the continuing development of small non-commercial farms whose output would be insignificant, whose information and outreach costs could be high, and whose potential for expansion could be limited.

Many constraints were identified in current production, and these appeared to be mostly input related – seed quality and supply, and feed application. On the technical side, the knowledge base of farmers in fish farming practices was very poor particularly in relation to feed as many for instance indicated not knowing how much feed to apply per biomass. According to Aeschliman (2005) up to 74.7% of fish farmers in Ghana indicated requiring training in feeding (made up of those who specifically mentioned feeding as an area requiring training and those who needed training in all aspects of aquaculture), 41% indicated requiring training in feed preparation, 41.8% in fish disease and treatment, 47.0% in fingerling production and 38.6% in all aspects of aquaculture

(38.6%). There also appeared to be marketing constraints, with a mix of supply irregularities, distribution constraints and at least among traditional market agents, a less positive view about the value, quality or attractiveness of aquaculture product.

The seed problem lies in the fact that many stocks, particularly those of tilapia were characterised by high incidence of inbreeding and low survival rates. This appeared to be irrespective of source i.e. inbred in ponds, wild sources, or supplied by government institutions/hatcheries. Delivery of "poor quality" seed by government institutions/ hatcheries was quite unexpected but could not be entirely attributed to production of poor quality seed as there is generally no guarantee that quality seed from research centres will reach producers as required because of issues with delivery (Little, 2004).

Strategies proposed for improving the quality of seed to farmers included the introduction or upgrading of improved strains and species, the application of genetic manipulation techniques such as Genetically Male Tilapia (GMT) and for species such as tilapia which have distinct sex-related growth differentials, the use of hormonal sex reversal (Little, 2004). This last is already being done by national institutions such as the Aquaculture Research and Development Centre of the Water Research Institute and some private hatcheries. One of the main problems however is the adequacy of supplies as some farmers reported having to wait for months to obtain seed. In subsistence farming where such measures may not be possible because of costs involved or the prices of purchasing higher quality stock, excess tilapia spawning in ponds can be controlled via polyculture with a predator species at the appropriate predator/prey ratio. In Asia the demand for all-male tilapia has mainly been associated with the needs of urban and export markets, rather than the demand by rural people (Little and Edwards, 2004).

Very strong correlations were found between quantities of feed applied and output. The quality of feed presumed from the price/kg also correlated with output but less strongly. Issues with feeding in regard to non-commercial producers were therefore attributed more to knowing how much to apply rather than the quality of feed being used as similar feed types were being applied by most non-commercial farmers.

### 6.2.2 Financial viability of fish farming in Ghana

For non-commercial farmers, analysis of viability was based on the five type categories mentioned, comparing profitabilities in relation to production techniques and inputs applied. Similar analyses was done for commercial farms but for individual farms as only three farms provided sufficient information. Analyses were in three parts; cost benefit/ profitability assessment, a sensitivity analysis to major variables and a production function analysis.

From the cost-benefit analysis, only farm types 1 and 2 were found to make positive net returns, the others made losses. A consistent difference between profitable and non-profitable farms was the annual yield per ha which was higher for profitable farms. In relation to input, production by profitable farms was generally more intensive than those of non-profitable farms in relation to stocking density and feed inputs. Similar observations were made with the commercial farms where the two farms with higher inputs made more profit/kg at GH¢ 1.12/kg (US$ 1.07) of fish produced than the one with much less input at GH¢ 0.74 (US$ 0.70). This suggested that intensive production was more profitable than semi-intensive production. Though implying a higher cost of production per unit area, cost of production per unit weight of fish was lower.

From the sensitivity analysis changes in price/kg or fish yield (i.e. for a given level of inputs) were found to have the largest impact on the net profits for all the farm types where for instance for farm type 1 a 10% rise in either would increase net profit by 246%. The main factors in improving viability therefore lie in increasing revenue either through increasing yield or prices. As options for increasing prices may be more limited (see later) yield increases are a more likely route to improving returns. More specifically, the relationship between input costs and quantities and output value is the key driving factor, and any processes which change these positively will be important. Profitability of commercial farms was also most sensitive to sale prices or yield.

Another finding was the influence of initial capital costs (costs of land, pond construction, and equipment) on the viability of non-commercial farms. Fully costing these, particularly for pond construction, resulted in NPV values of less than 1, IRR values lower than the threshold rate of 13% used in the analysis, and a minimum payback period of 14 years compared to a maximum of 5 years for the commercial farms. These however became much more viable with IRRs of 45% and 65% for farm types 1 and 2 respectively when initial capital costs were reduced to a minimum based on an assumption that pond construction is undertaken by farmers, their families or neighbours whereby “commercial labour rates” are not imposed. The opportunity cost of such labour was here assumed to be negligible. A similar effect could be found with family labour inputs in operating costs.

Break-even analysis was based on the level of production at which revenue just covers production cost. Among the non-commercial farms, farms type 2 was found to pose the least risk with current mean production of 4,423kg/ha being 19% (846 kg/ha) higher than the break even production of 3,577kg/ha (Table 6.2). The levels of risk however seemed to increase with increasing pond size. Farm types 3, 4 and 5 were producing below capacity and needed to increase production by between 35 to 55% to break even. Mean fish production for farm type 1 was just about even at 5% higher than current production of 2,284kg/ha/annum. Fish production by the commercial farms was the most efficient exceeding break-even production levels by between 37 and 60%.

Production function analysis supported the overall findings of the earlier analysis. Given experience elsewhere in the aquaculture sector (Munzir and Heidhues, 2002) gave an indication of increasing return to scale. The results also confirmed that the quantity of feed applied had a significant effect on the level of production and net profit levels. From the model presented in Table 6.2, a 10% increase in quantity of feed applied by farm type 1 for instance can be expected to increase net profit by 178% whiles a 30% increase will increase it by 534%. Similar trends were observed for the other farms but with relatively smaller margins of increase. From these results, one way of enhancing profitability and financial viability of the non-commercial farms was identified as the need to direct farmers' efforts at semi-intensive to intensive production rather than extensive production. From the general analysis practices that were common to non-profitable farms were low stocking rates, low levels of inputs, and higher fixed costs/variable costs ratios.

Table 6.2 Changes in output, total cost of production (COP) per ha and per kg with increasing quantities of feed applied per ha. In brackets are the percentage changes.

| Farm type | 10% increase in quantity of feed applied | | | | 20% increase in quantity of feed applied | | | | 30% increase in quantity of feed applied | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COP (GH¢/ha) | COP (GH¢/kg) | Output (Kg) | Net profit | COP (GH¢/ha) | COP (GH¢/ha) | Output | Net profit | COP (GH¢/ha) | COP (GH¢/kg) | Output | Net profit |
| 1 | 3840.9 (3.1) | 1.5 (-6.4)* | 2,517.0 (10.2) | 438.7 (178.0) | 3956.8 (6.2) | 1.4 (-11.8) | 2756.8 20.4 | 719.6 (356.0) | 4,072.7 (9.3) | 1.4 (-16.3) | 2984.7 (30.7) | 1001 (534.6) |
| 2 | 4815.2 (3.6) | 1.0 (-6.0) | 4875.0 (10.2) | 1,527.1 (28.4) | 4980.4 (7.1) | 0.93 (-11.1) | 5327.1 (20.4) | 1944.7 (76.8) | 5,145.6 (10.7) | 0.9 (-15.3) | 5780.0 (30.7) | 2368.4 (115.3) |
| 3 | 2946.7 (1.2) | 1.9 (-8.2) | 1582.8 (10.2) | -572.6 (-24.5) | 2981.4 (2.4) | 1.72 (15.0) | 1729.5 (20.4) | -387.1 (-48.9) | 3,016.1 (3.6) | 1.6 (-20.7) | 1876.6 (30.7) | -201.3 (-73.4) |
| 4 | 4194.7 (0.9) | 2.1 (-8.4) | 1969.6 (10.2) | -1,240.3 (-15.9) | 4233.4 (1.9) | 2.0 (-15.4) | 2151.3 (20.4) | -1005.0 (-31.9) | 4,272.1 (2.8) | 1.8 (-21.3) | 2335.3 (30.7) | -769.2 (-47.8) |
| 5 | 3540.5 (1.4) | 2.1 (8.0) | 1673.1 (10.2) | 361.5 (-40.5) | 3589.0 (2.8) | 2.0 (-14.7) | 1828.3 (20.4) | -115.3 (-81.0) | 3,637.5 (4.2) | 1.8 (-20.3) | 1983.7 (30.7) | 131.6 (-121.6) |

* negative (-) imply a reduction by the number in brackets

### 6.2.3 The size and nature of trade of the domestic market for Oreochromis niloticus

This aspect of the study focused on the fish market in Ghana, collecting data from four regions of the country and with particular reference to tilapia; assessing the nature of markets and marketing networks, consumer preferences and attitudes to the fish, and from these outlined implications for expanding aquaculture production.

Various market levels for tilapia (wholesale, intermediate wholesale and retail) were observed at the numerous fish sale outlets – including fish landing sites, fish markets, regular markets, pond sides and frozen foods stores. Infrastructure at all these outlets except for the frozen food stores and pond side (applicable only to commercial farms) were found to be poor with limited washing and cleaning facilities and no cold storage or freezing facilities which resulted in unhygienic handling of fish during and after harvest.

A key finding of this study was the level of acceptance of tilapia, whereby 89.3% of households in the study area indicated they liked the fish. This was across ethnic, income, family size and professional groups. Of these interviewed, 47.7% considered themselves regular consumers and the rest occasional consumers, the latter, citing price and unavailability as the main reasons for limiting consumption. The most preferred fish sizes by both food service outlets and domestic households were those weighing at least 200g.

The total quantities of tilapia traded per month by all the dealers interviewed was 62mt of which 57.8% was from capture and 42.2% from culture. Due to sampling limitations this could not however be extrapolated to provide patterns of national quantities, though some characteristics could be explored. The cultured fish was primarily dealt in by traders in the Greater Accra Region and most of which was from a single commercial farm. Based on national market levels, total tilapia demand per month for the country could be estimated at around 5,917mt. Production from capture was estimated at 2,100mt resulting in a supply deficit of 3,817mt, which would amongst other reasons account for the relatively high price of the fish. Of the four regions, the Greater Accra Region had a relatively larger market potential for tilapia 37% of the fish traded.

Cultured fish accounted for between 0 and 13% of total fish traded per month in other regions. Main issues identified as constraints to trading in cultured fish were perceptions held by some dealers in relation to tissue texture being softer than those from capture which resulted in it ripping when processed, to it deteriorating faster compared to those from capture, and to flavour issues. Reasons cited by traders who preferred culture fish were the better consistency in supply, the availability of required fish sizes and lower prices per kilogram.

A profile of the food service outlets also suggested an increasing number of operators entering the business. More than 65% of operators interviewed started their businesses within the last ten years. However, total monthly quantity of tilapia purchased by the operators interviewed was relatively modest, at about 16mt. Market size for the food service operators was assumed to be much larger in the Greater Accra region than the other regions based on the mean monthly quantities of fish purchased per operator which in Greater Accra region was 412kg compared to 73kg, 20kg, and 25kg for the Eastern, Ashanti and Volta regions respectively. The main sources of fish by these operators were wild-capture tilapia from landing sites supplied by intermediate wholesalers or roaming vendors. More than half of operators (57.1%) indicated getting sufficient supplies whiles 42.9% indicated only getting it sometimes and these were largely those who obtained supplies directly from the landing sites. Less than 10% indicated obtaining supplies from fish farms. Contrary to the dealers, most of the operators interviewed appeared to know very little about farmed tilapia.

A notable finding is also the apparent growing number of intermediaries in the sector. The average growth rate over five year periods since 1981 is 61.9% - a probable indication of a growing demand and possible increasing size of trade for the fish and a wider distribution around the country.

The main positive factor identified to support enhanced aquaculture production in Ghana was the acceptance of tilapia by the wider population and the huge supply deficit. It also appeared that at least for the present, dealers in farmed fish were making more profit than dealers in wild-captured tilapia with gross profit margins at GH¢ 0.49/kg and GH¢ 0.25/kg respectively. All the traders interviewed sold their fish within the country, there is however an established export trade involving the export of smoked tilapia and other fresh and marine water species to ethnic markets which could be exploited.

Preference for tilapia were influenced by availability, taste, quality and flavour perceptions as well as nutrition and health concerns but invariant to income, household size and educational levels of consumers. As discussed later, these will also have effects on potential farm-gate price levels which might be supportable to meet markets

An important constraint identified from this study which may affect the aquaculture as a whole is the import of cultured tilapia from Thailand. Officially the Ministry of Fisheries does not permit these but it is known to occur, though the quantities involved are difficult to define. This may have to be controlled if market opportunities for local production are to be supported, though not to the extent where local prices are kept above international open market rates.

### 6.2.4 GIS approach to assessing aquaculture potential in Ghana

This final aspect of the study used a GIS approach to update and reassess the potential for aquaculture development in Ghana in the light of the expected expansion in the sector, incorporating recommendations from previous studies with a focus on fresh water aquaculture. It incorporated primary definers of water, climate, soils and feed/fertiliser sources, together with more specific issues such as market access and other social and economic factors.

The study found that excluding areas designated as forest or games reserves, less than 1% (313.8 $km^2$) of the land area was found to be very suitable for commercial fish farming. 84.4% (161,943 $km^2$) was however suitable with 15.4% (29,596 $km^2$) being fairly suitable. With non-commercial production, about 2% (3,692 $km^2$) of the land areas was identified as very suitable, 97.4% was suitable with less than 1% being fairly suitable. The very suitable areas for both levels of production were all in the in the Ashanti and Eastern regions. The precise districts were identified as Kwaebibirem, Adansi East, Asante-Akim South, East Akim, Amansie East, Manya Krobo, Sekyere East, Fanteakwa, Bosomtwe-Atwima-Kwanwoma, and Akwapim North.  These were districts where a number of the relevant variables such as water availability, soil quality, market potential etc. overlapped as either suitable or very suitable level.

Verification of the integrated models based on the location of farms visited during the survey, using the assumption that these would all be located in areas best for aquaculture confirmed that the areas identified were indeed likely to be suitable, and conversely there was little development in areas not identified as suitable.

The potential for cage culture was also established where parts of the mid-section and the southern sections of the country were identified as suitable to very suitable for cage culture in reservoirs located in these areas. These were largely areas with good infrastructure, large market potential and potentially good supply of inputs. The volume of reservoirs in these areas exceed

Results from this study varied from previous studies in that relatively fewer areas (0.2%) were identified as very suitable for commercial farming compared to 70% by Aguilar-Manjarrez and Nath (1998) while Kapetsky (1994) identified 47% as being areas with optimum conditions for two crops per year and 53% having optimum conditions for one crop and fair conditions for the other crop. Differences in outcome were attributed to differences in resolution of the data used which was better in this study.

## 6.3 The potential for aquaculture in Ghana

This section attempts to specify in more detail what would be the practical ways in which aquaculture could develop in Ghana, how realistic could be the expectations of growth, and what could be the likely directions for national fishery supply. Clearly, market prices would have to be adequate to provide profitability for producers, and sufficient to stimulate investment, while not so high that aquaculture product is unaffordable for Ghana's consumers. Much of this scenario setting will depend on Ghana's economic growth expectations, population growth, changes in GDP per capita and the distribution of that income. Broadly speaking, economic growth exceeding population growth rate will increase per capita income, and equitable income distribution will increase purchasing power across wide parts of the population. In these circumstances, demand and prices for fish will increase in real terms and the prospects for aquaculture can improve. More static or falling GDP per capita, or negative trends in income distribution will limit prospects for aquaculture, or will only permit it to develop if real costs of production can be strongly contained or reduced.

### 6.3.1 Comparative growth rates and output targeting

Current growth in aquaculture development in Ghana as seen from above, is largely at the non-commercial sector. Annual fish production from the sector in 2006 was estimated at 423.9mt/annum while that of the commercial sector was estimated at 660.2mt/annum. Production projections based on 25%, 50% and 60% annual increases of the 2006 production figures are summarised in Table 6.3 (Details on how the projection figures were arrived at are presented in Appendix 3). A 25% increase in annual production from the non-commercial sector will amount to 4,440mt by 2020 Table 6.3) while a similar increase in the commercial sector will result in an annual output of 15,810mt by the same year. However, both of these are insufficient to make up the current shortfall in domestic fish supply.

Achieving a minimum target of 400,000mt/annum by 2020 may require increasing current production from all sectors (commercial and non-commercial) by about 60% annually (Table 6.3) which for the commercial sector may involve the number of fish farms increasing by about 39% each year, average farm size increasing by 18% to achieve 6.3ha average farm size, with annual output increasing by 5% to reach 91.1mt/ha for intensive medium scale commercial farming based on production model of commercial farm C, with the semi-intensive commercial (farm B) achieving outputs of 19.8mt and 8.9mt for the small scale commercial farm by 2020. This would imply establishment of 2,613 small commercial farms and 1010 each of the medium to large scale commercial farms. For the non-commercial sector, attaining a 60% annual increase could involve increasing current output by 10% annually to achieve an average of 5.6mt up from the current 2.4mt/ha by 2020 and farm size increasing by 18% annually to attain an overall average pond size of 1 ha and number of fish farms growing by 24% annually this will however imply the establishment of over 16800 non-commercial farms.

Growth in aquaculture production in Ghana from 1996 to 2006 based on data available at the FAO website (www.fao.org/fi/statist/FISOFT/FISHPLUS.asp) has been very erratic (Table 6.4) varying from an increase of 350% from 1997 to 1998 to a reduction in output of 84.4% in 2003. If this is to be accepted, production had reduced significantly in 2003 and since 2004 had been growing at an average rate of 7.5% but with a median of 1.3% which shows that the year-on-year growth rates are still very inconsistent. This falls far below the estimated growth rates of 60% needed to meet projected shortfall in domestic fish production of 400,000mt by the year 2020.

Besides commercial land-based production, a potentially viable option to achieving these targets may lie in cage aquaculture development which requires relatively low capital investment compared to ponds. The use of existing water resources and developing the number of ponds mentioned above could also lead to conflict as aquaculture must compete with general agriculture and other land use activities for basic inputs.

Table 6.3 Projected fish production by sector

| Year | Non-commercial production (‘000 mt) | | | Commercial production (‘000mt) | | | Total production (‘000mt) | | |
|---|---|---|---|---|---|---|---|---|---|
| Growth rate | 25% | 50% | 60% | 25% | 50% | 60% | 25% | 50% | 60% |
| 2006 | 0.19 | 0.19 | 0.19 | 0.66 | 0.66 | 0.66 | 0.85 | 0.85 | 0.85 |
| 2010 | 0.46 | 0.97 | 1.26 | 1.64 | 3.36 | 4.39 | 2.10 | 4.31 | 5.57 |
| 2015 | 1.43 | 7.50 | 13.67 | 5.09 | 25.64 | 46.82 | 6.52 | 32.67 | 58.38 |
| 2020 | 4.44 | 58.04 | 147.63 | 15.81 | 195.61 | 499.35 | 20.26 | 253.65 | 646.98 |

Table 6.4 Annual aquaculture production in Ghana (1996 – 2006)

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Prod (mt) | 550 | 400 | 1,800 | 2,900 | 5,000 | 6,000 | 6,000 | 938 | 950 | 1,154 | 1,150 |
| % change | | -27.3 | 350.0 | 61.1 | 72.4 | 20.0 | 0.0 | -84.4 | 1.3 | 21.5 | -0.3 |

Source: FAO Fishstat plus database

### 6.3.2 Locations and types of production

Rate of aquaculture development across the country is not even and is developing faster in regions which from the GIS study are areas with natural, economic and social potential. These for both commercial and non-commercial fish farming were areas in the southern and middle sectors of the country particularly in the Eastern and Ashanti regions where very suitable spots were identified.

Development of 10% of areas classified very suitable into fish farms in say five years based on the production model of the intensive commercial farm (farm C) with annual output of about 46mt per hectare would amount to 141,300mt while development of a similar proportion of land classified as very suitable for non-commercial farming using the farm type 2 production model with annual output of 4.4mt/ha/annum will yield an annual output of 13,516mt in the same period. The commercial option based on the results of the financial analysis (chapter 3) is more viable and also is a more effective use of land as the non-commercial option based on its average pond size of 0.03 ha will require the construction of over 153,000 ponds while the intensive commercial option will only require the establishment of 1,535 farms based on an average farm size of 2.0 ha.

Potential for cage culture development also exists and like the land-based aquaculture potential area, these are largely in the southern part of the country from the Ashanti region and southern western parts of the Brong-Ahafo region down to the coastal areas where market conditions, infrastructure, support and inputs are most favourable. Cage culture is one of the most rapidly growing sectors in aquaculture more widely and has received considerable attention as a means of intensive farming. It is however an emerging sector in Ghana and may need to be encouraged, while at the same time ensuring that environmental capacity issues were understood and applied.

Advantages of cage culture over pond culture as outlined earlier include the use of existing water bodies, comparatively low capital outlay, use of simple technology, high stocking density, optimum feed utilization, improved growth and ease of management (Beveridge, 1984; McGinty and Rakocy, 2003). Depending on depth, high yields of 100

– 2000 mt/ha/yr are attainable (Muir, 2005). However, there are several disadvantages, including risk of theft, low tolerance of fish to poor water quality, risk of loss due to cage damage caused by predators or storm, dependence on nutritionally-complete diets and greater risk of disease outbreak.

Intensive production as being proposed would require large amount of inputs particularly in the form of seed and high quality feed. Recommended stocking rate of tilapia fingerlings vary depending on cage volume, desired harvest size, production level and the length of culture period. Optimum stocking rate for production of 250g tilapia will for instance range from 600 to 800 fish per cubic metre; 300 to 400 to produce fish averaging 500g and 200 to 250 to produce fish averaging 750g (McGinty and Rakocy, 2003). According to Rana and Telfer (2006) a modest 100mt tilapia cage unit may require around half a million fry and 150 to 200 tonnes of pelleted feed. Intensive production in a land based system targeting the same output of 100mt with a stocking density of $5/m^2$ producing an average fish size of 250g will require 400,000 fry. Availability of quality seed as established from this study is however a major problem with current supplies being characterised by high incidence of in pond production and low survival rates. Problems with inbreeding will however not apply in cage culture as the breeding cycle of tilapia is hindered in cages. Any development in this direction should however prioritise these inputs which could be developed through a public-private sector initiative for efficient management and ease of access to finances. Also, although set up capital as indicated may be lower than land based operations, capital and operational costs can be high (Rana and Telfer, 2006) and therefore access to finances may also have to be considered.

The study so far has been based on tilapia production, but type of animal protein intake in Ghana as established from this study and from other studies (Seini et al. 2004) vary across the three ecological zones (coastal (southern sector), forest (mid-sector) and savannah zones (northern sector)). Where feasible, it may be important that species cultured in different parts of the country are based on consumer preferences within the potential market catchment area.

### 6.3.3 Market prices, profits and investment potential

The amount and price of a product, as is commonly known, are determined in the market place by the interactions between demand and supply. Current demand for tilapia in the country is driven by four main factors; the taste, availability, it being a healthy product and for health reasons. The analysis however revealed that current annual potential demand for the fish exceeds supplies by about 41,000mt a situation which seem to be driving up the price of the product. The shortfall in supply is attributed to declining availability of wild capture tilapia whose main source like other freshwater fish in Ghana, is the Volta. Diei-Ouadi and Mensah (2005) estimated the decline in general fish catch from the Lake to be about 0.225kg/boat landing/day. With an estimated 24,035 boats plying the Lake daily, annual decline in fish catch may be estimated at 2237mt of which tilapia being one of the main catches may form a substantial part. Retail prices across the study areas for fresh and smoked tilapia ranged from GH¢ 4.0 to GH¢ 10.0 (US$ 4.20 to US$ 10.40), which amongst the commonly consumed fish by households was only comparable to the smoked form of Red Pandora but much higher than the price of its frozen form which was commonly sold for GH¢ 2.50/kg. Continued buying of tilapia by its regular consumers has been attributed to its availability and taste.

Close to half (47%) of households interviewed however indicated consuming tilapia occasionally primarily because of the relatively higher price per unit. With cultured fish producers and dealers currently accounting for a small proportion of the overall tilapia market, they are more likely to be market price takers rather than price makers which with the current shortfall in supply and the resulting hike in price may work in their favour. Any further increases in prices following reduced availability of capture supplies will concentrate tilapia consumption even more within households and markets which are willing to pay higher prices. But as is common from the launch of major aquaculture species, increased availability of tilapia from this sector may eventually results in reduced prices, to the extent that producers may face unprofitability, reducing the tendency to further investment (Young and Muir, 2000). The question however is; how low a price may producers have to sell their products and still make profit? From the financial viability analysis, break-even prices per kilogram of fish by the two medium scale commercial producers ranged from GH¢ 0.81 to GH¢ 0.88 (US$ 0.84 to US$ 0.92) which were less than half the producer price of GH¢ 2.00 and from the sensitivity analysis the IRR remained above the 13% interest rate applied at 31% and 52% for the semi-intensive and intensive commercial farms respectively with a 30% reduction in their current producer price of GH¢2.00 to GH¢ 1.40. Risks associated with these commercial farms may as a result be described as very low and offer a good potential for investment. None of the fully costed non-commercial farms and the small scale commercial farm could however cope with similar reductions and still operate profitably.

Enhancing profitability of these farms may imply operating more efficient and producing the quality of fish which will attract the right prices.

### 6.3.4 Development of services

To meet the needs of the sector as defined above, measures ensuring better feed and seed supplies, access to resources, better efficiency (which also includes controlling

#### Resource use

The main legislative acts governing the practice of aquaculture in Ghana are: Fisheries Act 625 of 2002 section 60 which requires licensing of aquaculture and recreational fishing projects, the Environmental Protection Agency Act 490 of 1994 (LI1652) which requires the conduct of an environmental impact assessment (EIA) and finally the Water Resources Commission (WRC) Act 522 of 1996 requiring that a permit is obtained for use of the water. The EIA is necessary to identify prior to commencement of any project, potential negative impacts that may arise and how they are going to be dealt with to preserve the environment. Water permits are only granted when EIA reports have been approved by the EPA. It however takes on average six months from submission of application for a permit to be granted (Water Resources Commission; http://www.wrc-gh.org/WRC%20Application%20Form.doc – accessed 30/06/08). These requirements however only apply to commercial projects. Non-commercial farms are allowed to operate without the need for the above process as they are normally on a small scale. Encouraging the use of water resources for cage culture, for subsistence farmers could start on a pilot basis with existing poor performing non-commercial farms with very large ponds exceeding a hectare in size using cages constructed from inexpensive local materials. Once these are successful it may be easier to transfer the technology to communities with own water bodies and other small scale producers. To be successful there will be the need of adequate socio-economic appraisal of the projects and also the need to develop safeguards for sector expansion particularly in community water bodies with domestic uses ensuring that the carrying capacities are not exceeded.

In the 1950s a strategic policy by government to promote aquaculture was to convert 5% of lands around irrigation schemes into pond farms. Less than 20% of the potential 626.4ha was developed (Owusu et al. 2001). Among the reasons for the failure were the high costs involved. Another reason being that the policy was solely implemented by government. A number of the farms established have now being leased to private investors. A similar policy could be enacted where a number of irrigation reservoirs located in areas identified as very suitable or suitable (and where environmental conditions and physico-chemical properties of the water permit) are promoted for private investments in commercial cage culture. Commercial cage culture because of the types of inputs required. A common practice of all medium scale commercial farms in the country is to produce their own seed and feed. Promoting such operations in these areas could also therefore serve as sources of quality fingerlings and potentially, better feeds for other fish farmers around. There is however the need to access current and future demand for raw materials for feed and fertilizer and pursue linkages with agriculture development for establishing supply chains.

### Investment and sector development

Aquaculture as is practiced now is largely financed by the farmers themselves particularly at the non-commercial level. At the commercial level a third of the farmers indicated obtaining loans from commercial banks to partly fund their projects whiles the rest fully self funded their projects. Loans from commercial banks for fish farming is generally said to be hard to come by and this has often been attributed to poor repayment of loans granted prospective fish farmers during the previous major national campaign for aquaculture which resulted in massive failures thus the inability of several loan recipients to repay.

A recent effort directed at making credit more accessible to fish farmers is the proposed granting of soft loans to farmers by the Ministry of Fisheries for construction of ponds and buying of quality fingerlings which they would be expected to pay back after 12 months. Although this may be a laudable idea the pay back period of 12 months may only be possible if the production models are based on that of the intensive commercial farm featured in the study as it was the only farm with a payback period of less than 2 years. Attaining such production level may require the use of quality fast growing fingerlings, appropriate feeds, right feeding regimes and the right water conditions.

Other possible sources of loans to fish farmers identified by Manu (2004) in the Western and Ashanti regions which operate through the District Assemblies are the Poverty Alleviation Programme, the International Fund for Agriculture Development, Social Investment Fund, Poverty Alleviation fund, Rural Finance Services, Japanese funds for Women in Ghana, emergency social relief funds and the rural banks. It is important that all aquaculturists are linked to these programmes where they can relatively easily and cheaply access loans. Safeguarding repayment of loans may include proper appraisal of projects before loan approval and monitoring of loan use.

One area of promoting the sector is the provision of tax incentives which is being done, and is intended to serve as a motivation and means of reducing the tax liability and also lessens the tax burden on new operators. Fish farming is categorised with general livestock farming (except cattle) and cash crop farming (cassava, maize, yam, pineapple, rice yam) which are all given five years tax holiday during which producers are exempted from all taxes. This is however less attractive when compared to cattle rearing and tree planting which are given 10 years exemption.

### Market

Tilapia trade in Ghana as evidenced from this study is well established with a chain of market intermediaries between the producer and the final consumer of which there were two main types the food joint operator who buys, process (cook) and re-sells, and the household consumer. To the former, size, state and lastly the price were priority buying factors and to the later of which there were again two types; the regular consumer for whom taste, availability, and fish being a healthy product were the main reasons for purchase and the non-regular consumer for whom price of the product was the main issue, obviously desiring prices lower than currently prevails. Preferences by retailer dealers were generally defined by those of the consumers but key among the buying factors was the size of the fish, followed by the state (freshness) and finally the price. The wholesalers were more interested in the state of the fish.

Tilapia dealers interacted with during the study were made up those dealing primarily in wild capture tilapia, those dealing in the cultured tilapia and those dealing in both.

Dealers in wild-capture tilapia considered farmed tilapia to be of inferior quality in relation to shelf life, texture, taste and fat content which was high, whiles those who preferred it did because of consistency in preferred fish size, consistency in supply and the price which was lower than those from wild-capture. Those who dealt in both indicated selling cultured fish when the wild-capture was out of season which was between the months of January to about March. The most preferred size by dealers and consumers in the study area was fish of at least 200g, other sizes may though be preferred in other parts of the country.

A market strategy for cultured fish in Ghana would therefore be one which ensures the supply of good sized fish (at least 200g) with consistency of supply; guarantees good culture practices that result in fish of good quality but of reasonable price and the need for appropriate post-harvest handling and preservation of fish to maintain its quality, freshness, and ready to address any health and safety concerns that arise.

Production of good sized tilapia is currently being attained by some of commercial producers, but achieving that at the non-commercial level may require subsistence farmers being introduced to the right production practices and being assisted financially to obtain the right quality of inputs which could also ensure regular production and constant supplies to potential buyers.

Ensuring the health and safety of harvested fish to consumers may require improving equipment available to dealers such as the introduction of the locally made insulated wooden box mentioned in the discussion section in chapter 4 instead of the continued use of baskets and jute sacks which provide very little insulation against the hot humid weather in Ghana. To ensure quality and hygiene standards are followed, it may be necessary to train dealers through their respective associations in appropriate icing, chilling and preservation procedures. However, this will have to be done within realistic perspectives of costs, returns and consumer willingness to pay.

It may also be necessary for farmers to be made aware of off season periods for the wild-capture during which periods harvested fish are likely to sell faster through practical market information mechanisms.

### Support services

Support services was defined earlier (chapter 5) as the accessibility of farmers to aquaculture experts and extension officers for guidance, technical advice and access to quality fingerlings. One of the central reasons for disappointing outcomes of fish farming in Ghana as identified in other studies (Awity, 1996; Prein and Ofori, 1996) has been the failure of government to support its promotion campaign with advice, information and extension to the aspiring producers due to shortage of well trained staff. Three levels of core personnel required for aquaculture as identified by United Nations Development Programme (UNDP) and FAO are senior aquaculturists, technicians, and extension workers (Satia, 1989). Support services as also indicated earlier is available from the Fisheries Department's regional and district offices, research institutions, universities and commercial farmers. In practice however, most non-commercial producers depend largely on the Fisheries extension officers as their services are offered for free though farmers had to pay for the costs of transport, from the regional office to the farm location. Part of the Ministry's policy is to have extension officers at all the regional and district levels but of the four Fisheries regional offices visited, all three levels of the required core personnel were only observed in the Ashanti and Greater

Accra regions but not the Eastern and Volta regions and a number of districts that had no extension officers which according to key informants existed until the detachment of the unit from the Ministry of Food and Agriculture to form the new Ministry of Fisheries in 2005. In district where they existed, the officers complained of lack of resources (finances and equipment) needed for their day to day activities.

Improving support services to farmers may require strengthening Fisheries' regional and district offices by employing more personnel and equipping the units appropriately. Farmers relied largely on extension officers for the supply of fingerlings but again only two of the regional offices visited had hatcheries and those without hatcheries depended on other farmers for the supply of fingerlings which were either inbred or obtained from the wild which cannot be relied on for any form of commercial production.

**Human capital**

Aquaculture as already indicated earlier has a great need for practical scientific knowledge. Improving support services may therefore require regular training of extension officers who deal with farmers regularly to improve their skills in all aspects of fish farming such as site selection, pond construction, seed production, feeding regimes, feed preparation, harvesting, post-harvest handling and preservation who will transfer it appropriately to farmers. The CSIR-WRI being the main aquaculture research institution in the country has a wealth of expertise with PhDs (13), M.Sc (5) and B.Sc (1) degrees in the fields of aquaculture, fish genetics, fish breeding, fish biology, fisheries management, biological sciences and agricultural economics could be very useful in this. This may however require the Ministry of Fisheries providing some financial incentives to CSIR-WRI as it operates under a different sector ministry and as a result of a government policy enacted in the late 1990s, all CSIR institutions are expected to generate 30% of their annual expenditure which this could help in that direction. There have been such collaborations between the two institutions in the past.

Besides the WRI which has offices in Accra, Akosombo and Tamale which can serve various parts in the southern and northern belts of the country, Institutions with departments of agriculture such as listed in chapter 5 which are spread across the country could also be offered incentives and training of key staff in various aspects of aquaculture to assist farmers and extension officers within their localities. This may require a coordinated effort of the Ministry of Fisheries identifying the research needs in particular areas and identifying the appropriate experts and institutions to address them directly to the farmers through the fish farmers associations (where they exist) at their regular monthly meetings or the use of participatory strategies for technology transfer such as workshops and seminars at the community level which may have the advantage of attracting groups such women and the poor who may otherwise not participate in such programmes. There could also be the development of a network of resources in knowledge, based on strategic aims with specific themes, addressing social, technical, economic, environmental, production and policy aspects of aquaculture.

Other forms of expert and farmer training organised by the Ministry of Fisheries in recent times have been the sponsoring of selected farmers and staff to commercial farms locally and abroad to understudy their operations, the latter of which may not be sustainable because of the costs involved.

## 6.4 Summary of policy strategies

Based on information provided through the studies, policy strategies need to be put in place to ensure successful implementation of the campaign this time have been identified as resource access, investment and sector development, market strategies, support services and human capital

### 6.4.1 Resource access

Encouraging the use of water resources for cage culture for subsistence farmers should start on a pilot basis with existing poor performing non-commercial farms with very large ponds exceeding a hectare in size. Cages should be constructed from inexpensive local materials. Once these are successful it may be easier to transfer the technology to communities with own water bodies and other small scale producers.

On the commercial level, proposed policies may include:

- Enactment of a policy promoting the use of irrigation reservoirs for commercial cage culture in areas identified as very suitable or suitable
- Where possible shortening of the current six months average period required for the approval of water use permit, after submission of an approved EIA which can serve as a disincentive to potential.

### 6.4.2 Investment and sector development

Aquaculture as is being practiced now is largely financed by the farmers themselves particularly at the non-commercial level. To improve investment and development in the sector, the following policies are being proposed:

- An amendment to the proposed government policy of providing fish farmers with a loan to back pay in 12 months is the need to increase the period to 24 months but with the enforcement of proper appraisal of projects before loans are approved and also the need for monitoring of loan use.
- Lastly, there may be the need to increase the existing 5 year tax holiday to 10 years to match up that for cattle farming which may sound more attractive to potential investors.

### 6.4.3 Market strategies

Market strategy for aquaculture development in Ghana may be summarised as follows;

- The need for production of good sized fish which is of good quality and affordable price and ensuring consistency of supply.
- Fish farmers need to be aware of best times to harvest as harvesting during the peak season for wild capture tilapia for instance is likely to impact negatively on product prices.
- Improved post harvest handling and preservation of fish to ensure the supply of healthy and quality fish to customers.
- Finally there may also be the need to look at opportunities for expanding export

market for high valued fish and fish products.

### 6.4.4 Support services

In the areas of support, there is the need to

- Strengthen the Fisheries' regional and district offices ensuring that every district has at least one extension officer and each unit equipped appropriately to be in a position to assist the farmers.
- In collaboration with the Water Research Institute and other educational institutions involved in aquaculture, regular training opportunities should be offered the extension officers.

### 6.4.5 Human capital

Aquaculture has a great need for practical scientific knowledge. The CSIR-WRI being the main aquaculture research institution in the country has a wealth of expertise as well as the educational institutions. Improving human capital could be achieved through:

- A collaborative effort should be established between the Fisheries Department and the research and educational institutions, coordinated and supported financially by the Ministry of Fisheries where the expertise and experiences of researchers and made available to the wider fish farming community. There have been some forms of such collaborations between FD and WRI in the past.
- The development of a network of resources in knowledge, based on strategic aims with specific themes, addressing social, technical, economic, environmental, production and policy aspects of aquaculture.

- There should also be the use of participatory strategies for technology transfer such as workshops and seminars at the fish farmers' association's monthly meetings or meeting community level which may have the advantage of attracting groups such women and the poor who may otherwise not participate in such programmes.
- Other forms of expert and farmer training organised by the Ministry of Fisheries in recent times have been the sponsoring of selected farmers and staff to commercial farms locally and abroad to understudy their operations, the latter of which may not be sustainable because of the costs involved.

### 6.4.6 Further research

The current study provided detailed account of aquaculture operations and trends in Ghana, categorising existing practices and their outputs and identifying which technologies are financially viable to pursue. It also provided insights into marketing tilapia identifying what the consumers' needs and preferences are. Among the findings was a renewed interest in the aquaculture sector in both the commercial and particularly the non-commercial sector, that commercial aquaculture operations in Ghana is financially viable and poses minimal risk to investment, that there is a ready market for aquaculture products particularly tilapia which was the focus of this study and finally there is a huge potential in terms of natural resource for both pond and culture development. This renewed interest and potential is however faced with the number of the limitations that have hindered its successful development in earlier years, which include poor production practices resulting in unprofitability of a number of non-commercial fish farms, lack of quality fish seed, lack and inadequate poor extension services.

Recommendations for further research to improve future prospects for aquaculture in Ghana may include:

Detailed study into cage culture potentials assessing the suitabilities of reservoirs and other water bodies, located in areas identified as very suitable or suitable, this time based on the physico-chemical and other properties of the water bodies, identifying any ecological concerns that may arise from escapes, any potential impacts on quality of water, establishing carrying capacities potential conflicts of use that may arise and financial viabilities of such projects based inputs and resources available in the area. This study should be undertaken by a multi-disciplinary team of experts comprising water quality, aquaculturists, socio-economist and ecologists. Availability of results of such a study is likely to wipe up commercial interests.

Another area of future research is in post-harvest handling and preservation of fish to ensure fish is delivered in the best form which is healthy and safe to eat. This may involve studying existing practices by tracking quality changes in fish from producer to consumer and identifying the various stages and conditions under which changes in fish quality occur.

A detailed look at the fish market across the three agro-ecological zones of the country; the coastal (southern sector), forest zone (mid sector) and the savannah zone (northern sector), which traditionally are said to differ significantly in their preference for animal products, may be of interest. This may be able to establish changes in consumer preferences and perception to fish and protein intake in general, identifying size preferences and product forms and which cultured species is likely to be most preferred in particular areas. This may also reflect variations between urban and rural area protein preferences. The study was carried during the tilapia off peak season. It may be of interest to study the market during the peak season as the prices of the fish may drop significantly than that reported in the study and again observe again the attitude of dealers in the Greater Accra Region for instance to farmed fish during this period. This study could be done in a similar way to that reported in this study; through the use of questionnaires and interviews. Information from such a study will inform farmers in different parts of the country which product forms are likely to sell and possible prices ranges they may have to work within hence production practices to adopt.

# References


Abdelghany, A.E. and Ahmad, M.H. (2002) Effects of feeding rates on growth and production of Nile tilapia, common carp and silver carp polycultured in fertilized ponds. *Aquaculture Research* **33** (6):415-423.

Abila, R.A. (2003) Food safety in food security and food trade. Case study: Kenyan Fish Export. *2020 Vision for Food, Agriculture. and The Environment. International Food Policy Research Institute* **10**, 2(Abstract)

Adutwum, R. O. (2001) Policies and Strategies for Food Security in Ghana; A paper presented at a workshop organized by Reseau Ghaneen of SADAOC Foundation, ISSER, University of Ghana, Legon

Aeschliman, C. (2005) Results of the 2002-2004 baseline survey of Ghanaian fish farmers (Draft).

Aguilar, M.J. (1996) Development and evaluation of GIS-based models for farming and management to coastal aquaculture: A case study in Sinaloa, Mexico. Institute of Aquaculture, University of Stirling, Stirling, Scotland, U.K. PhD thesis.

Aguilar-Manjarrez, J. and Nath, S. (1998) A strategic reassessment fish farming potential in Africa . 170

Aguilar-Manjarrez, J. and Ross, L.G. (1995) Geographical information system (GIS) environmental models for aquaculture development in Sinaloa State, Mexico. *Aquaculture International* **3** 103-115.

Akrofi, J.D. (2002) Fish utilisation and marketing in Ghana: State of the art and future perspective. In: Jacqueline M. McGlade, P.C.K.A.K.a.N.J.H.-M., (Eds.) Large Marine Ecosystems: The Gulf of Guinea Large Marine Ecosystem - Environmental Forcing & Sustainable Development of Marine Resources, Volume 11. 345-354. Elsevier Science B.V

Alabaster, J.S. and Lloyd, R. (1982) Water quality criteria for freshwater fish. 2$^{nd}$ edn edn, 361pp Butterworth Scientific.

Amevenku, F.K.Y. (1999) An Evaluation of selected pilot fish hatchery operations in Ghana . University of Ghana.

Ampofo, J.A. and Clerk, G.C. (2003) Bacterial flora of fish feeds and organic fertilizers for fish culture ponds in Ghana. *Aquaculture Research* **34** (8):677-680.

Anon (2003) As reported in FAO (2004) Fisheries and aquaculture country profile: Ghana. Rome: FAO.

Apawudza, S.J. (2005) Study to explore opportunities for fresh fish marketing from Yeji. In: Ndenn, J., Teutscher, F. and Diei-Ouadi, Y.e., (Eds.) *Report and papers presented at the seventh FAO Expert Consultation on Fish Technology in Africa. Saly-Mbour, Republic of Senegal, 10-13 December 2001.*, Rome: FAO]

Asuming-Brempong, S. and Asafu-Adjei, K. (2004) Estimation of Food Production and Food Availabillity in Ghana: The Case of Year 2000. International Conference on Ghana at the Half Century. Institute of Statistical, Social and Economic Research (ISSER), University of Ghana and Cornell University. Accra, Ghana.

Atrill, P. (2003) Financial management for non specialists. 3rd edn, 478pp London: Pearson Education Limited.

Awity, L.K.A. (1996) National aquaculture profile and strategies for sustainable development and rapid growth in Ghana. Ghana: Fisheries Department.

Aryeetey, E. B. (2002) Spcio-economic aspects of artisanal marine fisheries management in West Africa. In: Jacqueline M. McGlade, P.C.K.A.K.a.N.J.H.-M., (Eds.) Large Marine Ecosystems: The Gulf of Guinea Large Marine Ecosystem - Environmental Forcing & Sustainable Development of Marine Resources, Volume 11, 323 – 344. Elsevier Science B.V

Barg, U. (1992) Guidelines for the promotion of environmental management of coastal aquaculture development. Fisheries Technical Paper 328. 122pp Rome, Italy: FAO.

Barg, U., Bartley D., Kapetsky, J., Pedini, M., Satia, B., Wijkstrom, U. and Willmann, R. , 1999: Integrated resource management for sustainable inland fish production. FAO Aquaculture Newsletter, 23: 4. (http://www.fao.org/fishery/topic/14751/en#container)

Bayoumi, A.R. and Khalil, M.T. (1988) Tilapia fisheries in Lake Manzala, Egypt. *Bulletin of Institute of Oceanography and Fisheries* **14**, 87-99.

Beveridge, M.C.M. (1984) Cage and pen fish farming. Carrying capacity models and environmental impact. FAO Fisheries Technical Papers - T255 . 131pp Rome: Food and Agriculture Organization.

Beveridge, M.C.M. (2004) Cage Aquaculture. 3rd edn, 368pp Blackwell Publishing.

Bilio M. (2008) Controlled reproduction and domestication in aquaculture –the current state of the art, Part I - IV. Aquaculture Europe 33 (2).

Blow, P. and Leonard, S. (2007) A review of cage aquaculture: sub-Saharan Africa. M. Halwart, D. Soto and J. R. Arthur (eds)., (Eds.) 188 – 207 FAO.

Boateng, E., Ayamga, T., Chidley, T., Elgy, J., Savory, D. and van Velthuizen Harrij/ (2001) Geospacial Modelling for Agro Ecological Assessments and Decision Support for Development Planning in Ghana - Land Suitability Analysis . 92 Accra, Ghana: Council for Scientific and Industrial Research - Soil Research Institute.

Bosworth,D.L (1976) Production functions: A theoretical and Empirical Study. Westmead, D. C. Heath Ltd. 158pp.

Boyd, C.E. (1982) Water quality management for pond fish culture. Developments in Aquaculture and Fisheries Science. 9. 318pp Amsterdam, Oxford, New York: Elsevier Scientific Publishing Company.

Boyd, C.E. (1995) Bottom Soils, Sediment, and Pond Aquaculture. 348 New York: Chapman and Hall.

Braimah, L.I. (2001) Volta Lake Fisheries Management Plan . 162 Fisheries Sub-sector Capacity Building Project of the Department of Fisheries.

Bremner, A. (2003) Post-harvest Technology and Processing. In: Lucas John S. and Southgate Paul C., (Eds.) *Aquaculture: Farming Aquatic Animals and Plants*, First edn. pp. 215-236. United Kingdom: Fishing New Books, a Blackwell Publishing Company]

Bosworth, D. L. (1976) Production function analysis: A theoretical and empirical study. 158pp. D.C. Heath Ltd. Westmead.

Brown, J. H. (2006) Shellfish culture in West Africa; economic and sustainable opportunities for artisanal fishing communities. Background paper fpr FAO/DFID SFLP Policy brief series, FAO, 2007

Burrough, P.A. (1986) Principles of Geographical Information Systems for land Resources Assessment. Oxford, UK: Oxford University Press.

Bush, S.R. (2003) Using a Simple GIS Model to Assess Development Patterns of Small-scale Rural Aquaculture in the Wider Environment. *Aquaculture Asia* VIII No. 1 40-42.

Bush, S.R. and Kosy, S. (2007) Geographical Distribution of Investment in Small-scale Rural Fish Ponds. *Aquaculture Economics & Management* **11** (3):285-311. 1365-7305.

Coche, A.G. and Laughlin, T. (1985) Soil and Freshwater Fish Culture, FAO Training Series, Simple Methods for Aquaculture. 174 Food and Agriculture Organization.

CSIR/WRI (2003) Ghana raw water quality criteria and guidelines reports, Volumes 1, 2, and 3. CSIR/WRI.

De Silva, S.S., Amarasinghe, U.S., Nissanka, C., Wijesooriya, W.A.D.D. and Fernando, M.J.J. (2001) Use of geographical information systems as a tool for predicting fish yield in tropical reservoirs: case study on Sri Lankan reservoirs. *Fisheries Management and Ecology* **8** (1):47-60.

Diana, J.S. and Lin, C.K. (1998) The Effects of Fertilization and Water Management on Growth and Production of Nile Tilapia in Deep Ponds During the Dry Season. *Journal of the World Aquaculture Society* **29** (4):405-413.

Diana, J.S., Lin, C.K. and Jaiyen, K. (1994) Supplemental Feeding of Tilapia in Fertilized Ponds. *Journal of the World Aquaculture Society* **25** (4):497-506.

Diana, J.S., Lin, C.K. and Schneeberger, P.J. (1991) Relationships among nutrient inputs, water nutrient concentrations, primary production, and yield of *Oreochromis niloticus* in ponds. *Aquaculture* **92** 323-341.

Diei-Ouadi, Y. and Mensah, M.E. (2005) Improving Livelihoods through exporting artisanally processed fish. No. C998. 40pp Rome: FAO.

Directorate of Fisheries (2003) Ghana: Post-harvest fisheries overview. 81 Directorate of Fisheries, Ministry of Food and Agriculture, Ghana.

Directorate of Fisheries (2004) Information on fisheries in Ghana. 24pp Accra, Ghana: Directorate of Fisheries, Ministry of Food and Agriculture, Ghana.

Drury, C. (2001) Management accounting for business decision. 2nd edn, 559 London, UK: Thomsom.

Eastman, J.R. (2001) IDRISI 32 Release 2: Guide to GIS and Image Processing. 151pp Worcester, MA, USA: Clark Labs, Clark University.:

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

El-Sayed, A.-F.M. (2006) Tilapia culture. 277pp Wallingford, UK: CABI Publishing.

Engle, C. (1998) Analysis of Regional and National Markets for Aquaculture Food Products in the Southern Region. edn, Stoneville, Mississipi: Southern Regional Aquaculture Centre.

Engle, C.R. and Quagrainie, K. (2006) Aquaculture Marketing Handbook. 271pp Iowa, USA: Blackwell Publishing.

Essuman, K.M. (1992) Fermented Fish in Africa: A study on processing, marketing and consumption. 80 FAO.

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

FAO (1996) Food for All Summit, 13-17 November 1996, Rome. (http://www.fao.org/docrep/X0262E/x0262e25.htm#y – accessed 14/11/2004)

FAO (1998) Information on Fisheries Management in the Republic of Ghana. Rome, Italy: FAO.

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

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

FAO (2004a) Information on Fisheries Management in the Republic of Ghana. Rome, Italy. (http://www.fao.org/fi/fcp/en/GHA/body.htm - accessed 14/11/07).

FAO (2004b) Aquaculture extension in sub-Saharan Africa. *FAO Fisheries Circular*. No. 1002. Rome, FAO. 55p. (govdocs.aquake.org/cgi/reprint/2005/115/1150200.pdf – accessed 25/07/07).

FAO (2006) Cultured aquatic species information programme: *Oreochromis niloticus*. 10 Rome: Fisheries and aquaculture department, FAO.

FAO (2006a) State of the world aquaculture 2006. FAO Fisheries Technical Paper No. 500. 149pp, FAO, Rome. www.aces.edu/dept/fisheries/education/documents/FAO_State_of_World_aquauculure_advanced_t500e.pdf

FAO (2006b) National aquaculture sector overview, Ghana. (http://www.fao.org/fishery/countrysector/naso_ghana/en).

FAO and UNDP (2001) Improved fish smoking: Ghana. Sharing Innovative Experiences: Examples of successful initiatives in agriculture and rural development in the South. 240-254pp. Rome: FAO.

Field, A. (2005) Discovering Statistics Using SPSS. 2nd edn, 771 London: SAGE Publications.

Fisheries Directorate (2003) National fish census data (Unpublished data).

Fitzgerald, W.J. (1988) Comparative Economics of Four Aquaculture Species Under Monoculture and Polyculture Production in Guam. *Journal of the World Aquaculture Society* **19** (3):132-142.

Ghana Highway Authority (2008)

Ghana Statistical Service (2002) 2000 Population and Housing Census: Special Report on Urban Localities. 131 Ghana: Ghana Statistical Service.

Gilbert, R.J. (1989) Small Scale Marketing of Aquaculture Products. Texas Agricultural Extension Services : Southern Regional Agriculture Centre.

Haard, N.F. (1992) Control of Chemical Composition and Food Quality Attributes of cultured fish. *Food and Research International* 289-307.

Hair, J.F.Jr., Anderson, R.E. and Tatham, R.L. (1998) Multivariate Data Analysis. 5 edn, 768 .Upper Saddle RiverN.J., USA: Prentice Hall.

Haylor, G. and Bland, S. (2001) Integrating aquaculture into rural development in coastal and inland areas. In: In Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, C.E. and Arthur, J.R.e., (Eds.) *Aquaculture in the third millennium technical. Proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25 February 2000*, pp. 73-81. Bangkok, Thailand and FAO, Rome, Italy: NACA and FAO]

Hecht, T. (2006) Regional review on aquaculture development. 4. Sub-Saharan Africa – 2005. FAO Fisheries Circular. No. 1017/4. Rome, FAO. 2006. 96 pp.

Heinbuch, U. (1994) Animal Protein Sources for Rural and Urban Populations in Ghana. Programme for Integration of Artisanal Fisheries in Wst Africa . 39 Rome: FAO.

Hepher, B. and Pruginin, Y. (1981) Commercial Fish Farmer. 261 United States of America: John Wiley and Sons, Inc..

Hishamunda, N. (2004) Policies at the farm level to promote commercial aquaculture in sub-Saharan Africa. *Aquaculture economics and management* **8** (1 & 2):85-94.

Hossain, M.S., Chowdhury, N.G., Das, N.G. and Rahamas, M.M. (2007) Multi-criteria evaluation approach to GIS-based land-suitability classification for tilapia farming in Bangladesh. *Aquaculture International* **15** (6):425-443.

Hossain, M.S. and Lin, C.K. (2001) Land Use Zoning for Integrated Coastal Zone Management: Remote Sensing, GIS and RRA Approach in Cox's Bazar Coast, Bangladesh. 25 Bangkok, Thailand: Asian Institute of Technology.

Institut du Sahel (1998) Food security and agricultural sub-sectors in West Africa: Future prospects and key issues four years after the devaluation of the CFA franc. 6pp

Jarding, S., Windmar, L., Paterson, R. and Fjallsbak, J.P. (2000) Quality issues in commercial processing of tilapia (*Oreochromis niloticus*) in Zimbabwe. In: Fitzsimmons, K. and Filho. J.C., (Eds.) *Proceedings from the Fifth International Symposium on Tilapia Aquaculture*, pp. 588-594. Rio de Janeiro, Brazil: American Tilapia Association, Charles Town, West Virginia and ICLARM, Penand, Malaysia]

Jolly .M. Curtis and Clonts, A.H. (1993) Economics of Aquaculture. The Howard Press, Inc., 10 Alice Street, Binghamton, NY 13904-1580: Food Products Press.

Kang'ombe, J., Brown, J.A. and Halfyard, L.C. (2006) Effect of using different types of organic animal manure on plankton abundance, and on growth and survival of Tilapia rendalli (Boulenger) in ponds. *Aquaculture Research* **37** (13):1360-1371.

Kapetsky, J.M. (1991) Technical assistance and investment framework for culture based fisheries in Ghana. Food and Agriculture Organization.

Kapetsky, J.M. (1994) A Strategic Assessment of warm-water fish farming potential in Africa. 67 Rome: Food and Agricultural Organization.

Kapetsky, J.M., Mcgregor, L. and Herbert, N.E. (1987) A geographical Information system and satellite remote sensing to plan for aquaculture development: A FAO-UNDP/GRID co-operative srudy in Costa Rica. 151 Rome: FAO.

Kapetsky, J.M. and Nath, S.S. (1997) A strategic assessment of the potential for freshwater fish farming in Latin America. 128 Rome: FAO.

Kapetsky, J.M., Wijkstrom, U.N., Macpherson, M. and Vincke, M.M.J. (1991) Where are the best opportunitiess for fish farming in Ghana? The Ghana Geographical Information System as a decision making tool for fish farming development.

Kelly, A.M. and Kohler, C.C. (1997) Climate, Site, and Pond Design. In: Egna, S.H. and Boyd, E.C., (Eds.) *Dynamics of Pond Aquaculture*, pp. 109-132. New York: CRC Press LLC]

Khalil, M.T. and Hussein, H.A. (1997) Use of waste water for aquaculture: an experimental field study at a sewage treatment plant. *Aquaculture Research* **28**, 859-865.

Kinnear, R.P. and Colin, D.G. (2006) SPSS 14 Made Simple. 569pp East Sussex: Psychology Press.

Kristjanson, P., Radeny, M., Baltenweck, I., Ogutu, J. and Notenbaert, A. (2005) Livelihood mapping and poverty correlates at a meso-level in Kenya: Poverty and Food Security Mapping. *Food Policy* **30** (5-6):568-583.

Kubota, S., Yotohara, H. and Sakaguchi, M. (1999) Textural changes by maturation. In: Extracellular matrix of fish and shellfish (Ed. by K. Sato, M. Sakaguchi, H.A. Bremner). 107-115pp . Trivandrum, India: Research Sign Post.

Kutty M.N. and Delince G. (1987) Site Selection for Aquaculture Water Supply. 11pp http://www.fao.org/docrep/field/003/AC173E/AC173E00.HTM

Larbi, W.O., Odoi-Yemo, E. and Darko, L. (1998) Developing a geographical information system for land management in Ghana. Land tenure in the developing world with a focus on Southern Africa. Conference proceedings, University of Capetown, 27-29 January 1998. Deutsche Gesellschaft für Technische Zusammenarbeit.

Lawson, T.B. (1995) Fundamentals of Agricultural Engineering. New York, USA: Chapman and Hall.

Lindsay, R.C. (1990) Fish Flavours. Food Reviews International; Special issue of Seafoods: Quality and Evaluation, 437-455.

Lisac, D. and Muir, J. (2000) Comparative economics of offshore and mariculture facilities. *Mediterranean Offshore Mariculture (Ed. by J.F. Muir & B. Basurco)* (Series B. No. 30. CIHEAM, Zaragoza):203-211.

Little, D. C. (2004) Delivering better quality seed to farmers Sixth International Symposium on Tilapia Aquaculture, 12-16 September, Manila, Philippines. 15pp (ag.arizona.edu/azaqua/ista/ista6/ista6web/pdf/003.pdf).

Little, D.C. and Edwards, P. (2004) Impact of nutrition and season on pond culture performance of mono-sex and mixed-sex Nile tilapia (Oreochromis niloticus). *Aquaculture* **232** (1-4):279-292.

Manu, S. (2004) Fish Marketing in South-Western Ghana. 56pp Accra: Food and Agriculture Organization, Project TCP/GHA 2904.

Martensson, U., Eklundh, L., Gyamfi-Aidoo, J. and Tetteh, E. (1999) Ghana: Country at a Glance. Data description and instructions for the use of the G-CAG. Final Report. 48 Accra, Ghana: Environmental Protection Agency, Ghana and The World Bank.

Mataka, L. and Kang'ombe, J. (2007) Effect of substitution of maize bran with chicken manure in semi-intensive pond culture of Tilapia rendalli (Boulenger). *Aquaculture Research* **38** (9):940-946.

McGeachin, R.B. and Stickney, R.R. (1982) Manuring Rates for Production of Blue Tilapia in Simulated Sewage Lagoons Receiving Laying Hen Waste. *The Progressive Fish-Culturist* **44** (1):25-28.

McGinty, A.S. and Rakocy, J.E. (2003) Cage culture of tilapia. *Southern Regional Aquaculture Center (SRAC) Publication No. 281* 4pp

McLeod, I., Pantus, F. and Preston, N. (2002) The use of a geographical information system for land-based aquaculture planning. *Aquaculture Research* **33** (4):241-250.

Meaden, G.J. and Kapetsky, J.M. (1991) Geographical information systems and remote sensing in inland fisheries and aquaculture. 262 Rome: FAO.

Ministry of Fisheries (2005) Forum on Aquaculture as a Business Venture. Accra International Conference. Accra: Ministry of Fisheries.

Ministry of Transport (2005) Relationship between population density, road density and poverty (http://www.mrt.gov.gh/statistics/DFR/ - accessed 17 05 08

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. (2004) Economics, Marketing and Investment Appraisal. Msc Aquaculture core course notes. 45pp Institute of Aquaculture, University of Stirling.

Muir, J. (2005) Managing to harvest? Perspectives on the potential of aquaculture. *Philosophical Transactions Royal Society LondonB Biological Science* (360(1453)):191–218

Muir, J.F. (1995) Aquaculture Development trends: Perspectives for Food Security. Contribution to the International Conference on Sustainable Contribution of Fisheries to Food Securiity, Kyoto, Japan, 4-9 December 1995, organized by the Government of Japan, in collaboration with the Food and Agriculture Organization of the United Nations (FAO). KC/F1/95/TECH/4.

Muir, J.F. (1996) A systems approach to aquaculture and environrmntal management. *In* Baird, D.J.//Beveridge, M. C. M//Kelly, L. A.//Muir, J. F.//(eds) Aquaculture and water resources management. UK: Blackwell Science Ltd.

Muir, J.F., Gitonga, N., Omar, I., Pouomogne, V. and Radwan, I. (2005) Hidden harvests: Unlocking the potential of aquaculture in Africa, Fish for all summit. 22 - 25 August 2005. Abuja, Nigeria. NEPAD.

Munzir, A. and Heidhues, F. (2002) Toward sustainable development of floating net cage culture for income security in rural Indonesia: a case study of common carp production at Lake Maninjau, Indonesia. In: Edwards, P., Little, D.C. and Demaine, H., (Eds.) *Rural Aquaculture*, pp. 143-153. Wallingford: CAB International]

Nandeesha M. C. and Heng N/ (1994) Women in Cambodian Fisheries. Proceedings of the National Workshop on Women in Fisheries. Bati Fisheries Station. PADEK, Cambodia:

Nath, S.S., Bolte, J.P., Ross, L.G. and Aguilar-Manjarrez, J. (2000) Applications of geographical information systems (GIS) for spatial decision support in aquaculture. *Aquacultural Engineering* **23** (1-3):233-278.

Naylor, L.R., Goldbury, J.R., Primavera, H., Jurgenne, K.N., Beveridge, C.M.M., Clayason, Folke, C., Lubchenco, J., Mooney, H. and Max, T. (2000) Effect of Aquaculture on World Fish Supplies. 405: 1017-1024, Rome: FAO.

Overå, R. (1995) Enterpreneurial women in Ghanaian canoe fisheries: The case of Fante fishing town Moree. Universitas Bergensis, Centre for Development Studies.

Owusu, B. S., Kuwornu, L., Lomo, A. (2001) Integrated Irrigation-Aquaculture development and research in Ghana. *In* J. F. Moehl, I. Beernaerts, A. G. Coche, M. Halwart, V. O. Sagua (Eds), Proposal for An African Network on Integrated Irrigation and Aquaculture. Proceedings of a workshop held in Accra, Ghana, 20-21 September 1999.

Panayotou, T., Wattanutchariya, S., Isvilanoda, S. and Tokrisna, R. (1982) Technical Report No.4. 72pp, Manila, Philippines: ICLARM.

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

Perez, O.M., Telfer, T.C. and Ross, L.G. (2005) Geographical information systems-based models for offshore floating marine fish cage aquaculture site selection in Tenerife, Canary Islands. *Aquaculture Research* **36** (10):946-961.

Perry, R.I. and Sumaila, U.R. (2007) Marine ecosystem variability and human community responses: The example of Ghana, West Africa. *Marine Policy* **31** (2):125-134.

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

Prein M. and 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.

Quagrainie, K., Kaliba, A., Osewe, K., Mnembuka, B., Senkondo, E., Amisah, S. Fosu, A. K., Ngugi, C. C. and Makambo, J. (2004) An Economic assessment of aquaculture in rural Africa: The case of Tanzania, Kenya and Ghana. Final draft report. 19pp.

Rana, K. and Telfer, T. (2006) Priamary drivers of cage culture and their relevance for Africa cage culture. In: M. Halwart and J. F. Moehl (eds.), (Eds.) *FAO technical workshop on cage culture in Africa. Entebbe, Uganda. 20 - 23 October, 2004*, pp. 99-107. Rome:

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

Rippon, P.W. and Wynessa, A.J. (1994) Integrated catchment modelling as water resources management tool. *Journal of the Institute of Environmental Management* **8** (6):671-679.

Robb, D. (2001) The Relationship between Killing Method and Quality . In: Kestin, S.C. and Wariss, P.D., (Eds.) *Farmed Fish Quality*, pp. 220-233. Oxford: Fishing New Books]

Ross, L.G. (1998) The use of Geographical Information Systems in aquaculture: A review. 19pp Institute of Aquaculture, University of Stirling:

Ross, L.G. and Aguilar-Manjarrez, J. (1993) Aquaculture development and Geographical Information Systems in the Institute. *Aquaculture News* **16** 14-15.

Saaty, T.L. (1977) A scaling method for priorities in hierarchical structure. *Journal of Mathematics and Physiology* (15):234-281.

Salam, A.M. (2000) The potential of Geographical Information System-based modelling for aquaculture development and management in Soth Western Bangladesh. PhD Thesis. 318pp. Institute of Aquaculture, University of Stirling.

Salam, M.A., Khatun, N.A. and Ali, M.M. (2005) Carp farming potential in Barhatta Upazilla, Bangladesh: a GIS methodological perspective. *Aquaculture* **245** (1-4):75-87.

Salam, M.A., Ross, L.G. and Beveridge, C.M.M. (2003) A comparison of development opportunities for crab and shrimp aquaculture in southwestern Bangladesh, using GIS modelling. *Aquaculture* **220** (1-4):477-494.

Satia, B. (1989) A regional survey of aquaculture in Africa south of the Sahara. Rome: FAO.

Seini, A.W., Nyanteng, V.K. and Ahene, A.A. (2004) Policy Dynamics, Trends in Domestic Fish Production and Implications for Food Security in Ghana. International Conference on Ghana at the Half CenturyJuly 18-20. Accra, Ghana: Institute of Statistical, Social and Economic Research (ISSER), University of Ghana and Cornell University .

Setboonsarng, S. (2002) Gender Division of Labour in Intergrated Agriculture/Aquaculture of Northeast Thailand. In: Edwards, P., Little D C and Demaine H, (Eds.) *Rural Aquaculture*, pp. 253-274. Oxon, UK: CABI Publishing]

Shang Y. C. (1981) Aquaculture Economics: Basic Concents and Methods of Analysis. Westview Press Inc., United States of America.

Shang, Y.C. (1990) Aquaculture Economic Analysis: An Introduction. Advances in world aquaculture. 2 edn edn, 211pp 16 E. Fraternity Lane, Louisiana State University, Baton Rouge, LA 70803: The World Aquaculture Society.

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

Shaw, S.A. (1990) Marketing A Practical Guide for Fish Farmers. 106pp Scotland: Fishing New Books in association with the Highlands and Development Board.

Singh, R.K.P. (2003) Economics of Aquaculture. 143pp Delhi: Daya Publishing house .

Southgate, P.C. (2003) Feeds and feed production. In: Lucas, J.S. and Southgate, P.C., (Eds.) *Aquaculture: Farming aquatic animals and plants*, pp. 172-198. UK: Blackwell Publishing]

Stevenson, J.R., Irz, X.T., Alcade, R., Petit, J. and Morissens, P. (2004) Working Paper 1: A typology of brackishwater pond aquaculture systems in the Philippines. 41pp UK: University of Reading.

Stickney, R.R. (2005) Aquaculture: An Introductory Text . 256pp Wallingford, Oxfordshire, UK: CABI Publishing.

Suresh, V. (2005) Tilapias. In: Lucas, J.S. and Southgate, P.C., (Eds.) *Aquaculture: farming aquatic animals and plants*, pp. 321-345. India: Blackwell Publishing Ltd.]

Tacon, A.G.J. (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.

Van Brakel, M. L. (2006) GIS application for poverty targeted aquaculture development in the Lower Mekong Basin. PhD Thesis, University of Stirling. 298pp.

Welcomme, R.L. (1988) International introductions of inland aquatic species. 328 Rome: FAO.

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

Whyte, S. A. (1981) A case for the salvaging of the Lower Volta Clam Industry. V.B.R.P. Technical Report.

Wijkstrom, U.N. and Vinke, M.M.J. (1991) Review of the Economics in Fish Farming and Culture-Based Fisheries in Ghana: Technical Assistance and Investment Frame for Aquaculture.

Williams, K. (2000) Marketing Fish in Oklahoma. Langston: Langston University Agricultural Research and Extension Programs .

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.

Young, J.A. and Muir, J.F. (2000) Economics and marketing. In: M. C. M. Beveridge and B. J. McAndrew (eds), (Eds.) *Tilapia: Biology and exploitation* , pp. 447-487. Great Britain : Kluwer Academic Publishers]

## Appendix 1 - Questionnaire for fish farmer survey

1. General Information

i. Name of Fish farm…………………………………………….…Date…………………

ii. Name of respondent…… …………Role of respondent..…..……….

iii. Address of Farm/Business ...…………………….…. Tel.…………..……

iv. Location of pond/cage …………Name of town/Village ………….……...
v. District …………………….…..Region…………………..………………
vi. Level of education of farmer

No formal education MLSC/JSS Secondary/Technical

Post-Secondary First degree Post-graduate

Others (please specify)……………………………………

vi. Pond Areas:

Nursery pond(s):

| Pond No. | Year Constructed | Depth | Area | Cost |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Rearing pond(s):

| Pond No. | Year Constructed | Depth (m) | Area (ha) | Method of construction | Cost of construction |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

vii. Total area of farm size (ha) ………………………………..…………

viii. Land ownership:

| | | Lease | |
|---|---|---|---|
| | Own land | From private owner | From government or chief |
| Area of land | | | |
| Annual rent | | | |
| Type of lease | | | |
| Fixed cash | | | |
| Length of lease (years) | | | |

ix. Experience:

What year was the farm established? ………………………..……………………………..

How many years of experience do you have as a fish farmer? ...………………………

Type of production system

Extensive Semi-intensive Intensive

xi. Size of farm

Less than 1 hectare Between 1 – 2 hectares Greater than 2 hectares

xii. Please tick from list below the types of equipment you have on your farm and the number

| Equipment | Please tick if available | Number | Year purchased | Initial cost |
|---|---|---|---|---|
| Aerators | | | | |
| Basket | | | | |
| Boots | | | | |
| Bucket | | | | |
| Cutlass | | | | |
| Earth chisel | | | | |
| Head pan | | | | |
| Hoes | | | | |
| Mattock | | | | |
| Milling machine | | | | |
| Nets | | | | |
| Pelleting machine | | | | |
| Pickaxe | | | | |
| Pumps | | | | |
| Shovels | | | | |
| Vehicles | | | | |
| Wheel barrow | | | | |
| Others: | | | | |

2. Economic data

Financing

i. What was the initial invested amount (estimate): ………………………… (Cedis)

ii. Source of funds: Bank Self Family Friends Others

iii. If funds were from a bank or a lender, please indicate the type bank or lender:
Rural Bank Commercial Bank NGO Private Lender Government

iv. What is the Interest rate payable on the loan per annum?
…………………………………………

v. How often do you harvesting your fish?

Quarterly Twice yearly Yearly Less than once a year
No specific schedule others (specify)

vi. On which months do you harvest your fish?
Jan Feb Mar April May June

July Aug Sept Oct Nov Dec

Others (please specify)……………………………………………………………

3. Annual production and revenue

| | Quantity | Unit Price | Revenue |
|---|---|---|---|
| Production sold | | | |
| Consumed on farm | | | |
| Gift | | | |
| Total | | | |

4. Monthly operating costs

| | Quantity | Type | Unit Price | Total Costs | % of total costs |
|---|---|---|---|---|---|
| Variable costs | | | | | |
| Hired labour<br>- Permanent<br>- Temporary | | | | | |
| Feed | | | | | |
| Seed | | | | | |
| Fertilization | | | | | |
| Electricity | | | | | |
| Fuel | | | | | |
| Water rates | | | | | |
| Others | | | | | |
| Fixed Costs | | | | | |
| Operator's salary | | | | | |
| Lease costs | | | | | |
| Maintenance costs<br>Pond<br>Equipment | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Water rent | | | | | |
| Marketing costs<br><br>Preservation<br>Processing<br>Storage<br>Transport<br>Commissions<br>Waste | | | | | |

vii. Who sell your products after harvest?
Self Spouse Other family members Fish dealer

viii. Where are your fish sold after harvest?
On-farm Fish market Regular market
Others (please specify)…………………………………………………………….…..

ix. In what form are they sold?
Live Fresh Frozen Salted Smoked Others

x Who determines the prices of your products?
Self Retailer Others ……………………………………………….

xi How are the prices determined?
Prevailing market price Based on cost of production Arbitrarily

xii What are the sizes of the fish, at harvest (number per kilogram) and their prices?

| Specie | Weight (g) or number/kg | Price/kg |
|---|---|---|
| | | |
| | | |
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| | | |

# Appendix 2 – Questionnaires for market surveys

## Questionnaire for Wholesaler and Retailers

1.Name of Business………………………………...…Date………….……………...

2. Name of respondent ………… ……………….. Sex ………………..……………

3. Role of respondent ……………………………………………………………..…….

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

5. Type of Business: Wholesaler Retailer Intermediate

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

7. Where do you get your supply of tilapia from (Please tick as many as applicable)?
Fish market Fish farm Fish landing site Fish Wholesaler
Others (Please specify) …………………………………………………

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

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

10. How often do you buy it?
Daily More than once a week Weekly Less than once a week
Monthly Less than once a month

11. In what forms do you buy it? Live fresh frozen smoked

12. In what form do you sell it? Live fresh frozen Smoked salted (koobi) Others (pls specify)

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

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

15. How much does it cost? ………………………………………………(Cedis)

16. Do current supplies satisfy your need? Yes No

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

18. In your opinion which fish specie do you consider the closest substitute to tilapia?…………………..……………………………………………………

**Questionnaire for Restaurants and Tilapia Joints**

1. Name of Business……………………………...…Date……………………...

2. Name of respondent …………………………….. Sex ………….……………

3. Role of respondent ………………………………………………………………….

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

5. Type of Business: Restaurant Tilapia Joint Chopbar

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

7. Where do you get your supply of tilapia from (please specify the supplier and location)? ………………………………………………………………………

8. How often do you buy it?
Daily More than once a week Weekly Bi-Weekly
Monthly Less than once a month

9. In what form(s) do you buy it? live fresh frozen
Smoked Salted Others (please specify)…………………

10. In what form(s) do you sell it? Grilled Boiled (as in soup) fried

Salted Frozen Smoked

11. Please indicate the size of Tilapia you normally prefer to buy (number of fish per kg)? <2 2 3 4 5 6 >6

12. What quantity do you buy each week? ..................................... ……………(Kg)

13. How much does it cost? ………………………………………………(Cedis)

14. How many kilograms do you sell per day or per week? …………………

15. How much do you sell per day or per week? ………………… (Cedis)

16. Does your current supply of Tilapia meet your requirement? Yes
No

17. What factors do you look out for before buying the fish?
Uniformity in size Price Freshness

18. In your opinion which fish specie do you consider the closest substitute to tilapia (You may please give local names)?……………………….…….……………

What other fish or meat products do you sell

| Product | Quantity bought per week (Cartons or kilograms) | Cost (Cedis) | Quantity sold per week (Cartons or kilogram) |
|---|---|---|---|
| | | | |
| | | | |
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**Questionnaire for Consumer Survey**

1. Name of respondent…………………………….………. Date ……………

2. Sex: Female Male

3. Where do you live?................................District/Region …………………..……

4. How many people make up your household? ……............................................

5. What are the ages? .........................................................……………………

6. What is the profession of the head of family? ………….…………………………

7. Please indicate your level of education?
No formal education Middle School Leaving Certificate or JSS Secondary
Post-secondary First degree Post-graduate
Others (please specify)…………………………………………………………..

8. Religion Christian Moslem
Others (please specify)……………………..…………

9. Tribe Ga Ewe Akan Hausa
Others (Please specify) ……………………………………………………………

10. How many members of your household are also working?
None 1 2 3 4 >5

11. If you ticked "none" please go to question number 12

12. Types of jobs of working family members …………………………………………

13. What is your family's monthly income (Ghana Cedis)?
< GH¢100 GH¢100 – 250 GH¢251 – 500
GH¢501 – GH¢750 GH¢760 – 1000 >GH¢1000

14. When did you last eat fish?
Today Within the week More than a week ago
About a month More than a month ago Cannot remember

15. How often do you eat fish?
Daily More than once a week Weekly More than once a month
Monthly Once a while

16. Which fish species do you prefer or buy most (you may give the local names)?
……………………………………………………………...………………………

17. Why that fish (Please tick as many as are applicable)?
Taste Price is reasonable Ease of processing availability

Others (please specify)……………………………………………………………

18. How many kilograms of fish do you buy per month? ………………….….…..............

19. How much do you spend on fish per month?………………….................……( GH¢)

20. In what form(s) do you normally buy it:
live Fresh Frozen Smoked Salted
Grilled Fried Others (please state)………………
20. Where do you normally buy it from?
Market Cold store Supermarket Fish market
Fish monger Sea side Fish farmer
Others (please specify)…………………...……….

21. Please indicate your regular sources of protein in order of preference (1 most preferred, 4 least preferred)
Meat ( ) Poultry ( ) Fish ( ) Bush meat ( )
Others ( ) please specify ………………………………………………

22.Do you like tilapia? Yes No

If you answered "no" please go to the next question if "yes" please jump to question 24

Why?
23. Too expensive Not available Doesn't like the taste Too bony

Others (please specify)…………………………………………………………………

24. In what form do you buy it?
Live Fresh Frozen Smoked Salted (kobi) Grilled Fried
Others (please state)

25. Where do you buy it from?
Market Fish market Supermarket Fish farmer
Fish monger Cold store Tilapia joint Others (specify)

26. How often do you buy it?
Daily More than once a week Weekly
More than once a month Monthly Once a while

If your answer to question 26 was "once a while", please go to the next question, otherwise please proceed to question number 28.

27. If you only buy tilapia once a while, can please indicate why?
Too expensive Not available Others (please specify)………..………

28. When did you last buy Tilapia?
Today Yesterday About a week ago About a month agoCannot remember

29. What size of tilapia do you prefer (number of fish per Kg)?

less than 2 2 3 4 5 6
7 8 >8

30. How many kilograms of tilapia do you buy per month?
1-5kg 5-10kg >10kg

31. How much do you spend each month on it? …………………………..………( GH¢)

32. In your opinion what is the closest fish substitute to the tilapia? ……

## Appendix 3 - Estimation of production figures based on subsistence farm type models

The total number of fish farms in 2004 according to the fish farm census by the Fisheries Directorate (Unpublished data) reported in Chapter 2 was 966. Based on the estimated national fish farm development growth rate of 16% per annum, the potential number of fish farms in 2006 was obtained as 1,300. Using the same ratios of 97% non-commercial to 3% commercial (Chapter 2 - Farm types, page 26) 1,261 of the projected number of farms was assumed to non-commercial and 39 (3%) as commercial. The non-commercial farms were then sub-divided into the five farm groups based on the percentage of each farm type to the total as presented in the initial analysis (see Table 6.1, page 211). From this, the number of farms types 1, 2, 3, 4 and 5 were obtained as 303, 593, 214, 50 and 101 respectively (adds up to 1,261). The number of commercial farms A, B and C were obtained as 29, 5 and 5 respectively.

The number of fish farms was assumed will continue to grow at the estimated annual growth rate of 16% while average pond size which had remained fairly unchanged over the years, a modest size increase of 3% each year. Fish production per hectare was also assumed will grow at 5% per year with increasing experience of the farmer. Similar growth rates were assumed for commercial farming. This culminates in an annual increase in fish production of about 25%. Obtaining a 50% increase involved increasing the rate at which fish farms are developing by 20% annually, average farm sizes increasing by 20% and mean output per farm type by 5% per hectare annually. Finally a 60% increase requires farm sizes increasing annually by 18% with rate of growth in number of fish farms increasing by 39% and 5% respectively.

From the analysis total fish production for 2006 from all the farm types and groups was obtained as 1,083mt which is reasonably close to official production figure for 2006 of 1,150mt for 2006 (FAO fishstat data base – (Table 6.4, page 225).

Production projections based on 25% annual increase in farm outputs from both non-commercial and commercial farm types working from current production practices are presented in Appendix 3 – Tables 1 to 8.

Appendix 3 - Table 1 Production projection for farm type 1

| | No. of farms | Mean size ($m^2$) | Yield | | | |
|---|---|---|---|---|---|---|
| | | | mt/ha | $Kg/m^2$ | Kg/unit | Output (mt) |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 303 | 1100 | 2.8 | 0.28 | 308.0 | 93.3 |
| 2010 | 549 | 1238 | 3.4 | 0.34 | 420.9 | 230.9 |
| 2015 | 1153 | 1435 | 4.3 | 0.43 | 617.2 | 711.1 |
| 2020 | 2420 | 1664 | 5.5 | 0.55 | 915.1 | 2214.8 |

Appendix 3 - Table 2 Production projection for farm type 2

| | No. of farms | Mean size/$m^2$ | Yield | | | |
|---|---|---|---|---|---|---|
| | | | mt/ha | $Kg/m^2$ | Kg/unit | Output (mt) |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 production level | 593 | 200 | 4.4 | 0.44 | 88.5 | 52.5 |
| 2010 (projected) | 1,074 | 225 | 5.3 | 0.53 | 119.3 | 128.1 |
| 2015 (projected) | 2,255 | 261 | 6.8 | 0.68 | 177.4 | 400.2 |
| 2020 (projected) | 4,737 | 303 | 8.7 | 0.87 | 263.2 | 1,246.6 |

Appendix 3 - Table 3 Production projection of farm type 3

| | No. of farms | Mean size ($m^2$) | Yield | | | Output (mt) |
|---|---|---|---|---|---|---|
| | | | mt/ha | Kg/$m^2$ | Kg/unit | |
| Expected growth rate (%) | 16 | 3 | 5 | | | |
| 2006 level | 214 | 6,600 | 1.4 | 0.14 | 924.0 | 197.7 |
| 2010 | 367 | 7,428 | 1.8 | 0.17 | 1,262.8 | 464.0 |
| 2015 | 772 | 8,612 | 2.3 | 0.22 | 1,894.5 | 1,462.1 |
| 2020 | 1,621 | 9,983 | 3.8 | 0.28 | 2,795.3 | 4,530.9 |

Appendix 3 - Table 4 Production projection of farm type 4

| | No. of farms | Mean size/$m^2$ | Yield | | | Output (mt) |
|---|---|---|---|---|---|---|
| | | | mt/ha | Kg/$m^2$ | Kg/unit | |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 50 | 4700 | 1.8 | 0.18 | 846.0 | 42.3 |
| 2010 | 91 | 5,290 | 2.2 | 0.22 | 1,253.2 | 105.4 |
| 2015 | 190 | 6,132 | 2.8 | 0.28 | 1,717.1 | 326.5 |
| 2020 | 399 | 7,109 | 3.5 | 0.35 | 2488.2 | 993.7 |

Appendix 3 - Table 5 Production projection of farm type 5

| | No. of farms | Mean size ($m^2$) | Yield | | | Output (mt) |
|---|---|---|---|---|---|---|
| | | | mt/ha | Kg/$m^2$ | Kg/unit | |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 101 | 2,500 | 1.5 | 0.15 | 375.0 | 37.9 |
| 2010 | 183 | 2,814 | 1.8 | 0.18 | 506.5 | 92.6 |
| 2015 | 384 | 3,262 | 2.4 | 0.24 | 782.9 | 300.7 |
| 2020 | 807 | 3,781 | 3.0 | 0.30 | 1,134.4 | 915.2 |

Appendix 3 - Table 6 Production projection for small scale commercial production (Farm A)

| | No. of farms | Mean size ($m^2$) | Yield | | | Output (mt) |
|---|---|---|---|---|---|---|
| | | | mt/ha | kg/$m^2$ | Kg/unit | |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 29 | 10,100 | 4.5 | 0.45 | 4,545.0 | 118.2 |
| 2010 | 53 | 12,800 | 5.5 | 0.55 | 6,252.2 | 367.2 |
| 2015 | 110 | 16,452 | 7.0 | 0.70 | 9,224.7 | 1141.2 |
| 2020 | 232 | 26,798 | 8.9 | 0.89 | 13,596.7 | 11020.4 |

Appendix 3 - Table 7 Production projection for semi-intensive medium scale commercial Farm B

| | No. of farms | Mean size ($m^2$) | Yield | | | |
|---|---|---|---|---|---|---|
| | | | mt/ha | Kg/$m^2$ | Kg/unit | Output (mt) |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 5 | 20,200 | 10.0 | 1.00 | 20,200 | 101.0 |
| 2010 | 9 | 22,735 | 12.8 | 1.28 | 27,737.0 | 251.1 |
| 2015 | 19 | 26,356 | 15.5 | 1.55 | 40,852.4 | 776.8 |
| 2020 | 40 | 30,554 | 19.8 | 1.98 | 60,497.5 | 2416.1 |

Appendix 3 - Table 8 Production projection for intensive medium scale commercial Farm C

| | No. of farms | Mean size ($m^2$) | Yield | | | |
|---|---|---|---|---|---|---|
| | | | mt/ha | kg/$m^2$ | Kg/unit | Output (mt) |
| Expected growth rates (%) | 16 | 3 | 5 | | | |
| 2006 level | 5 | 19,200 | 46.0 | 4.6 | 88,320 | 441.0 |
| 2010 | 6 | 21,610 | 56.0 | 5.9 | 120,798 | 1,093.6 |
| 2015 | 8 | 25,052 | 71.4 | 7.1 | 178,868 | 3,401.2 |
| 2020 | 13 | 29,042 | 91.1 | 9.1 | 264,570 | 10,566.3 |