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AQUACULTURE IN GHANA: ECONOMIC PERSPECTIVES OF GHANAIAN AQUACULTURE FOR POLICY DEVELOPMENT

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ABSTRACT

One of the major ways worldwide to supplement low fish catches from the wild is through aquaculture. Ghana has a great potential for aquaculture development, but is still in the developing stages. Most people entering aquaculture do so as a part time activity. This study attempts to demonstrate the profitability of aquaculture in Ghana by performing a cost-benefit analysis for investment in a 2000 m^2 pond for a 10.5 year investment period. Profitability indicators such as NPV, IRR, payback period and benefit-cost ratios were determined based on assumptions derived from secondary data obtained from the Department of Fisheries in Ghana. The study shows aquaculture in Ghana to be feasible and profitable with positive NPV and IRR of 32%, a benefit-cost ratio of 1.18 and a payback period which is slightly longer than four years. A sensitivity analysis shows that the cost of feed, the survival rate as well as the farm gate price of fish are the main factors affecting profitability. The most constraining factor on the development of aquaculture on a commercial level appears to be high start-up cost. Fixed cost constitutes 68.1% of the start-up cost and variable cost forms the other 31.9%. The cost of feed forms the bulk (83.8%) of the variable cost. To address the issue of high costs and the apparent inability of financial institutions to alleviate the problem of moral hazard, the study recommended government policy intervention that seeks to develop clusters of production facilities to be made available for individuals to rent or lease for a period of five years after which they could become owners.

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1. INTRODUCTION

The fisheries sector has played a vital role in the socio-economic development of Ghana since independence. The sector has the potential to contribute substantially to the national economy through employment, gross domestic product (GDP), foreign exchange earnings, food security and poverty reduction. Despite this great potential, the sector has over the past two decades registered a slow growth of 3% per annum, falling short of its expected potential. The sector accounts for 4.5% of the national GDP (DOF, 2009). Fish is the most important source of animal protein in Ghana. The country's total annual fish requirement has been estimated to be 880,000 tonnes while the nation’s annual fish production average is 420,000 tonnes, leaving an annual deficit of 460,000 tonnes (DOF, 2009). This deficit is made up for through fish imports which were estimated at 213,000 tonnes in the year 2007 and valued at US $262 million (DOF, 2007).

Ghana is thus presently not self-sufficient in fish production and with the country’s prospects for higher landings from capture fisheries being limited, coupled with the issue of increasing population growth, the demand for fish will continue to increase and become higher than what can be supplied. The situation of net deficit is thus expected to worsen in time and aquaculture production is expected to play a key role in ensuring food security by increasing progressively to bridge that deficit.

Aquaculture in Ghana is still in the developing stage even though it started about 50 years ago. Ghana is endowed with good natural resources such as land and water (rivers, lakes and the sea) that can support aquaculture production. One may ask, why is aquaculture still not developing at a faster rate like in other developing countries such as China?

According to reports from the Directorate of Fisheries there are a number of constraints affecting the expansion of aquaculture in Ghana. These include lack of adequate supply of seed, lack of quality fish seed and suitable feeds. Low investment from the private sector is also listed as one of the major problems as well as lack of information concerning economic profitability of aquaculture. Aquaculture in Ghana is mostly done on a subsistence basis with very few commercial operators. According to Gitonga *et al.* (2004) and Hiheglo (2008) most people in Ghana see aquaculture as a part-time, limited investment hobby due to the poor regard they have for aquaculture as an economic activity.

This perception needs to be changed for any meaningful development in aquaculture to be realised. This can be done by, among other things, promoting aquaculture as a commercial enterprise in which people or investors see the potential to make a profit. The Directorate of Fisheries is doing its best to assist fish farmers through input acquisition and technical assistance, however it also needs to have appropriate information available to investors in the process of making decisions on aquaculture investments and also to financial institutions so that they can better assess the viability of aquaculture projects to make credit available for fish farmers. The success of aquaculture not only depends on the use of higher yielding species and efficient aquaculture production technologies, but also on investor confidence (Mbugua, 2007).

It is in light of this that this study seeks to provide a clear description of aquaculture in Ghana and also demonstrate the profitability of a given small scale aquaculture enterprise to serve as a source of information to help both farmers and investors. Hopefully this study will give a better understanding of the basic economics involved in aquaculture that can help in policy making towards accelerating aquaculture development.

The objectives of this study are to:

1. Look at the trends in the development of aquaculture over the years and identify reasons for its success or failure.
2. Analyse the strengths and weaknesses of the existing government policies that directly or indirectly affect aquaculture development.
3. Do a cost-benefit analysis of the profitability of a typical small scale commercial aquaculture enterprise.
4. Provide policy recommendations, based on the results from the cost-benefit analysis that could help in promoting future aquaculture development in Ghana.

Chapter one gives an introduction to the study, a country profile and a general overview of the fisheries sector in Ghana. Chapter two deals with aquaculture in Ghana and focuses on its development since its introduction in the 1950s and the current status and conditions affecting its development in the country. Chapters three and four elaborate on the cost-benefit analysis to determine the profitability of aquaculture in Ghana and chapter five focuses on the existing economic policies and some policy recommendations for the development of aquaculture in Ghana.

1.1 Background

Ghana is a tropical country and lies in the western part of West Africa between latitudes 4° N and 12° N and longitudes 3° W and 1° E. The country spans an area of 238,533 km^2, has a coastline of nearly 540 km and a continental shelf of about 24,000 km^2. Ghana is bounded on the east by Togo, on the west by Cote d'Ivoire, on the north by Burkina Faso and the south by the Gulf of Guinea of the Atlantic Ocean (Figure 1). The capital, and also the largest city, of Ghana is Accra. The country is divided into 10 administrative regions which are subdivided into 138 individual metropolitan and district assemblies. As of the year 2008 50% of the Ghanaian population lived in urban areas of the country with an annual urbanization rate of 3.5% (CIA, 2010).

Figure 1: Map of Ghana (NOP, 2011)

In 1957 Ghana became the first sub-Saharan African country to gain independence from its colonial rulers. Today the population of Ghana is well over 24 million people (Table 1) and life expectancy at birth is 60.5 years. The literacy rate in Ghana is 57% which represents the percentage of the population 15 years and over who can read and write. The economy of Ghana has been experiencing rapid growth in recent years with the real GDP growth rate reaching 4.7% (Table 1) and the GDP per capita reaching 1,600 USD in the year 2010, one of the highest in Africa. Recently, the inflation rate in Ghana has dropped from above 20% to 9.1% at the end of the year 2010.

Ghana is relatively diverse and rich in terms of natural resources and the economy is largely natural resource and agriculture based. Ghana's main export is cocoa, timber and gold. The agricultural sector accounts for one-third of the country's GDP (Table 1) and two-thirds of foreign earnings from exports, and employs the largest proportion of the total work force of the country followed by service and then manufacturing (Figure 2).

Table 1: Demographic, geographic and economic indicators, CIA (2010)

Total geographical area	238,533 sq km
Population	24,339,838
Annual population growth rate	1.855%
Labour force	10.33 million
Unemployment rate	11%
GDP (real growth rate)	4.7%
GDP composition by sector	
-Agriculture	37.3%
-Industry	25.3%
-Service	37.5%
Inflation rate	9.1%

The proportion of the labour force in the agricultural sector is substantially higher (70.1%) in the rural areas, where 50% of the population live, than in urban areas (19.9%). About 57.2% of heads of households in the country are engaged in the agriculture, forestry or fisheries sectors. The percentage rises to 74.7% for heads of households in rural areas. Households in rural areas also constitute the largest proportion (87.1%) of households in the poorest quintile (Ghana Statistical Service, 2002).

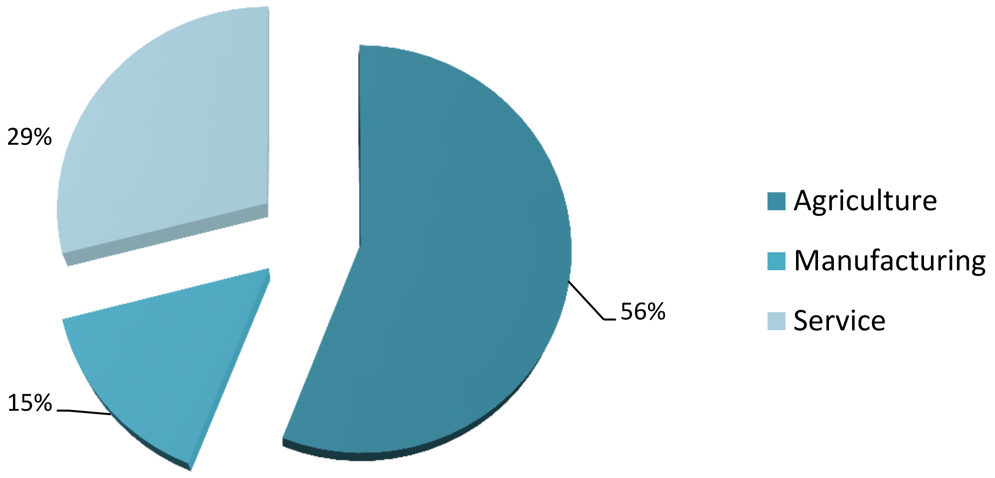

Figure 2: Labour force composition by sector for 2005, CIA (2010)

1.2 The fisheries sector in Ghana

The fisheries sector in Ghana plays a major role in the national economy. It contributes 5% to the GDP and supports the livelihood of about 10% of the population (Seini *et al.* 2004). Its significance to the economy of Ghana can be seen in key economic variables such as employment, livelihood support, poverty reduction, food security and foreign exchange earnings. The fisheries sector is very important from a gender perspective, since it provides employment to a large group of women. Men also play a major role in the sector and are engaged in the main fishing activity whereas the women are involved with the on-shore post-harvest activities which include processing, storage and trading (FAO, 2008). Ghana's fisheries sector comprises a diverse and vigorous spectrum of fishing enterprises ranging in scale from subsistence to industrial. Within this broad range, fish stocks are exploited from rivers, lakes, coastal lagoons and shallow seas and offshore on the high seas. Ghana thus has six distinct sources of domestic fish supply which include the marine fisheries, lagoon fisheries, Lake Volta, other inland fisheries, aquaculture and imports. The fisheries sector itself is divided into marine fisheries, inland fisheries, the post-harvest sub-sector and the aquaculture sector.

1.2.1 Marine fisheries

The marine sub-sector is the most important source of local fish production delivering about 80% of the total fish supply in Ghana. Average annual domestic production between 1993 and 2000 was about 358,000 tonnes and was approximately 80% of overall fish supply (FAO, 2004) (Figure 3). The marine sector has three sub-sectors, small scale (artisanal or canoe), semi-industrial (or inshore) and industrial. The artisanal sector is most important in terms of output, with about 70% of the total marine supply (DOF, 2005). It is operated from 304 landing centres in 189 fishing villages located along the coast and about 1.5 million people depend on it for their livelihood. The semi-industrial (or inshore) sector exploits both small pelagic and demersal species and operates from only 7 centres. It contributes 2% of the total marine catch. The industrial sector is made up of trawlers, shrimpers and tuna vessels. The tuna fisheries constitute 22% of the total marine catch and the shrimpers account for 6% of the marine fish supply (MFRD, 2007).

1.2.2 Inland sector

The inland fisheries sector is made up of the inland capture fisheries (freshwater) and the inland culture fisheries (culture based fisheries and aquaculture). Lake Volta is the single most important source of inland capture fishery providing livelihood for about 300,000 people who live around the lake and supporting about 140 species of fish (Braimah, 2003). 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 fisheries 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 one million 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*.

Production from inland fisheries over the years has been fairly stable (Figure 3). This is because important stocks of Lake Volta have been overfished since the early 1990s (Braimah 2003). Measures have now been taken to manage the lake fisheries. Productions from marine fisheries on the other hand have been fluctuating over the years (Figure 3). Periods of low landings correspond to periods were there is low upwelling which normally leads to low harvest of small pelagics such as the *Sardinella sp.* and mackerels which normally form the bulk of landings during the bumper seasons. The upwelling index calculated in 2008, for instance, was 18.3 as compared to 11.7 in 2007, favouring high production and abundance of fish (DOF, 2009). However, it is reasonable to assume that the marine fisheries have limited potential for further growth in the future.

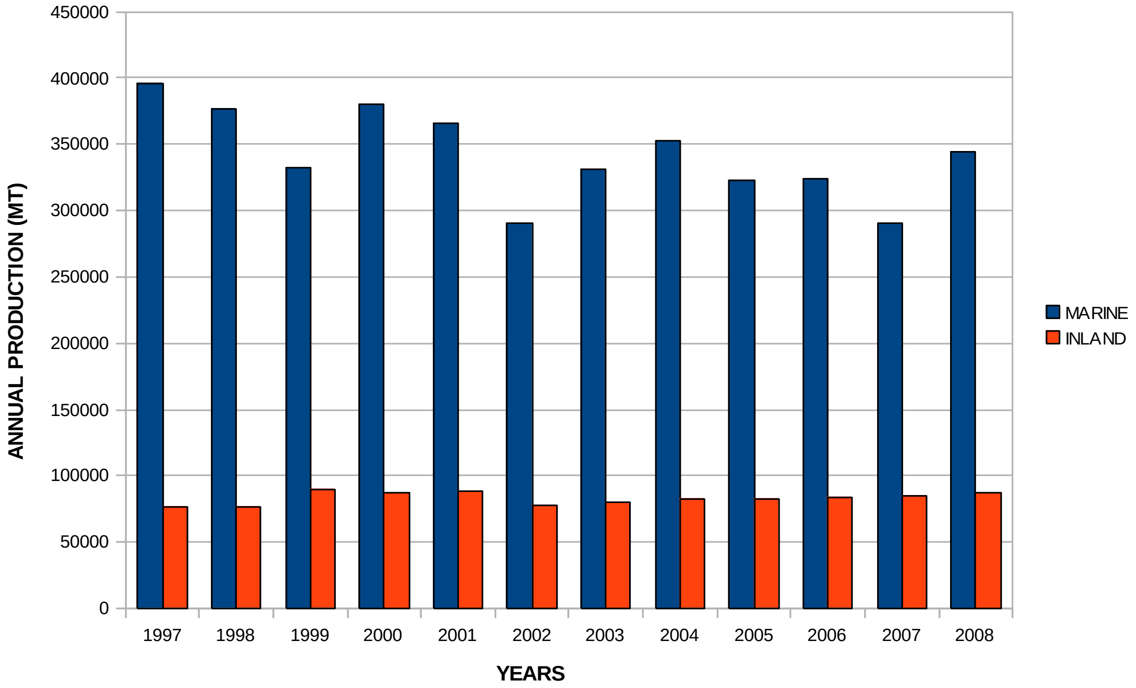

Figure 3: Marine and inland fish production (1997-2008), DoF (2009)

1.2.3 Post-harvest sector

The post-harvest sector in Ghana involves a large number of fish processors, wholesalers and retailers. Women are the key players in the sector and are thought to form about 70% of the sector but data on the number of people who are directly or indirectly benefiting from the sector are limited. Furthermore, it is often almost impossible to separate post-harvest livelihoods from fisheries livelihoods in general.

2. AQUACULTURE IN GHANA

Aquaculture in Ghana is dominated by small scale operators. Ghana has a great potential for aquaculture development and this potential is largely underexploited (Hiheglo 2008). The sector's contribution to the national economy has not been disaggregated from the overall contribution of fisheries to the national economy. However the development of aquaculture is important to the Ghanaian government as it can bridge the gap between demand and supply of fish and even produce in excess of domestic demand for export.

2.1 Brief history of aquaculture in Ghana

The development of aquaculture in Ghana over the years has been based on two different approaches. One has been to target communities for adoption of communally owned and managed ponds. This was a means of bringing benefits in the form of fish for nutrition and cash to communities so as to reduce poverty. This approach was adopted in Ghana when aquaculture started in the country in the 1950s. The government embarked on policies to promote aquaculture and culture based fisheries in the northern regions of the country. These areas have a long dry season and a single and unreliable rainy season leading to long periods of drought which seriously affect human and livestock populations. The government thus embarked on a programme to construct dugouts and dams to provide a reliable source of water. Integrated aquaculture in high potential areas was promoted as a means of making economic use of on-farm agriculture by-products and also to improve the income and nutrition of people in that area who were traditionally not accustomed to fishing. However this type of community based aquaculture was unsuccessful because of lack of proper management.

The second type of approach adopted in the early 1980s targeted individuals or households who were landowners or entitled to making management decisions and were the only beneficiaries. The government embarked on a massive campaign to persuade the public to establish pond fish culture (MacPherson and Agyenim-Boateng, 1991). This campaign was effective since a large number of people responded by building ponds in different parts of Ghana, especially in the southern part of the country (Hiheglo 2008). The government's main goal with promoting aquaculture was to develop culture-based fisheries in freshwater environments to try to take an advantage of the huge potential that the country has for aquaculture which has been underutilised for years. Although there was a massive entry into the aquaculture industry, the program was not sustainable. At the end of the 1980s, about 23% of ponds constructed had been abandoned and those remaining in operation were not very productive (FAO 1990). The reason for the failure was that the government did not support its campaign with advice and extension services.

Little support was available for new adopters on issues such as pond siting, pond size, necessity of drainability, fertilization, pond management and harvesting strategies. Errors in any of these may place the entire operation in jeopardy. This was the case during the 1980s surge.

Despite earlier failures, effort is still being made to promote aquaculture development in the country. Studies conducted by Asmah (2008) reported a 16% mean annual growth rate in the number of aquaculture farms since the year 2000.

2.2 Current state of aquaculture in Ghana

The aquaculture sub sector is comprised largely of small scale subsistence farmers who practise extensive farming with very few commercial operators. Its contribution to the national economy has, however, not been disaggregated from the overall contribution of fisheries to the national economy, so its importance is not fully recognized. Information on the exact contribution of aquaculture to food security, employment and poverty alleviation is not available. However statistics from FAO's (1990) report stated that tilapia and *Clarias* contribute to 5% of the total supply of fish in the country.

It has been estimated that the production from ponds and culture-based fisheries is worth about USD 1.5 million a year. In 2007 the production rate from small-scale operators was estimated at 1.5 tonnes/ha/yr (FAO, 2010a). In recent years production from aquaculture in Ghana appears to be growing at a near exponential rate (Figure 4), growing from less than 1,000 tonnes in 2003 to over 7,000 tonnes in 2009. According to a survey conducted by the Directorate of Fisheries (2007) this rapid growth is attributed to increasing production from commercial operators which account for about 75% of the production since 2006.

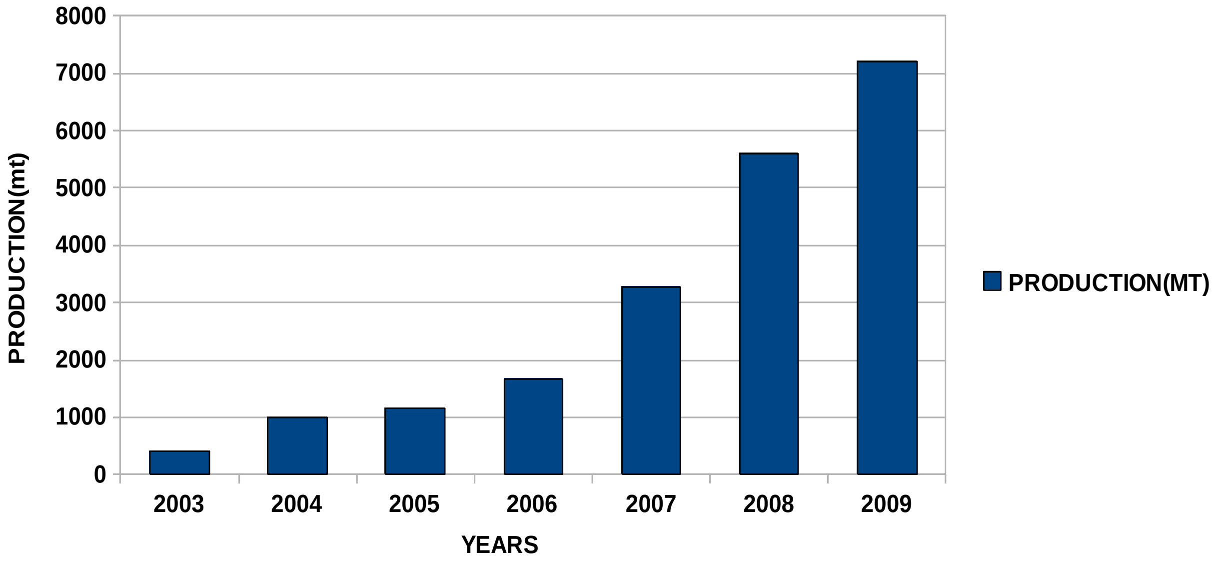

Figure 4: Aquaculture production in Ghana, DoF (2009)

2.2.1 Types of production systems

The aquaculture sub-sector is comprised largely of small-scale farmers who practice on a subsistence basis using the semi-intensive system of production in earthen ponds. Extensive culture is also practised but mostly associated with dams, dugouts ponds and small reservoirs. However in recent times there are a few people who are producing on a commercial basis using intensive systems. These commercial initiatives have contributed to the increase in production (Figure 4) and have also provided employment. Aquaculture development efforts in Ghana have always focused on the freshwater environment and no projects have yet been developed in marine environments.

2.2.3 Types of production facilities

Earthen ponds account for over 98% of the existing farms, dominating the southern and middle belts of the country. Concrete ponds, used more rarely, are normally small and mostly used in hatcheries. Pens and cages are more recent additions since 2003. The use of cages is however growing in the commercial sector which currently accounts for less than 5% of the existing farms. These are expensive, not so much in the cost of the structures themselves but the cost of reasonably balanced feeding. Reservoirs and dugouts are mostly found in the northern belt of the country and this has been attributed to the relatively poor rainfall in northern Ghana. When it comes to pens, the cost of feeding is not very high especially for a plankton feeder like *O. niloticus.* The main concern regarding the pens is the limited suitable environment for their introduction.

Some farmers rely wholly on the natural productivity of their ponds while others use agricultural by-products as inputs. To a large extent, feedstuffs are used by small-scale fish-farmers in unbalanced proportions which usually leads to slow growth in fish. Most fish farmers fall into this kind of group (FAO, 2010a). Fish production in ponds range from about 35 kg to about 25,750 kg/ha/year (Asmah, 2008). Maximum production from about 60% of the fish farmers ranges from less than 1,000kg/ha/year to 5,000 kg/ha/year. In addition, less than 10% of fish farmers exceed production levels of 20,000 kg/ha/year, most of whom are expected to be commercial producers. Production cycles range from three months to two years with an average production cycle for non-commercial farming of one year, and that for the commercial farm of about 7 months. The sizes of tilapia at harvest range from 50 g to about 400 g with an average size of 170 g. Less than 30% of the farmers are able to produce tilapia larger than 200 g.

2.2.4 Types of fish cultured

The main species of fish cultured is the *Tilapia niloticous* species which represents 80% of aquaculture production. The remaining 20% is comprised of catfish (*Clarias gariepinus* and *Heterobranchus* species). These are cultured in monoculture or poly-culture with *Tilapia niloticous* in which case the catfish is used to control the population of the tilapia which can be highly prolific. *Heterotis niloticus* is another species that is also cultured. Other species which have been introduced and grown on an experimental scale are *Oreochromis macrochir*, silver carp and tiger prawn (*Penaeus monodom*).

2.3 Marketing

Fish trading is an important occupation in Ghana with an estimated 10% of the population engaged in it on a full time or part time basis, both in rural and urban communities. The farmed fish produced in Ghana is sold at local markets to local consumers but not exported because production is low. Harvested fish are largely sold fresh. Commercial farms mostly deal with wholesale buyers who buy the bulk of the harvested product and go on to sell to retailers or fish processors while fish harvested by the non-commercial farmers is mostly retailed by themselves or their spouses. Only a few non-commercial farmers sell their product to wholesale buyers. Unsold fish is either frozen or processed via smoking, salting and/or fermentation. According to a survey conducted by Asmah (2008) consumers prefer the size of tilapia to be 200 g or more and farmers producing fish of such size generally did not have problems selling their fish.

Fish marketing is mostly centralised in the southern and the middle zone of the country, where fish consumption is also highest. Per capita fish consumption is estimated 30 kg/person/year in the southern zone, 20 kg in the middle zone and 10kg in the northern zone (Hiheglo, 2008). Import of farmed fish is not allowed so as to ensure good prices for fish farmers.

2.4 Constraints in the aquaculture sector

Aquaculture development in Ghana according to Hiheglo (2008) is constrained by several factors which include:

- Lack of information concerning the economic profitability of fish farming in the sector. This makes it difficult for people to invest in the sector.
- Limited availability of fingerlings.
- Lack of affordable and good-quality feed.
- Lack of financial resources/credit for the development of profitable operations. This is probably one of the most restraining factors with respect to the development of commercial aquaculture.
- Low investment from the private sector.
- Absence of properly targeted research (e.g. on socio-economic, organizational or financing aspects) of aquaculture development.
- The existence of the general threat of poaching. This problem is persistent in aquaculture across developing countries and has the effect of increasing the riskiness of operations and increases surveillance costs.

However the government has taken several steps to support and accelerate aquaculture development in Ghana (DOF, 2008). The measures are mainly steps to support fish farmers and these mostly include:

- *The provision of free extension services* – The government through the Directorate of Fisheries assists in providing extension services to farmers throughout the whole country. These extension services are effective to some extent, however they face many challenges. There is a lack of logistical support such as vehicles which makes movement of extension field workers very difficult, thus the extension services are ineffective in providing services to farmers living in remote parts of the country.

- *Training in fish farming techniques* – The establishment of the Aquaculture Demonstration Centre as part of the Fisheries Sector Capacity Building Project (FSCBP) was a major step to assist individuals and organisations interested in aquaculture. As of 2008 the Department of Fisheries has assisted in training more than three hundred people countrywide in aquaculture and in the government budget over USD 500,000 have been allocated to newly trained farmers (as start-up capital) and existing farmers to promote production (Hiheglo, 2008).
- *Local and foreign study tours for fish farmers and staff* – This is done in order for both existing and new farmers to gain new experiences and also to acquire more knowledge of fish farming.
- *Training of gangs of youth to construct ponds* – The goal of this is to reduce the cost of manual pond construction as well as to provide employment for youths. This can therefore be viewed as a policy with mixed objectives that might not be optimal with respect to commercial aquaculture development since most commercial operators prefer to use excavators for pond construction rather than manual construction. The reason for this is that mechanically constructed ponds are more productive than manually constructed ponds. However, in rural parts of the country where fish farmers don't have access to excavators, the training of gangs of youth comes in handy.
- *Strengthening the organizational capacity of fish farmers' associations* – This has been done through training in bookkeeping, group dynamics and the preparation of business plans. Also these associations are assisted in acquiring inputs for their farms so as to reduce the cost of operations.
- *Fingerling production for sale to fish farmers* – This is a way of ensuring that farmers are able to get access to good quality fingerlings to stock their farms. The Directorate of Fisheries through its hatcheries is able to provide fingerlings at a lower price to farmers compared to the open market. This could be seen as a form of indirect subsidy to the farmer. In some instances fingerlings as well as feed are even given to prospective farmers on credit by the Directorate of Fisheries (Hiheglo, 2008).

2.5 Mechanisms for investment

A foreign investor wishing to establish a business in Ghana must go through the Ghana Investment Promotion Centre (GIPC). According to GIPC (2010), GIPC was established with the main objective to encourage, facilitate and promote foreign investments in the Ghanaian economy and to coordinate and monitor all investment activities by:

- facilitating and liaising between investors and relevant ministries, departments and agencies as well as institutional lenders;
- providing and disseminating up to date information on the available incentives;

- assisting incoming and existing investors by providing supporting services needed. The GIPC's website provides full information on incentives and a wealth of other information on the business environment in Ghana and the specific processes that apply.

However, for an investment in the aquaculture sub-sector the most important initial assistance is provided by the Fisheries Commission which is central to all aquaculture development in Ghana and is able to facilitate identification of potential partners and areas for the actual investment plans. Recent studies conducted by Henriksen (2009) to assess the investment profile in the aquaculture sub-sector shows that conditions in Ghana are favourable and that investors find Ghana to be a sound location for business development (Table 2).

Table 2: Investment climate (SWOT) analysis for aquaculture in Ghana (Henriksen 2009).

STRENGTHS	WEAKNESSES
• Access to a large regional market • Government committed to creating an enabling environment for investors • GIPC to facilitate investment • Politically stable	• Weak but emerging financial sector • No firm regulations in place for aquaculture • Weak aquaculture advisory services and input supply
OPPORTUNITIES	THREATS
• Rapidly growing excess demand • Farm gate price higher than world market price (high demand) • Social and economic conditions improving • Large areas of water and land available for aquaculture • A number of local potential investment partners	• Potential of reduced price for tilapia if production increases significantly • Price drop to international level can be expected • Effect of HIV/AIDS on the work force

To promote and encourage the development of businesses in the country, the government has incentives such as tax breaks for new businesses. For instance new aquaculture enterprises are allowed a five year tax free period. The government has also set up a special fast track court system in order to provide a quicker response to solving disputes and enforcing contracts which is a key factor in providing a healthy and efficient business environment.

Henriksen (2009) in his study mentioned that a number of other agencies are available throughout the country that provide assistance to potential investors in Ghana. The following list provides information on such agencies:

- Ghana Exports Promotion Council (GEPC) assists the private sector with market information and statistical trade services;
- The Ghana Free Zones Board (GFZB) manages Free Zones Schemes, an integrated programme to promote processing and manufacturing of goods by establishing specific export processing zones;
- The Export Development and Investment Fund (EDIF) and the Ghana Investment Fund (GIF) were established to assist in overcoming some of the financial constraints on private sector development. While EDIF provides financial resources to address problems associated in the exporting sector, GIF aims to provide loans to small and medium scale enterprises (SME's) at concessional rates;
- The Association of Ghana Industries (AGI) is a non-profit organisation whose aim is promoting growth and development of the industries in Ghana and to create an enabling business environment;
- The Ghana National Chamber of Commerce and Industry (GNCCI), has the vision of providing leadership for the growth and prosperity of business in Ghana;
- The National Fisheries Association of Ghana (NAFAG) is the umbrella organisation for the fisheries sector and together with the Ghana Fish Processors Association also has the potential to assist and facilitate potential foreign investments.

2.6 Governing regulations

The Fisheries Act, 2002, (L.I. 625 of 2002) is the main legislative instrument that governs the aquaculture sector in Ghana. The fisheries regulations, 2007, are the main support measures. The regulations cover various aspects of aquaculture such as aquaculture inputs including seed, seed production certification, responsible aquaculture practices, import of live fish and transfer of fish within the country. However, the regulations are lacking in important economic aspects such as the right to private ownership.

The Environmental Protection Agency Act 1994 (Act 490) requires that aquaculture projects do not damage the environment as is also a requirement of the fisheries law. Schedule 2, (regulation 3) of the environmental assessment regulations, 1999, prescribes land-based aquaculture as one of the undertakings for which an environmental impact assessment (EIA) is mandatory. In the same legislative instrument, schedule 5 (regulation 30 (2)) contains the provisions to regulate fish cage culture. It characterizes water trapped for domestic purposes, water within controlled and/or protected areas, and that water which supports wildlife and fishery activities as environmentally sensitive areas whose uses should be subjected to environmental impact assessment. The Environmental Protection Agency Act, like the Fisheries Act, is lacking in important economic aspects such as the enforcement of monetary fines in cases where the environment has been damaged due to negligent behaviour.

The Food and Drugs Law, 1992, prohibits the sale of unwholesome, poisonous or adulterated substances and prescribes penalties for breaching the law. This law is useful in deciding whether aquaculture products are of required quality.

3. COST-BENEFIT ANALYSIS AND FINANCIAL VIABILITY

Aquaculture like any other business activity involves benefits and costs that are expected to occur in the future. One way of assessing how promising or successful an aquaculture enterprise might be is by conducting a cost-benefit analysis (CBA). CBA for an aquaculture enterprise essentially involves comparing initial start-up costs and on-going expenses with a revenue stream that accrues over time, usually at the end of each production cycle.

The total cost involved in an aquaculture operation is the total sum of money invested in two forms: fixed costs and variable costs. Those costs are inherently different both with respect to the cost structure itself and to the timing of accrual. Fixed costs according to Jolly and Clonts (1993) are those costs that must be paid whether there is production or not and they usually accrue before the first production period in the form of start-up costs. They include the cost of capital assets such as cost of land and costs involved in pond construction. Variable costs include the cost incurred during the operation and they depend directly on the scale of operations. Payments made for inputs such as labour, feed, fingerlings and transport all come under the variable cost and are either assumed to accrue at the beginning or end of each production cycle. Variable cost is the sum of the quantity of variable inputs used multiplied by the price per input unit as shown in Equation (1):

$$VC(t) = \sum w(j,t) * x(j,t) \qquad \text{Equation (1)}$$

Where *VC* is the variable cost in period t, *w(j,t)* is the price of inputs j in period t and *x(j,t)* is the quantity of input j in period t. The total cost of investment in any given period will be estimated by the total sum of money involved in both the fixed and the variable costs.

The benefits that are involved in aquaculture operations are attributed to financial gain from selling the finished product at the end of each production cycle. This could be described as the sum of the quantity of outputs at the end of the period multiplied by the price of the output at that period as shown in Equation (2):

$$B(t) = \sum p(i,t) * q(i,t) \qquad \text{Equation (2)}$$

Where *B(t)* are the benefits in period t, *p(i,t)*is the price of output i in period t and *q(i,t)* is the quantity sold of outputs i in period t. In this context it is noteworthy to mention that the farm gate price of tilapia depends on the size of the final product. More specifically, consumers are willing to pay more for larger sizes of tilapia (Asmah, 2008). In addition to the revenue accruing at the end of each production cycle it is reasonable to assume that the fixed assets, i.e. the land and the pond, have some positive monetary value at the end of the estimation period. Such a value is called a terminal value and it will at least partly depend on the depreciation schedule of the fixed assets.

Furthermore, net benefits in each period can be found by subtracting total costs from the benefits (Equation (3)), which in terms of financial viability can also be stated as Equation (4).

Net benefits = Benefits – Total cost Equation (3)

Net revenue (Profit) = Total revenue – Total cost Equation (4)

A profitability analysis is one of the major ways of assessing or evaluating the feasibility of an investment project. One way of doing this for a project such as an aquaculture enterprise which involves large sums of initial investment with returns that normally extend beyond a year is through capital budgeting (Jolly and Clonts, 1993). Capital budgeting involves the mapping out of the cash-flow or net benefits that the project is expected to provide over a given time period, which often is determined by the project's economic life. The most common indicators that are normally used in capital budgeting to determine the financial desirability of an investment include: net present value (NPV), payback period (PBP) or discounted payback period, internal rate of return (IRR) and the benefit-cost ratio (BCR). When faced with a limited investment budget and having to choose among a range of feasible investment projects, NPV provides the best estimate of profitability compared to the other indicators. IRR can be highly sensitive to the project's time horizon and accruals of costs and revenues at different time periods and can therefore give conflicting results of profitability compared with NPV.

3.1 Net present value (NPV)

NPV is a key indicator of financial viability. The NPV of a project is found by discounting its expected cash-flow with an appropriate discount rate, or rather the required rate of return, and thereby taking the time value of money into consideration. The discount rate generally depends on the project's perceived risk. NPV is given by the difference between the sum of the discounted cash-flow, i.e. the net benefits, which is expected from the investment and the amount which was initially invested in the project as shown in Equation (5).

$$NPV = -INV + \frac{P_1}{(1+r)^1} + \frac{P_2}{(1+r)^2} + \ldots + \frac{P_n}{(1+r)^n}$$ Equation (5)

Where *INV* is the initial investment in the project, $P_1, P_2, \ldots, P_n$ is the expected cash-flow in each period, 1 to n is the total number of periods in operation and r is the discount rate or the required rate of return. The basic assumption is that benefits accrue at the end of each time period unless otherwise specified.

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 at the given discount rate and if NPV equals zero (NPV = 0) it would be a break-even situation where the investor would be indifferent to investing. The larger the NPV is for a given investment level, the more viable the project is. The advantages of using NPV when evaluating a project's profitability is that it allows for the comparison of different projects, irrespective of specific cash-flow schedules and economic life.

3.2 Internal rate of return (IRR)

IRR is the discount rate that provides an NPV of zero. Like the NPV, the IRR is also used in evaluating the desirability of an investment or a project given that a project with a higher IRR is considered to be more desirable. It can be computed by using the trial and error method where different discount rates are used to find which one makes the NPV zero (Jolly and Clonts, 1993). It can also be calculated by solving for IRR in equation (6):

Equation (6)

$$0 = -INV + \frac{P_1}{(1+IRR)^1} + \frac{P_2}{(1+IRR)^2} + \ldots + \frac{P_n}{(1+IRR)^n} \quad \text{Equation (6)}$$

Where, the definitions for *INV*, $P_1, P_2, \ldots, P_n$ and n are the same as defined for Equation (5).

In evaluating the desirability or the feasibility of a single project both the IRR and the NPV methods usually result in the same decision making at the end of the day as to either accept or reject a project. However Mbugua (2007) suggested the use of the NPV method for evaluating the profitability of long term projects like aquaculture projects. The IRR method assumes a single discount rate for every period but with long term investments like aquaculture, the discount rate may change during the life span of the project hence making the NPV method more appropriate. The main disadvantage of using the IRR involves its inability to allow for comparison between different projects irrespective of specific cash-flow schedules and economic life as mentioned earlier.

3.3 Payback period

The payback period is the length of time required for an investment to recover the original cost of the investment from the net cash-flow. For a profitability study this is normally useful for projects with shorter maturity periods. According to Jolly and Clonts (1993) it does not account for cash-flows beyond the payback period and hence it is not very reliable when it comes to ranking projects based on viability. This is because some projects give a lot of returns in the early stages while others yield more returns in the later stages of the project so basing viability on this could lead to poor decision making. However Mbugua (2007) mentioned that for projects such as aquaculture the payback period could be used during the initial stage to determine the period for the investment to be paid back. The payback period is estimated by dividing the investment cost of the project by the project's annual cash-flow (Mbugua, 2007) and it is expressed in number of years. It is the author's belief that most Ghanaian investors tend to prefer the investment alternative with the shortest payback period, weighing the near future more heavily than the distant future in the decision making process.

The discounted payback period is the length of time required for an investment to recover the original investment cost from the discounted net cash-flow. Apart from using the discounted cash-flow instead of the cash-flow as the payback period does, the same principles that apply to the payback period will also apply to the discounted payback period. However since money has a positive time value, the discounted payback period will always be longer than the payback period.

3.4 Benefit-cost ratio (BCR)

Benefit-cost ratio is a ratio which is also used to tell whether or not an investment will be profitable. BCR is calculated by taking the net present value of the expected future benefits, or revenues, and dividing it by the present value of all costs as shown in Equation (7):

$$BCR = \frac{\sum_{t=0}^{n} B_t/(1+r)^t}{\sum_{t=0}^{n} C_t/(1+r)^t} \qquad \text{Equation (7)}$$

Where B_t are total benefits in period t, C_t are total costs in period t, n is the number of periods and r is the required rate of return. A ratio above one indicates a positive NPV and that the investment is a profitable one while a ratio below one indicates a negative NPV and that the investment is not profitable.

3.5 Sensitivity analysis

Every project involves some amount of uncertainty that may occur during the life time of the project. These uncertainties may affect the profitability of the project and thus affect decision making. Uncertainties may come in the form of variations in production inputs, changes in market prices and even output quantities. In making investment choices one may want to know the effect these variations could have on the profitability or the returns of the investment. Sensitivity analysis is one important tool that can be used to demonstrate the impact of these uncertainties. By creating a set of scenarios, one can determine how changes in one variable can impact the profitability of the project.

4. AQUACULTURE INVESTMENT FEASIBILITY STUDY

Data used for this study were secondary data obtained from the Directorate of Fisheries (DoF) head office in Accra. Estimates for cost of inputs such as the cost of land and the cost of constructing a pond were mostly sourced from estimates which the DoF have prepared for the "Youth in Aquaculture" project. This project is to take place throughout the country and using cost estimates from it will reduce the extent of bias in costing items. Operational information was also sourced from the Aquaculture Demonstration Centre which is a centre of the DoF involved in aquaculture training and fingerling production. Information obtained from this source mostly includes cost of fingerlings, cost of fertilization and liming, stocking density, mortality rate of fingerlings, farm gate prices and weight of tilapia and cost of feed.

The basic assumption in this study is that an investment is being made into a $2000m^2$ (0.2ha) production pond (earthen pond) for the culturing of all male tilapia table size fish. The pond is stocked with fingerlings with an average weight of 5g at a stocking density of 5 fingerlings per square meter with an expected mortality rate of 10% for a production cycle of seven months. A feed conversion ratio of 1.2 is assumed. The table size fish that will be harvested at the end of the seven months would be sold at farm gate prices to wholesalers. It should however be noted that the price of the fish is directly related to the size of the fish at the end of the production period (Table 3). For the purpose of this study it is also assumed that the weight of the fish at the end of the production cycle is within the range of 400g to 450 g. Production for a period of 10.5 years, or more precisely 18 production cycles of 7 months, is considered and it is also assumed that the yield per production cycle is the same for the entire period. With these assumptions, the expected annual production per hectare will be approximately 35,000 kg/ha/yr.

Table 3: Size range and farm gate price of tilapia

Size of tilapia	Farm gate price per kg
250g-333g	3.5
334g-450g	4.2
451g-550g	5.5
551g-650g	6
651g-850g	7.8

The financial viability study of the aquaculture investment was done in three parts. First of all an estimate of the production costs and revenues was done and this was followed by determination of a number of viability indicators such as net present value (NPV), internal rate of return (IRR), payback period (PBP) and cost-benefit ratio and then lastly a sensitivity analysis was done to assess variability in certain input variables on NPV.

4.1 Estimation of costs and revenue

Data collected for this part of the study includes data on capital investment costs, operational costs and operational income or revenue. As outlined in chapter 3, total costs involved in aquaculture are the sum of fixed costs and variable costs. To a large extent capital investment costs can be categorized as fixed costs with the exception of the cost of equipment which depends directly or indirectly on the quantity produced. The capital investment costs considered in this project are the cost of land, the cost of pond construction and the cost of equipment. In addition to the cost of equipment, variable costs include general operational costs. For the purpose of this study the operational costs considered are the costs of production inputs, wages and the cost of maintenance. The benefits or revenue depend on production quantities, production size and farm gate prices. A key variable in this respect is the mortality rate.

4.1.1 Capital investment costs

The cost of land in Ghana varies from region to region but for the purposes of this study most of the estimates are sourced from the government's "Youth in aquaculture" project. According to that, the cost of land is estimated to be 2,000 Ghana cedis. But for an investor to secure a piece of land other fees for documentation are incurred. The breakdown for the cost of land is thus shown in Table 4 below.

Table 4: Estimated cost of land (DoF 2011)

Item: Land	Cost (GH Cedis)
Land acquisition	2,000
Topographical survey charges	1,000
Documentation/ other contingencies	3,000
Sum:	6,000

Pond construction is either done manually or mechanically. Mechanically constructed ponds are said to have very good dikes and usually it only takes a few days, four at the most, to construct a 2000 m^2 pond as compared to a manually constructed pond which may take more than a week to construct depending on the number of workers. Studies conducted by Asmah (2008) also show that mechanically constructed ponds are less expensive (GH 12,000 cedis in 2008) while a manually constructed pond of the same size costs GH 13,000 cedis. For this reason most people now prefer mechanically constructed ponds especially when constructing larger ponds like this. Thus, for the purpose of this evaluation an estimate for pond construction is given as GH 5,926 cedis (Table 5). The cost of hiring of the excavator (GH 5,926 Cedis) includes the cost of fuel as well as the cost of bringing the excavator to the site.

Table 5: Estimates for pond construction

Item: Pond	Cost (GH Cedis)
Hiring of excavator (2 days) Cost of grassing Cost of materials (e.g. PVC pipes for inlets and outlets)	5,606 200 120
sum:	5,926

Estimates for the cost of equipment were based on the quantity of equipment needed and the prevailing prices of the equipment (Table 6). When calculating the expected cash-flow, the life expectancy for specific equipment needs to be considered and the cash-flow adjusted for the reinvestment needed.

Table 6: Estimates for equipment

Item: Equipment	Cost (GH Cedis)	Life Expectancy (years)
Water quality sampling kit	200	5
Farm house	3,000	20
Generator	600	5
Refrigerator	1,000	5
Cutlass	3.85	2
Shovels	5.51	2
Boots	10.22	2
Head pan	3.7	2
Buckets	3.32	2
Wheel barrow	56.4	3
Weighing scale	6.5	4
Nets	130.42	3
Pumps machine	725.27	5
Aerator	2,500	5
Sum:	8,195.19	

4.1.2 Operational costs

Estimates for operational costs include the cost of fingerlings, feed, liming the pond and the fertilizer, packing and transportation of fingerlings, wages for two workers for the entire production cycle of 7 months and the wages for at least two extra workers at the time of harvest, as well as the costs of electricity and maintenance and repairs. Operational or variable cost estimates (Table 7) were used based on the assumption that the cost of fingerling packaging and transport, feed, and liming and fertilizer had to be paid in advance of each production cycle. The cost of electricity and wages of the workers were assumed to be paid at the end of each production cycle and the cost of maintenance was assumed to accrue at the end of each year. The workers are assumed to be paid a minimum wage of 3.11 GH cedis per day. Having the entire wage paid out at the end of each production cycle is to make all cash-flow calculations easier but it is however unrealistic. Since the wages are an insignificant part of total cost the relieving of this assumption would not change the estimates of the viability indicators enough to alter the ultimate decision regarding the project.

Table 7: Estimates for operational costs

Item	Quantity	Unit price cost (GH cedis)	Total cost (GH cedis)
Seed	10,000	0.08	800
Feed	4,800kg	33 per 20kg	7,920
Lime	30kg	1.2 per 1 kg	36
Fertilizer	200kg	55 per 100kg	110
Packaging of fingerlings	10,000	2.0 per 250	80
Labour	2	3.11 per day	1,306.2
Transportation		250	500
Electricity			60
Harvesting cost			16
Maintenance and repairs		720 per year	720

4.1.3 Breakdown of total cost

Using the data above the initial investment or the initial start-up cost for the aquaculture project was obtained. The total estimated start-up cost, i.e. expenses that occur before the first production cycle, are summarized in Table 8 below. This was obtained from the total sum of the fixed costs and the variable costs for the first production cycle by multiplying the quantity of each item by the price (Equation 1). The total fixed cost constitutes the bulk (68.1%) of the total start-up cost while the variable cost or the operational cost constitutes 31.9% of the total cost. The higher value of the fixed cost is mostly attributed to the high cost of the farmhouse building and equipment which forms 41% of the total fixed cost. This is followed by the cost of land (30%) and then the cost of pond construction which forms 29% of the fixed cost.

The cost of feed contributes to the largest share (83.8%) of the start-up variable cost. This is followed by the cost of fingerlings, constituting 8.5% of the start-up variable cost. The remaining 7.7% of the start-up variable cost account for the cost of fertilization, liming, packaging and transportation (Table 8).

Table 8: Summary of the start-up cost for a 2000 m^2 (0.2ha) pond

Item	**Start-up cost (GH Cedis)**	**start-up cost (%)**
Land Pond construction Building & equipment	6,000 5,926 8,195.19	
Total fixed cost	**20,121**	**68.1%**
Fish seed (fingerlings) Feed Lime Fertilizer Packaging of fingerling Transportation	800 7,920 36 110 80 500	
Total variable cost	**9,446**	**31.9%**
Total cost	**29,567**	**100%**

4.1.4 Revenues

The revenues at the end of each production cycle were estimated by using an expected mortality rate of 10% to estimate the quantity of tilapia surviving at the end of the production cycle. The revenue from stocking a 2000 m^2 pond with 10,000 fingerlings (Table 9) was then multiplied by the farm gate price to get the total revenue (Equation 2). The farm gate price used in this evaluation was GH4.2 cedis per kilogram which is the price of tilapia of the size 450 g. These assumptions provide a revenue stream at the end of each production cycle of GH 17,010 cedis (Table 9). The revenue at the end of each production cycle depends on the quantity of fish remaining at the end of the production period as well as the weight of the tilapia that is produced at the end of the period. This is because the larger the fish, the higher the price of the tilapia (Table 3) and hence the higher the revenue at the end of the period.

The net revenue was thus obtained by subtracting the total costs (sum of capital cost and operational cost) from the total revenues (Equation 4).

Table 9: Analysis of total revenue

Item	**Value**
Price of fish per kg Quantity stocked Quantity remaining at harvest Expected size at harvest in kg	4.2 10,000 9,000 0.45
Total Revenue (price*quantity*size of fish)	GH17,010

4.1.5 Terminal value

Estimates for the terminal value for land, pond and the farm house (Table 10) were obtained through a linear depreciation. For assets such as the pond and the farm house, a 20 year economic life expectancy was given. The value for land however was thought not to depreciate as is customary. The evolution of the market value of the above mentioned fixed assets was in this respect ignored.

Table 10: Terminal value of assets for 2000m^2 pond

Asset	Terminal value in GH cedis
Land	2000
Pond	2815
Farm house	1425

4.2 Viability results

From the cost and revenue data, Excel was used to create a cash-flow for each of the 7 month production cycles over a period of 10.5 years. Cash-flow for each production cycle depends on the assumptions made above, i.e. about costs, revenues and the life expectancy of the equipment. The cash-flow stream, or the net benefits, in thousands of GH cedis for each production period are presented in Figure 5. The fluctuations in cash-flow between periods are attributed to the start-up cost in the beginning and to the reinvestment of the equipment throughout the life span and the terminal value in the final cash-flow. The full cash-flow schedule can be found in Table A in the Appendix.

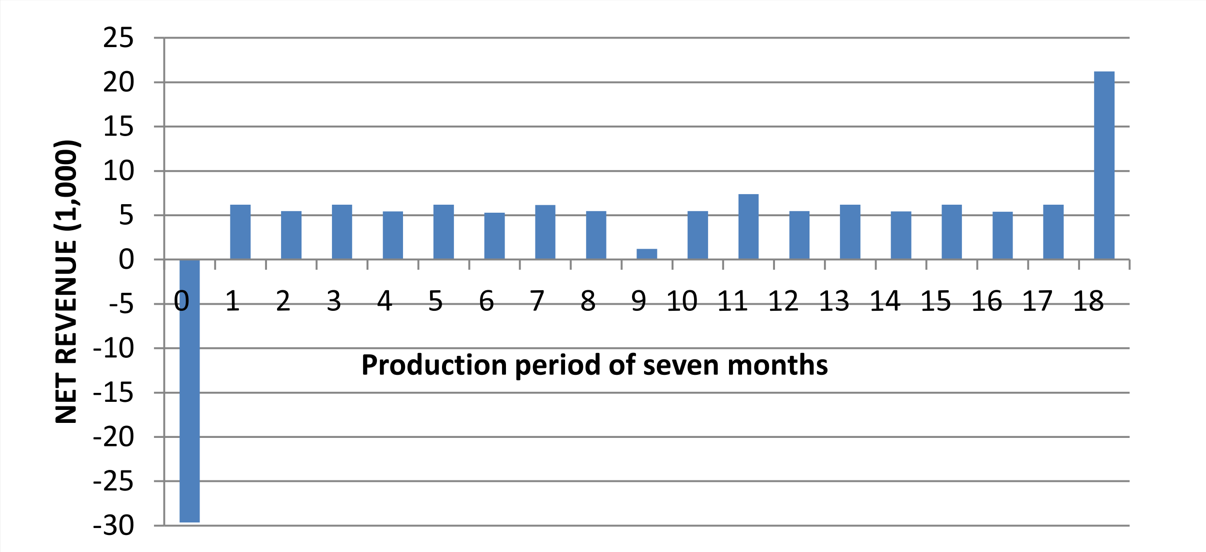

Figure 5: Cash-flow analysis for a 10.5 year aquaculture enterprise

The net revenue at the end of each period (Equation 4) was discounted to a present value assuming a 15% annual required rate of return or discount rate, which is reflected in discount rate of 8.75%[1] per production cycle, using the NPV method. The discount rate was chosen with respect to Ghana's Central Bank most current monetary rate of 13.5% and the addition of a premium on the monetary rate due to the riskiness of the project. An annual discount rate of 15% provides a positive NPV of 23,793 cedis which shows that the investment is a profitable one as well as having a fairly short payback period of 6 production cycles or 42 months and discounted payback period of 49 months or 7 production cycles as shown in Table B in the Appendix. Since the farmer is not able to sell his production until the end of the production cycle, the payback period and the discounted payback round up to an even number of production cycles. This indicates that all things being equal an investment can recover its initial cost of investment after seven production cycles and can still make a profit. Using the cash-flow obtained above to calculate the internal rate of return provides an annual IRR estimate of 32%. A benefit-cost ratio of 1.18 was also obtained which indicates that the investment is profitable (B/C ratio>1) as shown in Table C in the Appendix.

4.3 Sensitivity analysis

A sensitivity analysis was conducted to assess the effects that changes in certain variables such as the cost of fingerlings, cost of feed, survival rate, farm gate prices and the discount rate would have on dependent variables such as the net present value (Figure 6). This was done by varying one variable at a time while keeping the other factors constant. With the exception of the survival rate which was varied between -50% and 10%, all the other variables were varied between -50% and 50% of their original values.

[1] Assuming a flat annual discount rate provides a monthly discount rate of 1.25% and hence an 8.75% discount rate per 7 month production cycle.

The analysis shows that the aquaculture investment is very sensitive to the survival rate (quantity of fish remaining) at the end of the production and the price of fish (farm gate prices). The revenue depends linearly on both variables so deviations in the survival rate and price of fish will provide the same result. Figure 6 shows that with just under a 20% decrement in both the survival rate and the price of fish, the NPV becomes negative (NPV<0) showing that the enterprise is not profitable since it is making losses at that level. An increase in the cost of feed of 30% or more will result in a negative NPV and thus financial losses. It is noteworthy to mention that a calculated 30% increase in the cost of feed corresponds to an increase in the feed conversion ratio from 1.2 to 1.7 since the cost of feed depends on both the price of feed per kg and the quantity used of feed. Therefore, assuming that prices per kilogram were unchanged and only the quantities were varied shows the sensitivity of the NPV with respect to changes in the feed conversion ratio. The profitability of the enterprise is however fairly insensitive to changes in the discount rate and the cost of fingerlings. Increasing the discount rate as well as the cost of fingerling by 50% respectively still gave a positive NPV value which shows that the operation is still making profits at that level.

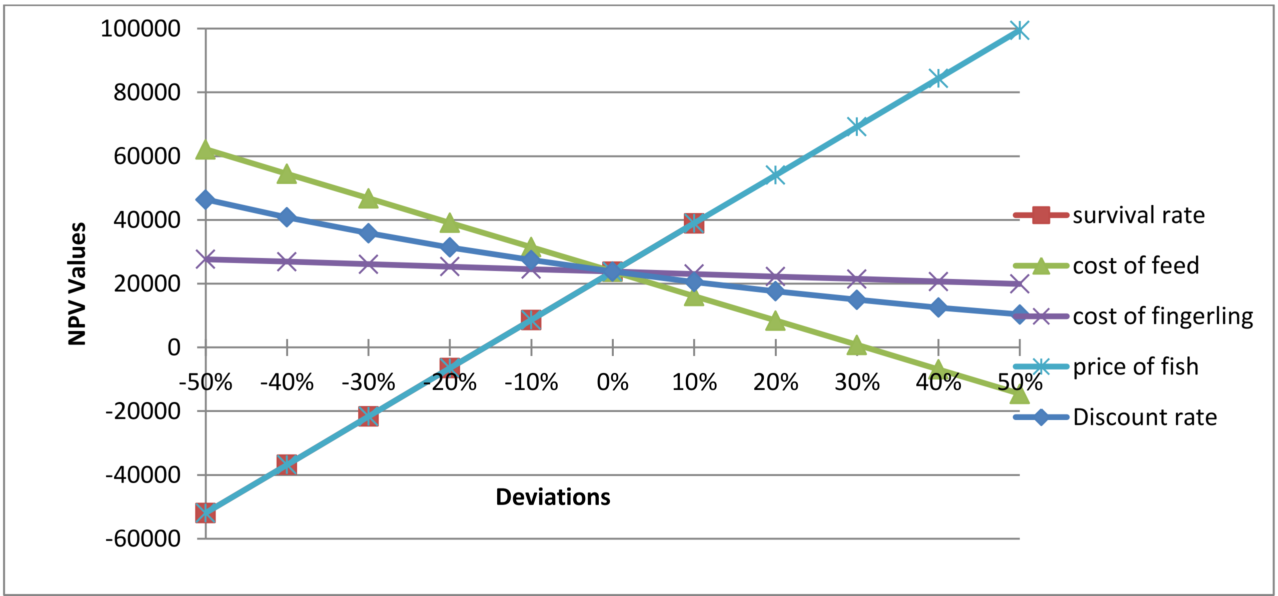

Figure 6: Effect of changes in survival rate, cost of feed, cost of fingerlings, price of fish and discount rate on NPV

The price of the fish is however directly related to the size of the fish obtained at the end of the production period so a further analysis of the correlation between production sizes, and thus farm gate prices, and the NPV is warranted. The larger the fish, the higher the farm gate price (Table 3). The revenue that the farmer receives is not a linear transformation of prices times quantities since the prices jump up and down with the size of fish, which can in a sense be viewed as a hurdle rate. The price of fish was thus varied in accordance with deviations in size of fish, keeping all other variables constant at the same time, to get a better grasp of the relationship between the size of fish and NPV (Figure 7 and Table D in the Appendix). As it turns out, the relationship between sizes and NPV is a steep stepwise function with a positive slope indicating that, other things being equal, the bigger the size of fish at harvest the higher the NPV. Figure 7 shows that the NPV is negative for a size of 350g or lower. It can therefore be stated that it is of vital importance for the viability of aquaculture that the farmers are able produce bigger sizes of tilapia.

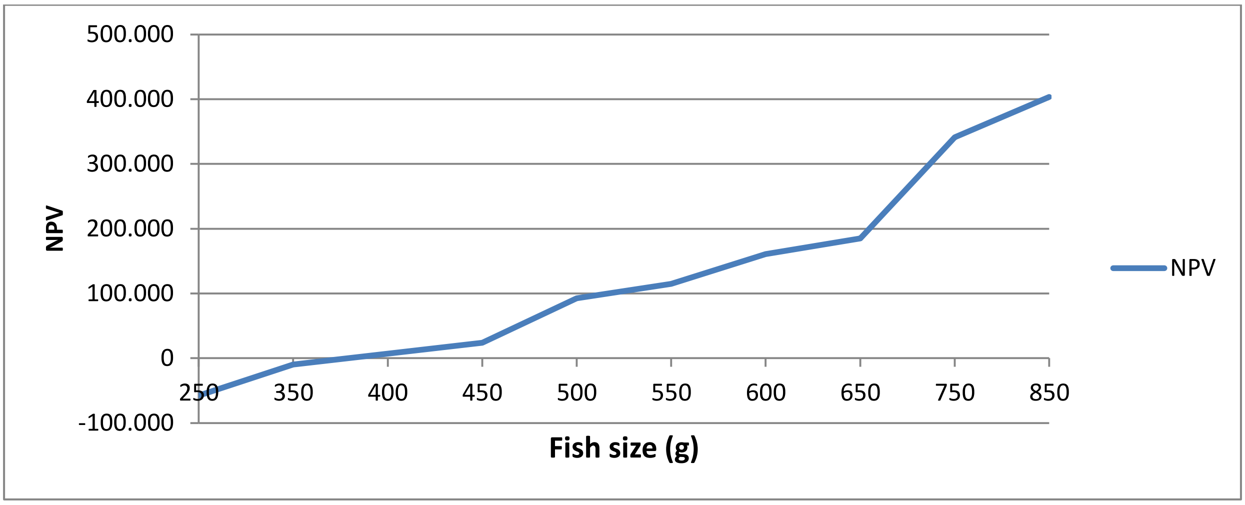

Figure 7: Effects of size variations on NPV

4.4 Viability of a smaller pond

The viability of investing in a 1000 m^2 (0.1 ha) pond was also investigated using the same assumptions and methods as in the previous analysis.

The underlying assumption of the smaller pond is that all costs and revenues depending on the scale of operations behave in the same manner as they would in the bigger pond scenario. However, there are assumed to be diminishing returns to scale with respect to the cost of procuring the land, the cost of the equipment, the amount of labour needed and the cost of electricity and maintenance. Explicitly, the costs of procuring a piece of land are the same regardless of the size of the pond and so forth. Table E in the Appendix shows the cash-flow, or net benefit, schedule for the smaller pond.

A financial viability analysis of the net benefits gave a negative NPV value of -4,245 (NPV < 0) with an IRR on an annual basis of 10.5% and a benefit cost ratio of 0.94 (B/C ratio < 1), assuming an annual discount rate of 15%. This goes to show that the investment is not feasible. The payback period obtained was 15 production cycles (8.75 years) and the discounted payback period exceeded 18 production cycles since the NPV was negative. With a smaller pond the operation will take a longer time to payback the initial investment than what is presumed to be the life span of the project. Hence this kind of investment is not profitable.

4.5. Discussions

According to the results of the study, investment in aquaculture in Ghana is a feasible and a profitable business opportunity. The calculated NPV and IRR values are much higher than zero which indicates that the investment is potentially highly profitable, that is given that the assumptions which the estimates were based on are fairly accurate. The payback period of 49 months (which is approximately 4.1 years) obtained in this study is within the ten years period considered for this operation as well as four to five years recommended by Engle (2010) for commercial operations in aquaculture to payback after investment. This is however not surprising looking at the short production cycle (7 month) for tilapia as compared to other species such as salmon culture with production cycle of more than a year (Bjorndal, 1990). Most investors find projects with short payback periods more economically attractive, especially in markets that are lacking in credit facilities. An aquaculture business which takes 10 or more years to payback the cost of investment is considered to be unprofitable (Atrill, 2003). Hence this could serve as an encouragement to investors who normally would prefer a short term investment as a measure of reducing risk. Risk is time-related in the sense that the longer it takes for an investment to recoup its cost of investment, the greater the risk of failure.

The study however shows that like many business investments, aquaculture is also a highly capital-intensive business. The estimates show that for one to enter into a production unit of 0.2 ha (2000 m^2) pond production, a total start-up capital of 29,567GH cedis (USD 21,120) is needed. Out of the start-up cost more than half (68.1%) goes into the fixed cost which involves the cost of land, pond construction and buildings. High level of investment capital needed as start-up in an aquaculture business usually stems from the high level of the fixed costs (Engle, 2010). This has become a major obstacle for many people who are interested in going into aquaculture as a business since it is fairly difficult to get access to financial support in the country.

The variable costs constituted 31.9% of the total start-up cost and this is very close to the range of 33.5% to 55% obtained by Asmah (2008) for commercial operators in the country. This rate, compared to what was obtained by Asmah (2008), is also not surprising looking at the current steps taken to reduce the operational costs in the form of availability of inputs such as fingerlings at reduced or subsidised cost. It is however very important to note that the variable costs can vary depending on the scale and the level of production that one wants to engage in. Feed is an essential commodity needed in aquaculture operations and the efficiency with which it is utilised for growth depends on its quality and its utilisation. In Ghana good quality feed is a major constraint faced by many operators. Since the country has very few feed producers, majority of the feed used in the country is imported, resulting in the high cost of feed as seen in this study. In order to obtain bigger sizes of fish, good quality feed with a high feed conversion ratio is needed. Good quality feed may cost more than what was assumed in this study. Increasing the cost of feed by 30% and above will lead to the enterprise making losses.

Good quality fingerlings are needed to maximise production so as to increase profitability. According to the results of this study, the profitability of the operation is not sensitive to changes in the cost of the fingerlings. Increasing the cost of fingerlings by 50% gives the prices at which fingerlings are sold to farmers by private operators and even at this point the operation is still profitable.

Survival rate and the farm gate price of the fish were also sensitive factors that affected the profitability of the enterprise aside from the cost of feed. The survival rate determines the quantity produced at the end of the production period. Increasing mortality rates leads to low survival rate and thus lower yields. Higher yields coupled with good prices are needed to increase revenue and thus profitability. The profitability depends on one’s capacity to increase production, reduce cost of production and also to secure a good price for the produce (Engle, 2010). Comparing the profitability of the level of investment used in this study to a production system of 1000 m^2 reveals the smaller pond to be relatively unprofitable (with B/C ratio < 1) and to have a substantially longer payback period of 8.75 years (discounted payback more than 10.5 years) as compared to just over 4 years for a pond twice the size. This is the situation of most fish farms in the country. About 60% of the production facilities are of size of less than 2000 m^2 (0.2 ha) making them unprofitable due to high start-up costs and insufficient yields as compared to most commercial operators in the country operating with larger production units above 2000 m^2 (Asmah, 2008).

Profitability is largely affected by the price at which the fish is sold (Figure 6 and Figure 7). The government’s policy to ban imports of farmed fish aims at enabling local fish farmers to get better prices and increase their profit margin at the cost of the domestic consumers and foreign producers. Price however is also strongly dependent on the size of fish. This is where good fish production technology is essential. Asmah (2008) goes so far as to imply that the ability of a Ghanaian producer to produce bigger sizes of fish allows him to set the price of his production as opposed the price-taking behaviour of those who can only produce smaller sizes of fish. Thus to be able to produce bigger sizes of fish is an advantage for the producer.

To summarize, the discussion above demonstrates that aquaculture in Ghana has a great potential to be highly profitable at the commercial level, depending on the scale of production as well as the size of the fish and the price at which the producer is able to sell the fish at the farm gate. Increasing the scale of production could mean moving from producing on a subsistence basis to a commercial basis by increasing the factors of production such as feed, fingerlings, labour, etc. By increasing the factors of production, the producer however will incur more costs, in absolute terms, than otherwise. If the production exhibits positive returns to scale, the average cost per production unit will however be lower than before.

5. AQUACULTURE POLICIES IN GHANA

Ghana's first policy for the development of the aquaculture sector dates back to the early 1950s when the government started promoting culture-based fisheries in the northern part of the country on a subsistence basis as a means to alleviate poverty. As documented in detail in chapter 2, the 1950s initiative did not see much success. Since then other sectorial policies such as the Food and Agricultural Sector Development Policies (FASDEP I & II) have been put into place. These policies have aspects that among other things focus on the development of aquaculture in the country by addressing issues concerning inputs, institutions and production systems. Aside from these sectorial policies, the current fisheries and aquaculture policy document, which is still in a draft form, is the only comprehensive policy document which has been adopted by the Fisheries Commission to serve as a blue print to govern the management of the fisheries sector (MOFI, 2008). The policy document outlines diverse strategies to promote the development of the fisheries sector in Ghana and also addresses issues concerning the development of the aquaculture sector. In order to achieve its aim of developing aquaculture, the policy outlines various operational objectives to address the specific issues concerning the sustainable development of aquaculture in Ghana. Among these are issues that concern inputs such as seed and feed, capital, human resources at various levels, partnerships, research, education and extension services, as mentioned in chapter 2, which are mostly identified or perceived as impeding the development of the sector. Recognizing the importance of promoting commercial farming, the policy also aims to encourage commercial operations on a scale that will be more profitable to enable the country to achieve its goal in providing food security, poverty alleviation and more employment.

Ghana's aquaculture policy, like most aquaculture policies in other African countries such as Uganda and Malawi, is focused on solving the problems associated with input acquisition as well as the technological development which can only be viewed as a step in the right direction. They are considered essential steps in any aquaculture development that need to be solved to serve as a stepping stone towards the development of the sector. Most of the government's interventions as well as policy measures that are put in place in the current aquaculture policy document go to show the government's interest in supporting aquaculture development in the country and furthermore in promoting commercial aquaculture production. This should be viewed as a positive step in the right direction; however to be able to appropriately target the problem at hand the policies need to be less general and more specific in nature. They need to outline steps that are clearly defined and actually implementable and should optimally have minimum short run vs. long run conflicting impacts. In this context it is vital to realize that one and the same policy is unlikely to be able to both enhance the development of aquaculture and at the same time alleviate poverty on a general basis.

5.1 Existing economic policies

The fundamental goal with any economic policy is to influence individuals, businesses or the economy as a whole to alter their behaviour. Economic policies often have conflicting short run vs. long run impacts as well as distributional impacts since their aim should always be to maximize welfare. Often, the policy goal of maximizing welfare is unattainable without making some groups of the society worse off, at least in the short run. Furthermore, economic policies need to be incentive compatible so that the resulting behaviour change is not different from what the policy makers intended to achieve.

It seems that policy makers in many African countries tackle poverty and the promotion of food industries at the same time with policies that end up having more in common with social policies than actual economic policies. When the aquaculture policies in Ghana are viewed in economic terms they can broadly be categorized into 6 groups of interventions: import bans on farmed fish, training of gangs of youth to lower the cost of pond construction, a 5 year tax break for new aquaculture enterprises, research and development aimed at lowering the cost of inputs and lowering the learning curve for better aquaculture practises, provision of fingerlings or feed and finally providing financial capital to set up an aquaculture farm.

The policy of banning imports of farmed fish with the goal of promoting good prices for locally farmed fish is a justifiable strategy in the short term to help the Ghanaian aquaculture industry in its infancy stage by raising prices of tilapia domestically and thus raising the profits of fish farmers. This can be seen in the high prices of tilapia on the market as compared to some fish species from the wild (Hiheglo, 2008). However, if the bans are not lifted when the aquaculture industry has matured, the consumer is stuck with prices higher than the prevailing world market price permanently. Thus, the policy makes producers better off and consumers worse off and is therefore not well-suited to tackle both the problems of the aquaculture industry and general poverty alleviation in the country at the same time. Furthermore, not lifting the bans on imports when the industry has matured can lead to a situation where the industry is not able to compete in the world market since the incentives to minimize costs and maximize efficiency might be partly lacking. This would have the effect of making export of tilapia from Ghana unable to compete on the world market.

Interventions such as training of youth gangs to construct ponds has the effect of lowering the cost involved in manually constructing ponds and providing employment and specialization to the youth. However, as mentioned in chapter 2, most people prefer ponds that are constructed with the help of excavators since they are more productive and often cheaper. This policy is therefore ineffective in terms of the aquaculture sector and especially with respect to the development of commercial aquaculture in Ghana. The policy is a social policy that really has the only effect of providing employment to gangs of youth that otherwise might behave in socially undesirable ways.

Setting up an aquaculture business is capital intensive. Most of the start-up capital that is needed is needed to obtain fixed assets as discussed in chapter 4. This has become a major drawback for many people interested in investing into aquaculture since getting access to financial support continues to be a major problem in the country. The government has tried to intervene by providing start-up capital to support individuals in the form of loans. Financial institutions are also encouraged to provide financial assistance, for instance financial support of over USD 500,000 to newly trained fish farmers is provided for in the 2008 government to serve as start-up capital for farmers (Hiheglo, 2008). The problem with this kind of initiative is the existence of the moral hazard problem, that is to say the risk the lender faces of the behaviour of the investor to be different than what was originally planned or agreed upon. The experience with this policy is that most people take the money and divert it into something else other than aquaculture. That is to say, these policies have turned out to be incentive incompatible. Financial institutions have also been faced with the issue of moral hazard (MacPherson, 1991) and have therefore been reluctant to provide loans. The issue of moral hazard is that people tend to take greater risks or behave differently than the financial institutions expects of them. This situation is not good for any government seeking to develop aquaculture.

Other economic policies that give incentives in the form of tax exemptions on aquaculture equipment and tax breaks, which in this case is for a period of five years, encourage entry into the aquaculture industry and enable operators to increase their profitability. Efforts to reduce the cost of fingerlings as well as the availability of fingerlings through the development of both public and private hatcheries could be seen to be paying off looking at the result of the study since the cost of fingerling is low and does not really affect the profitability of the project. However, much attention is needed in terms of technological development to produce good quality fingerlings that will enhance the productivity of the aquaculture industry.

5.2 Policy recommendations

Aquaculture in Ghana has a great potential to develop if given the right attention and assistance through good policy development. Studies conducted by Hiheglo (2008) show that the interest for people to enter into aquaculture is there but they do so as a hobby and not as a business, thus the high rate of subsistence farming in the country. The essence of this study was to demonstrate the profitability of aquaculture in Ghana so that it could serve as a source of information to both those who are already in it and to promote the idea of commercial aquaculture as a profitable business opportunity. The government should encourage fish farming on a commercial scale since subsistence operations will only have the effect of locking people in poverty for the long term since it is unprofitable.

The central problem of commercial aquaculture in Ghana is the relatively high start-up cost and weak financial institutions that are reluctant or unwilling to lend to investors due to the problems of moral hazard, asymmetric information and adverse selection. Therefore, any future policies concerning aquaculture in Ghana need to find ways to minimize start-up costs and/or find ways to provide financial assistance to fish farmers in a manner that is incentive compatible. It is in this light that the following policy plan is proposed.

The government could initiate a programme that provides production facilities such as commercially sized ponds in clusters to be leased to individuals or groups on a fairly short term basis with the possibility of gaining ownership at the end of the lease term. Placing the commercial aquaculture industry in clusters will among other things have the effect of providing maximum scale of efficiencies in terms of lowering the cost of security from poachers and lowering the cost of transportation, especially if hatcheries are placed within the clusters. Having commercial farmers all in the same place will also strengthen their collective power to bargain with wholesale buyers on the farm gate prices of fish and thereby increase their share in the retail price of fish. With respect to the clusters, the Ghanaian government could look to the Asian aquaculture industry which has over the years gained a valuable experience on the use of clusters in aquaculture (Umesh *et al*., 2010). It is essential in these kinds of systems that measures are put into place to eliminate the possibility of cross contamination between individual ponds to prevent diseases from spreading from one production unit to another.

This kind of policy intervention could help alleviate the problem of moral hazard as explained earlier. With this kind of financial assistance, the renter could realistically, based on the assumptions made in the cost-benefit analysis of the 2000 m^2 pond, become the owner after a period of five and a half years which is equivalent to nine production cycles given that the government's only objective is to break even and not to make profits in the form of rents. Table F in the appendix shows the financial viability of the policy from the government's perspective given a 13.5% annual discount rate since the government should at least be able to finance itself at a rate as low as the central bank rate. The results show that a rent of 4,718 GH cedis at the end of each production cycle is needed for a NPV value of zero and therefore a discounted payback period of 9 production cycles.

The opportunity for fish farmers to be able to rent a pond from the government provides them with the chance to learn by doing without directly incurring the risk of high start-up costs. The policy should have clearly defined terms of productivity which sees to it that those who are not functioning well or producing efficiently are replaced with new renters. It should also allow for some level of shocks in production such that if one loses its production during a production period, the lease could be extended for a production cycle since aquaculture is a highly risky business with respect to disease and harvest shocks. In this regard there should also be some implementable constraints that would make the farmers save a part of their income to face any future uncertainties or shocks that might arise. Table G in the appendix shows financial viability of renting a 2000 m^2 pond from the farmer's perspective based on the cash-flow calculations from chapter 4. The assumptions being made in the scenario are that the farmer is responsible for all operational costs incurred and will be the beneficiary of any extra revenue left over after having paid the production cost for the next cycle and the rent owed to the government. The results in Table G show that given the break even rent of 4,718 GH cedis, the cash-flow assumptions from chapter 4 and an annual discount rate of 13.5%, each farmer will have a positive NPV of 8,620 GH cedis for a period of 9 production cycles. For this scenario to be incentive compatible, the government would need to have a centralised authority that would be in charge of paying the farmers rent and operational costs for the next production cycle before the farmer would be able to receive his benefits which are operational revenues minus cost and rent. That is to say, the farmer's income from operations would depend on the revenues from production minus the expected cost for the next production cycle. If the farmer produces efficiently he will be able to receive positive benefits but if he is unproductive or experiences production shocks, he will only receive the minimum wage and be given one extra production cycle to prove his ability to take part in the program. Those farmers who are able to finish the programme successfully will become the owners of their ponds after 9 production cycles and the sole beneficiaries to the associate revenue stream or net benefits that can be seen in Table A in the Appendix.

A GIS study conducted by Asmah (2008) reveals that 2% (3,692 km^2) of Ghana's available land is suitable for subsistence farming and 0.2% (313.8 km^2) suitable for commercial operation. Most of these lands are found in areas with good markets for tilapia. With this kind of policy, developing the 0.2% land available for commercial operations alone could lead to the production of an estimate of 1,098,300 tonnes of fish per year which exceeds the 460,000 tonnes needed to bridge the nation's annual fish deficit. In this way the country could be sure of solving the issue of the nation's fish deficit.

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APPENDIX

Table A: Cash-flow analysis for investing into a 2000 m^2 pond

Production period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Start up cost																			
1 Land																			
Land acquisition	-2000																		2000
topographical/survey charges	-1000																		
Documentation	-1000																		
Contingencies	-2000																		
2 Pond construction																			2814.85
Hiring of excavator(2 days)	-5606																		
Cost of grassing	-200																		
Cost of PVCpipes for inlets and out lets	-120																		
3 Equipments																			
Cutlass	-3.85				-3.85			-3.85				-3.85			-3.85				
Shovels	-5.51				-5.51			-5.51				-5.51			-5.51				
Boots	-10.22				-10.22			-10.22				-10.22			-10.22				
Head pan	-3.7				-3.7			-3.7				-3.7			-3.7				
Buckets	-3.32				-3.32			-3.32				-3.32			-3.32				
Wheel barrow	-56.4						-56.4					-56.4					-56.4		
Weighing scale	-6.5							-6.5							-6.5				
Nets	-130.42						-130.42												
Pumps machine	-725.27									-725.27									
Aerator	-2500									-2500									
Water quality kit	-150									-150									
Generator	-600									-600									
Refrigerator	-1000									-1000									
Farm house	-3000																		1425
Variable cost																			
Fish seed (fingerling)	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	-800	
Feed	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	-7920	
Lime	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	-36	
Fertilizer	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	-110	
Packaging of fingerling	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	
Labour (2)		-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2		-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2
Transportion	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	-500	
Electricity	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	
Maintanace and repairs			-720		-720		-720		-720		-720		-720		-720		-720		-720
Harvesting cost		-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16
Quantity of tilapia * farm gate price * size		17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010	17010
Net benefit	-29627.2	6181.8	5461.8	6181.8	5435.2	6181.8	5274.98	6148.7	5461.8	1206.53	5461.8	7405	5461.8	6181.8	5428.7	6181.8	5405.4	6181.8	21207.65

Table B: Cumulative cash flow and cumulative PV of cash flow

Production cycle (month)	Cash flow	Cumulative cash flow	PV of cash flows at 15%	Cumulative PV
0	-29627.2	-29627.2	-29627.12	-29627.2
7	6181.8	-23445.4	5684.4	-23942.8
14	5461.8	-17983.6	4618.2	-19324.5
21	6181.8	-11801.8	4806.5	-14518.0
28	5435.2	-6366.6	3886.0	-10632.1
35	6181.8	-184.8	4064.1	-6567.9
42	5275.0	5090.2	3189.0	-3379.0
49	6148.7	11238.9	3418.1	39.0
56	5461.8	16700.7	2791.9	2830.9
63	1206.5	17907.2	567.1	3398.1
70	5461.8	23369.0	2360.7	5758.8
77	7405	30774.0	2943.1	8701.9
84	5461.8	36235.8	1996.1	10698
91	6181.8	42417.6	2077.5	12775.4
98	5428.7	47846.3	1677.6	14453
105	6181.8	54028.1	1756.6	16209.6
112	5405.4	59433.5	1412.4	17622.1
119	6181.8	65615.3	1485.3	19107.4
126	21207.7	86823.0	4685.6	23793.0
NPV: 23793				
IRR: 32%				

Table C: Benefit-cost ratio

Production cycle #	Total benefits	Total costs	Discounted benefits	Discounted costs
0	0	-29627.2	0	-29627.2
1	17010	-10828.2	15641.4	-9957.0
2	17010	-11548.2	14382.9	-9764.6
3	17010	-10828.2	13225.6	-8419.2
4	17010	-11574.8	12161.5	-8275.5
5	17010	-10828.2	11183.0	-7118.9
6	17010	-11735.02	10283.2	-7094.3
7	17010	-10861.3	9455.8	-6037.8
8	17010	-11548.2	8695.0	-5903.1
9	17010	-15803.47	7995.4	-7428.3
10	17010	-11548.2	7352.1	-4991.4
11	17010	-9605	6760.6	-3817.5
12	17010	-11548.2	6216.6	-4220.5
13	17010	-10828.2	5716.4	-3638.9
14	17010	-11581.3	5256.5	-3578.9
15	17010	-10828.2	4833.5	-3076.9
16	17010	-11604.6	4444.6	-3032.2
17	17010	-10828.2	4087.0	-2601.7
18	23249.9	-2042.2	5136.8	-4512025
sum =	312419.9	-225596.9	152828.0	-129035
				BCR: 1.18

Table D: Effect of size variation on the NPV

Size(g)	Farm gate price (GH cedis)/kg	Revenue	NPV
250	3.5	7875	-57541
350	4.2	13230	-9862.4
400	4.2	15120	6965.3
450	4.2	17010	23793.0
500	5.5	24750	92706.5
550	5.5	27225	114742.7
600	6	32400	160818.6
650	6	35100	184858.2
750	7.8	52650	341115.5
850	7.8	59670	403618.4

Table E: Cash flow analysis for investing into a 1000 m^2 pond

Production periods	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Start up cost																			
1 Land																			
Land acquisition	-2000																		2000
topographical/survey charges	-1000																		
Documentation	-1000																		
Contingencies	-2000																		
2 Pond construction																			1331.43
Hiring of excavator(2 days)	-2803																		
Cost of grassing	-200																		
Cost of PVCpipes for inlets and out lets	-120																		
3 Equipments																			
Cutlass	-3.85				-3.85			-3.85				-3.85			-3.85				
Shovels	-5.51				-5.51			-5.51				-5.51			-5.51				
Boots	-10.22				-10.22			-10.22				-10.22			-10.22				
Head pan	-3.7				-3.7			-3.7				-3.7			-3.7				
Buckets	-3.32				-3.32			-3.32				-3.32			-3.32				
Wheel barrow	-56.4						-56.4					-56.4					-56.4		
Weighing scale	-6.5							-6.5							-6.5				
Nets	-130.42						-130.42												
Pumps machine	-725.27									-725.27									
Aerator	-2500									-2500									
Water quality kit	-150									-150									
Generator	-600									-600									
Refrigerator	-1000									-1000									
Farm house	-3000																		1425
Variable cost																			
Fish seed (fingerling)	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	-400	
Feed	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	-3960	
Lime	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	
Fertilizer	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	-55	
Packaging of fingerling	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	
Labour (2)		-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2	-1306.2
Transportion	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	
Electricity	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	-60	
Maintanace and repairs			-720		-720		-720		-720		-720		-720		-720		-720		-720
Harvesting cost		-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16
Revenue = Quantity of fish*Price*Size		8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505	8505
Net revenue	-22101	2399.8	1679.8	2399.8	1653.2	2399.8	1492.98	2366.7	1679.8	-2575.5	1679.8	2316.8	1679.8	2399.8	1646.7	2399.8	1623.4	2399.8	11219.2
Discount net revenue	-22101	2206.71	1420.36	1865.9	1181.98	1577.72	902.565	1315.64	858.664	-1210.6	726.047	920.803	613.912	806.482	508.868	681.924	424.187	576.604	2478.77

Table F: Financial viability of policy from government's perspective

Production periods	0	1	2	3	4	5	6	7	8	9
Start-up cost	-29627.2									
rent		4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1
Net benefits	-29627.2	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1	4718.1
Discounted net benef	-29627.2	4373.7	4054.4	3758.4	3484.0	3229.7	2993.9	2775.4	2572.8	2384.9
NPV	0									

Table G: Financial viability of policy from farmer's perspective

Production periods	0	1	2	3	4	5	6	7	8	9
rent		-4718.1	-4718.1	-4718.1	-4718.1	-4718.1	-4718.1	-4718.1	-4718.1	-4718.1
wages		653.1	653.1	653.1	653.1	653.1	653.1	653.1	653.1	653.1
Expected revenues		17010.0	17010.0	17010.0	17010.0	17010.0	17010.0	17010.0	17010.0	17010.0
Expected costs		-10828.2	-11548.2	-10828.2	-11574.8	-10828.2	-11735.0	-10861.3	-11548.2	-15803.5
Net benefits	0	2116.8	1396.8	2116.8	1370.2	2116.8	1210.0	2083.7	1396.8	-2858.5
Discounted net benef	0	1962.3	1200.3	1686.2	1011.8	1449.0	767.8	1225.7	761.7	-1444.9
NPV		8620.0								