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F. K. E. Nunoo
University of Ghana

Eunice Konadu Asamoah
University of Ghana

Aquaculture Research

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Economics of aquaculture production: a case study of pond and pen culture in southern Ghana

Francis Kofi Ewusie Nunoo[1], **Eunice Konadu Asamoah**[1] & **Yaw Bonsu Osei-Asare**[2]

[1]Department of Marine and Fisheries Sciences, University of Ghana, Legon, Ghana

[2]Department of Agricultural Economics and Agribusiness, College of Agriculture and Consumer Sciences, University of Ghana, Legon, Ghana

Correspondence: E K Asamoah, Department of Marine and Fisheries Sciences, P.O. Box LG 99, University of Ghana, Legon, Ghana. E-mail: ekonadutwum@yahoo.com

Abstract

This study was carried out in four regions in Southern Ghana with the objective of assessing the demographic profile of farmers and determining the profitability of the industry. A structured questionnaire was used to collect primary data from 74 pond and 13 pen farmers in the selected regions. The results showed that species mostly cultured were tilapia (*O. niloticus*), catfish (*Clarias* sp.), *Heterotis* sp. and snakehead (*Parachanna* sp.). Descriptive analysis showed the ponds were generally larger than pens. More than 50% of the total farmers had between one and two ponds or pens. The average net returns were US$ 0.55 and US$ 0.42 m^{-2} for pond and pen culture respectively, making both systems profitable. On a regional basis, pond aquaculture was most profitable in the Western Region. From the results, both pond and pen aquaculture are presently a profitable venture in Ghana that will continue to attract more potential investors even in the next decade. Pond aquaculture was classified into small-, medium- and large-scale operations. Results indicated that small-scale operations were economically non-viable under the present situation, with large-scale operations being the most profitable. The main constraints affecting production were lack of capital, fish predators and poaching.

Keywords: aquaculture, cost structure, profitability, net returns, break-even analysis

Introduction

Fisheries resources provide food, income and employment for people in many parts of the world (Bledar 2007). In Ghana, the fisheries industry is estimated to contribute 4.5% to the national GDP and employs an estimated 2 million people (Kwadjoss 2009). The country is considered one of the highest fish-consuming countries, with an average annual *per capita* fish consumption estimated at 23 kg, which is higher than the World average of 13 kg (FAO 2004). The total annual fish requirement is estimated at 880 000 tons, while national fish production stands at an average of 420 000 tons, implying a deficit of 460 000 tons, which is bridged through fish imports (Kwadjoss 2009). The Ghana government spends an average of US$ 200 million annually importing fish to supplement local production (Quagrainie, Kaliba, Osewe, Mnembuka, Senkondo, Amisah, Fosu, Ngugi & Makambo 2005). Foreign exchange rates, however, constrain importation. The decline in marine fisheries resources, overfishing in inland waters and increasing population growth rate estimated at 1.822% (Central Intelligence Agency [CIA] 2011) with attendant higher demand for fish have encouraged Ghanaians to look closely at the opportunities presented by aquaculture.

Aquaculture has the potential to reduce pressure on natural stocks and support local communities that have for years relied on fishing (Bledar 2007). It is also an important domestic provider of high-quality animal protein, generally at prices affordable to the poor segments of society (Barg, Bartley, Kapetsky, Pedini, Satia, Wijkstrom & Willmann 1999). The practice of aquaculture was introduced in Ghana in 1953 by the Directorate of Fisheries (FAO 2006–2012). A lot of people are engaged in aquaculture, especially through the awareness creation efforts of the Directorate of Fisheries. It has been estimated that the production from ponds and culture-based fisheries is worth about US$ 1.5 million a year (FAO 2006–2012).

Most fish farmers in Ghana use earthen ponds and rely on natural productivity to feed fish, while others supplement feed with agricultural by-products (FAO 2006–2012). Pens, on the other hand, are relatively a new production system to Ghana. A fish pen is defined as a fixed enclosure in which the bottom is the bed of the water body (SEAFDEC/IDRC 1979). Pens are generally built in large open waters such as lakes, reservoirs and rivers. Fish pens are distinguished from a fish cage, which is defined as an enclosure with bottom and sides of netting or bamboo, etc., whether floating at the surface or totally submerged. Cursory information on pens indicates that the practice is in use only in areas especially along the Volta River such as Sogakope, Adidome and Mepe. In the absence of technological limitations, the selection of species for culture to obtain maximum profit is usually determined by the relative economics of production and marketing. The Nile tilapia, *Oreochromis niloticus* (Linnaeus 1758) is a high-value species (Popma & Masser 1999) and is the predominant species cultured, constituting over 80% of aquaculture production. The catfish (*Clarias* sp., *Heterobranchus* sp.) and African bonytongue, *Heterotis niloticus* (Cuvier 1829) account for the remaining 20% (FAO 2006–2012).

The continued growth and development of aquaculture production will be dependent on its ability to make profits. Therefore, measuring current and past profitability and projecting future profitability as well as the associated risks are of great importance to current and prospective entrepreneurs and likely financiers. As the aquaculture sector is expected to contribute towards economic growth, food security and poverty alleviation of present and future generations of Ghanaians, it is expedient to examine the profitability of aquaculture to identify possible areas that require improvement.

The objective of the study was to assess the demographic profile of the fish farmers, describe their operations and to determine the profitability of pond and pen culture systems in the Western, Central, Volta and Greater Accra regions of Ghana.

Methodology

The study was conducted in four regions of southern Ghana; the Western, Central, Greater Accra and Volta Regions, which are highly populated and cover an area of approximately 57 562 km^2 or 24% of Ghana's total area (Ministry of Local Government & Rural Development [MLGRD] 2006). These regions were selected because of the high concentration of fish farmers, high fish consumption and marketing rates. Pond culture is practised in all these areas, whereas pen culture is found mainly in the Volta region and most especially at Sogakope, Mepe and Adidome areas. A structured interview guide, with closed and open-ended questions, was used to collect data on management practices and input–output data for 74 of 202 farmers (37%) pond and 13 of 20 farmers (65%) pen farmers, from October 2007 to June 2008. For pond culture, systematic random sampling was used to collect data. First, the number of farmers to be sampled, for each region, was calculated by proportion from the total population of farmers in the region. The farmers were then numbered, and every third farmer was selected until the required number was obtained. The regional break-downs are as follows: 38 of 83 farmers (46%), 19 of 53 farmers (36%), 11 of 57 farmers (19%) and 6 of 9 farmers (67%) farmers from the Western, Central, Volta and Greater Accra Regions respectively. Interviews and on-farm observations were used in data collection.

Data processing and analysis

Cost structure analysis

Costs of production were classified as variable and fixed costs (Engle & Neira 2005). Variable costs include cost of fingerlings, feed, fertilizer, transportation, labour and interest on operation capital. Cost of family labour was calculated as an opportunity cost of the farmer. It is estimated that one unskilled individual will spend 5% of the available time to manage the pond, which includes feed preparation/collection, feeding, harvesting and marketing (Quagrainie *et al.* 2005). Family labour was utilized based on the availability of the individual. Full-time workers, on the other hand, worked for the whole week (i.e. 7 days a week). The cost is based on a minimum daily wage of US $ 1.97 for 2008. Interest on operating capital and investment was calculated based on a 27.25% interest rate (ranging between 19.5% and 35.0%) for fourth quarter of 2008 (Ghana Business News [GBN] 2009). Fixed costs include depreciation of pond/pen and equipments. Depreciation was calculated using the straight line method by dividing the cost by the life span of the equipment/facilities (Cruz, Al-Ameeri, Al-Ahmed & Ridha 2000).

Ponds and pens were depreciated, on the average, over 10 (Amos & Bolorunduru 2000) and 5 years respectively. The value of land is based on the opportunity cost of not producing maize on the plot allocated to fish farming. Maize is an important crop in areas that have potential for aquaculture operation.

Profitability analysis

Increasing profitability is one of the most important drivers of business managers who continually look for ways to change the business to attain this objective (Engle & Neira 2005). A properly conducted profitability analysis provides very useful evidence concerning the earnings potential of a company and the effectiveness of management. A simple economic analysis detailing costs and returns is used to estimate profitability of each production system. The data required for calculating profitability include the following: gross revenue; variable costs: expenses that are actually paid and vary with quantity of fish produced and fixed costs, which are independent of production. Gross revenue includes part of total output consumed, given away as gift and sold.

Performance indicators

The performance indicators of interest were (i) gross revenues; (ii) gross margin/profit; (iii) net returns; (iv) break-even price; (v) break-even production; (vi) returns to capital and management; (vii) returns to land, capital and management; (viii) rate of return to capital invested; (ix) rate of return to total investment. These indicators were estimated based on cost and returns tables derived from survey questionnaires.

Statistical analysis

Data and information collected were coded and incorporated into computerized databases using Statistical Package for Social Science (SPSS) and Excel software. The primary data were tested for normality (using the Jarque–Bera test). The Wilcoxon Rank-Sum Test was then used when there was non-normal distribution. Data for profitability estimation were standardized for pond sizes (that is, data were divided by pond size, for each farmer, to give a per-meter square value that could be compared). Data were analysed using descriptive statistics and budgetary techniques. ANOVA was used where necessary to test statistical significance of the parameters. The alternate least squares difference (LSD) approach was used to test for significant differences in pond culture for the different regions (that is between Greater Accra and Western region; Greater Accra and Central region; Greater Accra and Volta region; Western and Central region; Western and Volta region and Central and Volta region).

Results and discussion

Demographic profile of farmers

Of the respondents, there were 65 males and nine females for pond culture, whereas there were 12 males and one female for pen culture (Table 1). Aquaculture is therefore principally male-oriented particularly in relation to pond preparation, input procurement (fingerlings, fertilizer and feeds) and application of fertilizer and harvesting. Asmah (2008) attributed the low number of female ownership of farms to the fact that traditionally men

Table 1 Average age of farmers, median household size and years spent in fish farming

	Gender				
Region	Male	Female	Average age	Median household size	Median number of years in farming
Greater Accra	6	0	49.8 ± 7.8	5	3
Western	32	6	49.6 ± 11.5	7	4
Central	16	3	50.4 ± 13.2	8	12
Volta	11	0	52.2 ± 14.7	4	12
Av. total	65	9	50.2 ± 12.0	7	6
Volta	12	1	47.1 ± 16.1	5	2

are deemed to be the heads of the household unit in Ghana and farms owned and run by a family are likely to be in the name of the head of the family. Also, the involvement of women in subsistence fish farming activities also remains relatively unchanged and limited to feeding, processing of harvested fish and marketing. This level of participation contrasts with the situation in crop farming where the male to female ratio is about 1:1 (Ghana Statistical Service 2002). In some Asian countries, low participation of women in aquaculture has been reported, where their role has been limited to mechanical and menial tasks (Setboonsarng 2002). Women have been thought to play a crucial role in aquaculture production where their participation is higher. A study in Cambodia found that where women carried out 50% or more of the tasks associated with the culture of fish, there were higher yields than those with lower participation by women (Nandeesha & Heng 1994).

All the respondents (pond and pen farmers) had an average age of 48.7 ± 12.6 SD years) (Table 1). Pond farmers had an average age of 50.2 ± 12.0 SD years), whereas the average age of pen farmers was 47.1 ± 16.1 SD years), placing both in the middle-age class. The difference in ages of pond and pen farmers was, however, not statistically significant (ANOVA, $F = 0.64$, $P > 0.05$). From the survey, the youngest farmers were in their late 20s and early 30s. This is consistent with observations made by FAO (2005) that age of the Ghanaian fish farmers, in keeping with the population itself, shows clearly that fish farming is something older and middle-aged farmers do; very few young people venture into aquaculture. Addae-Mensah (1981) placed the economically active age group in Ghana at 15–65 years. Onumah and Acquah (2010) stated that older farmers are technically less efficient than the younger ones who are progressive and willing to implement new production systems. Therefore, if aquaculture is to survive in Ghana, effective programmes therefore urgently need to be conceived and implemented that will attract youth to aquaculture.

Household size distribution was found to be non-normal and hence the median values were used, which were for 7.0 and 5.0 individuals, for pond and pen farmers respectively. The difference between the household size was, however, statistically significant (Wilcoxon Rank-Sum Test, $z = 0.006$, $P < 0.05$). The differences in size of households engaged in pond culture activities were not significantly different (Wilcoxon Rank-Sum Test, $P > 0.05$). The large households could be a source of cheap and affordable labour for the farmers. In terms of aquaculture farming experience, pond and pen farmers reported a median of 6.0 and 2.0 years respectively (Table 1). This difference was, however, statistically significant (Wilcoxon Rank-Sum Test, $z = 4.3e{-}005$, $P < 0.05$). Pen culture is relatively new, judging by the number of years it has been in practice. Pond culture farming experience was significantly different between only Western and Central regions (Wilcoxon Rank-Sum Test, $z = 0.0002$, $P < 0.05$) and Western and Volta regions (Wilcoxon Rank-Sum Test, $z = 5.7e{-}005$, $P < 0.05$).

About 43.2% of pond farmers had completed middle school education, whereas the others had completed various levels of education (primary, tertiary and post secondary). On the other hand,

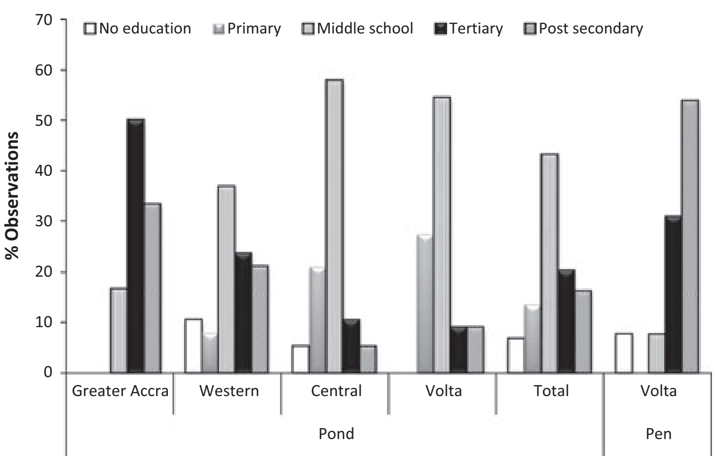

Figure 1 Educational attainment by culture facility and region.

however, 53.8% of pen farmers had completed post-secondary education (Fig. 1). Pen farmers in the Volta region appeared to have a higher educational achievement as compared with pond farmers from the same region (Fig. 1). The level of education of the fish farmers is generally thought to have an effect on the knowledge level, skill development, exposure to production technology and marketing practices, and adoption level of improved technology (Singh 2003). Onumah and Acquah (2010) reported a positive relationship between households with high level of formal education and technical efficiency of farmers. The level of education can help in designing training programmes tailored to their levels, which, in the long-term, would contribute to the development of aquaculture.

A total of 9.5% and 15.4% of pond and pen farmers respectively claimed that fish farming was their major occupation, while a greater percentage (51.4%) of pond farmers were engaged in crop production. Fish farming was a secondary occupation for farmers in the Central and Volta Regions. A greater majority of pen farmers (84.6%) were engaged in other occupations, like civil servants, artisans, self-employed etc. (Fig. 2). This supported findings by FAO (2005) that farmers use occupational diversification as a survival strategy as well as a means of spreading risk in case of failure.

As to the source of water for pond operations, 39.2% used water from nearby stream, 59.5% depended on ground water and rainfall, and 1.4% used water from a reservoir. There are, however, some disadvantages and advantages on relying solely on rain or ground water source, even though they make up a higher percentage of water sources for pond culture (Kelly & Kohler 1997). Rainwater is not considered an ideal sole source as during dry or drought periods, water losses from the pond may result in higher densities of fish in the pond, which can lead to various water quality problems, resulting in the loss of all the fish. On the other hand, water from streams and rivers usually has high oxygen concentrations and, if the topography is right, pumping into the ponds may be unnecessary. Groundwater, on the other hand, is most preferred for aquaculture, particularly if an abundant supply of good-quality water could be obtained without having to drill a deep well (Stickney 2005). Problems, however, arise when it renders the pond un-drainable, and where water exchange depends primarily on infiltration. Pen farmers used water from the Volta River.

Farm level information

The median farm size (Fig. 3) was estimated at 1187 and 648 m^{-2} for pond and pen systems respectively (statistically not significant; Wilcoxon Rank-Sum Test, $z = 0.12$, $P > 0.05$). Farms were categorized as small (1000 m^{-2} and less), medium (between 1001 and 3000 m^{-2}) and large (more than 3001 m^{-2}) based on wide spread of sizes observed. Small-scale operations were numerically dominant in all districts. Pond sizes were much larger than pens, with median values of 514.0 and 162.0 m^{-2} respectively (Fig. 3) The difference was statistically significant (Wilcoxon Rank-Sum Test, $z = 0.008$, $P < 0.05$). Both systems, however, averaged two units per farmer. By numbers, those with one to two ponds or pens were the majority (Fig. 4). Some pond farmers had more than seven ponds on their farms, whereas the maximum number of pens was six.

Land ownership in Ghana is either by stools or skins (i.e. lands under the custodianship of chiefs, who are the cultural heads of traditional areas), clans, families, individuals or the state. The stools, clans, families and the individual together are

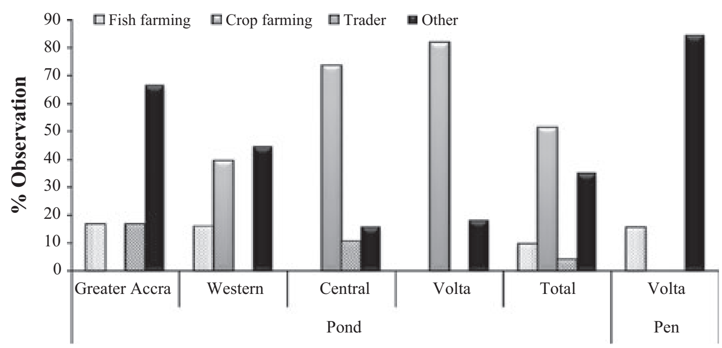

Figure 2 Major occupation by culture facility and region.

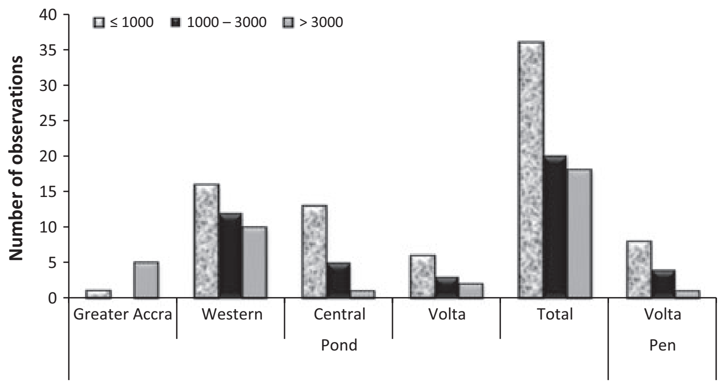

Figure 3 Distribution of farm size by region.

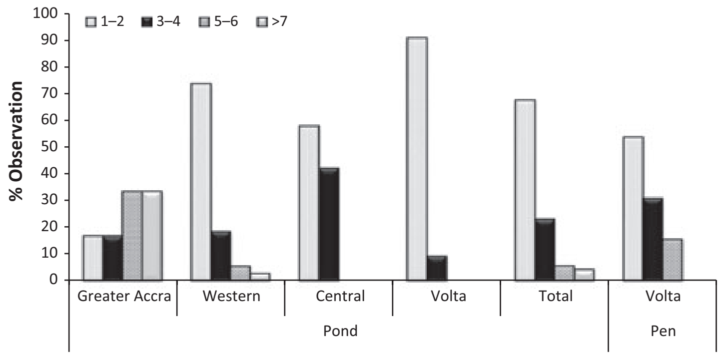

Figure 4 Distribution of culture systems by number and region.

custodians of about 70% of the land (Larbi, Odoi-Yemo & Darko 1998). From the results, about 59.5% and 76.9% of pond and pen farmers respectively owned their facilities, whereas the others leased (Table 2). Leases were generally given for 99 years. The study illustrates that access to water and land, along with supply of inputs, opens up opportunities for aquaculture. Non-ownership of land does not always deter entry to tilapia farming. Owner-operators have secure leases to their land. The ability to purchase the required inputs depends on access to funds, whether from one's own savings or from external sources. Most farmers use their own resources to finance their operations. For those who have inadequate family resources, the financial barrier can be overcome by credit lines with feed suppliers, friends, relatives or financiers. Net profits were divided between farmers and relatives.

Pond construction was largely by manual excavation. Pen construction, on the other hand, was entirely manual (Table 2). Farmers used manual construction because of the alleged high cost of using mechanical methods. However, this perception was not validated by information obtained from this study, which showed that the cost of mechanical construction was lower than that for manual construction (i.e. GH ¢1.61 and GH ¢ 2.87 m^{-2} for mechanical and manual respectively). This observation was consistent with those made by Wijkstrom and Vinke (1991) and Asmah (2008) that manual construction was of a slightly higher cost than mechanical methods. Economically, mechanical methods of construction have the advantage of reducing the labour force needed in construction as well as producing efficient structures (Pillay & Kutty 2005). Manual construction, on the other hand, generates employment and family labour can be utilized.

The underlying reason for undertaking aquaculture was to make profit (Table 2). 89.2% and 100% of pond and pen farmers respectively gave profitability as their main reason for engaging in aquaculture, highlighting the role of aquaculture

Table 2 Farm-level information for pond and pen farmers

		Pond										Pen	
		Greater Accra		Western		Central		Volta		Total		Volta	
Farm-level information		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ownership	Owned	1	16.7	23	60.5	14	73.7	6	54.5	44	59.5	10	76.9
	Leased	5	83.3	15	39.5	5	26.3	5	45.5	30	40.5	3	23.1
	Total	6	100	38	100	19	100	11	100	74	100	13	100
Type of construction	Manual	1	16.7	31	81.6	19	100	11	100	62	83.8	13	100
	Mechanical	5	83.3	7	18.4	0	0	0	0	12	16.2	0	0
	Total	6	100	38	100	19	100	11	100	74	100	13	100
Reason	Profitability	6	100	33	86.8	17	89.5	10	90.9	66	89.2	13	100
	Own consumption	0	0	5	13.2	2	10.5	1	9.1	8	10.8	0	0
	Total	6	100	38	100	19	100	11	100	74	100	13	100

in generating cash income for the household rather than food for home consumption. Other reasons were for personal consumption and for pleasure, but these were just secondary. A study in Thailand attributed 100% of the reason for farming as profitability (Boonchuwong, Boonchuwong & Noorit 2007) To some extent, advice from family members and observation of other tilapia farms also influenced decision making (FAO 2006–2012).

Culture type and stocking

A majority of pond (i.e. 55.4%) and pen (i.e. 92.3%) farmers practised polyculture. Rakocy and McGinty (1989) reported that tilapia are frequently cultured with other species to take advantage of many natural foods available in ponds and to produce a secondary crop, or to control tilapia recruitment and allow the original stock to attain a larger market size.

The species mostly used in polyculture included tilapia (*O. niloticus*), catfish (*Clarias* sp.), *Heterotis* sp. and snakehead (*Parachanna* sp.). Monoculture practices involved stocking with all male, sex-reversed, hand sexed or both sexes of tilapia. A reliable supply of good quality fingerlings obtained at a reasonable cost is one of the most important requirements for aquaculture (Shang 1985). Fingerlings were sourced from the Aquaculture Research and Development Centre (ARDEC, Akosombo), other farmers, commercial fingerlings producers (for example Tropo Farms) and from the wild. Some farmers cited that catfish from adjacent water bodies get into their facilities. A report by FAO (2006) stated that the reliance of farmers on fingerlings from wild stocks and fellow fish farmers could constrain the sector as fingerlings available from the wild are considered an unreliable source in large-scale farming, as their abundance in nature depends on a number of unpredictable factors and are also either matured or of poor genetic quality and health or are undesirable species.

A mid-2004 training of fish farmers in catfish fingerling production resulted in more farmers specializing in fingerling production for sale to other farmers (FAO 2005). The usual sizes for stocking of tilapia was 5 g and catfish was 10 g. Average stocking density for tilapia was 4.9 ± 5.7 and 16.9 ± 10.8 fish m^{-2} for pond and pen farmers respectively. This was higher than that recommended by the Directorate of Fisheries i.e. four fish per m^2.

Feeding, pond fertilization and equipments used

A wide variety of feeds were used by farmers, with the most common comprising of wheat, rice and maize bran, supplemented by various leaves and vegetables, especially cooked cassava, and a variety of other foodstuffs, which was consistent with a study conducted by FAO (2005). These were mostly obtained from local markets with prices ranging from US$ 1.75 to US$ 2.63 per bag (GH ¢ 1.14 was equal to US$ 1.0 at the time of this study). Some farmers used compound feeds like the Ranaan feed and fish meal, which, they complained, was expensive.

Only pond farmers applied fertilizer or manure in their operations. Twenty-five (25) farmers used chemical fertilizers largely for basal application.

The most commonly used manure by far was from poultry, sheep, goat and swine. The application of manure practised by most of the farmers is considered to be the cheapest way to increase pond productivity at minimal cost (Mataka & Kang'ombe 2007). Poultry manure, used by most farmers, has been found to enhance production of phytoplankton more than any other organic fertilizers or chemical fertilizer (Boyd 1982). The significance of using poultry manure cannot be overemphasized as the Nile tilapia is an omnivorous grazer that feeds mostly on phytoplankton (FAO 2006–2012). Manure was obtained from other farmers at about US$ 0.50 per bag (a bag weighed 50 kg) or sometimes given away by the poultry farmers for free. Also, some farmers practised integrated aquaculture, where they kept mostly poultry or swine and used their wastes as manure for their ponds.

The equipment widely used by large numbers of farmers included shovels, boots, buckets, cutlasses, pick-axes, earth chisels and wheelbarrows. More expensive types of equipment such as pumps, scales and even nets, are owned only by few. Most farmers used nets belonging to the Fish Farmers Associations they were part of. One farmer in the Greater Accra Region owned a pellitizer, a corn mill, aerators and fish graders.

Labour utilization and cost

Labour was categorized as full-time, part-time or family labour. Part-time labour was normally hired during pre-stocking operations to excavate, clean and repair ponds and pens and during post-stocking activities particularly harvesting. Farmers employed a median of 2.0 and 2.5 full-time employees with average ages of 30.8 (SD ± 9.2) and 33.0 (SD ± 5.9) years for ponds and pens respectively (differences in number employed and ages of pond and pen farmers not statistically significant; Wilcoxon Rank-Sum Test, $P > 0.05$). ANOVA, $P > 0.05$). On the other hand, farmers employed, on average, 2.6 (SD ± 3.5) and 0.1 (SD ± 0.3) workers on part-time basis. Family labour was also important, especially for farmers with large families, during construction and harvesting. Full-time workers were paid, on average, not less than US$ 0.88, whereas family labour was estimated using the minimum daily wage rate of US$ 1.97 for 2008 (GhanaWeb 2008). Family labour was compensated with giving either fish or meals or housing.

Harvest and market outlet

Harvesting of fish is done by draining water from the pond or by using a net, especially for pen culture systems. The marketable size for tilapia and catfish is around 250–300 g and 1–2 kg in weight respectively. Harvesting is done more than once (partial harvest) for most farmers, with a few harvesting only once per pond/pen per cycle. The average culture period for pond farmers was 698.3 ± 771.7 days and that for pen farmers was 301.8 ± 151 days. Although consumers prefer medium-sized fish, when the price of fish is relatively low, farmers may delay their harvest to get the right sizes. This prolongation or delay of harvesting time, however, is constrained by the cost of additional feed, foregone interest, the probability of disease and possible delay of the next crop (FAO 2006–2012). Generally, most farmers, except the few with large farms and high capital investment, are unable to delay or prolong their harvest.

There are a variety of market outlets ranging from selling at pond/pen site to local markets to wholesalers markets or to regular customers, who are informed of the harvest in advance. Some farmers in Greater Accra Region send their fish to Weija Fish market for sale. Most farmers stored their catch in freezers at home and sell from there. Generally, only fish that cannot be sold fresh are processed. Processing includes smoking, salting, fermenting and frying or various combinations of these. Farmers, however, prefer to sell their fish fresh as they claim that it gave more revenue.

Cost structure and profitability

Cost structure

Costs were categorized into two components and computed m^{-2} of pond or pen (Table 3): variable cash costs, i.e. expenses that are actually paid and vary with the quantity of fish produced, such as fingerlings, feed, labour and transportation; fixed costs, which are independent of the operation, such as depreciation of ponds, equipments and land use. Variable cost accounted for more than 77.4% and 73.2% of the total cost for pond and pen respectively; the rest was fixed cost. Among the variable costs, the cost of labour accounted for 38.4% for pond culture, whereas in pen culture the cost of fingerlings dominated, accounting for about 44.1%. The cost of feed came second at

Table 3 Average cost, average revenue and average returns of pond and pen farmers

	Pond					Pen
	Greater Accra	Western	Central	Volta	Av. total	Volta
Item (US\$ m^{-2})	*N* = 6	*N* = 38	*N* = 19	*N* = 11	*N* = 74	*N* = 13
Revenue						
Tilapia	1.86	1.3	0.73	1.32	1.3	4.1
Catfish	0.66	3.96	1.01	0.21	1.44	0.78
Fingerlings	0.95	0.13	0.38	0.11	0.31	0
Other	0.01	0.33	0.09	0.09	0.13	0
Total gross receipts	3.48	5.72	2.2	1.73	3.18	4.88
Variable costs						
Tilapia fingerlings	0.28	0.11	0.1	0.2	0.17	1.44
Catfish fingerlings	0.03	0.21	0.06	0	0.07	0.02
Other fingerlings	0.06	0	0.01	0	0.01	0.01
Feed	0.32	0.52	0.46	0.36	0.42	0.17
Fertilizer	0	0.01	0.01	0	0.01	0
Transportation	0.05	0.08	0.13	0.01	0.06	0.05
Hired labour	0.34	0.82	0.39	0.99	0.52	0.87
Family labour	0.29	0.11	0.27	0.08	0.16	0.05
Interest on operating capital	0.12	0.11	0.11	0.07	0.37	0.7
Total variable costs (TVC)	1.49	1.97	1.52	1.71	1.79	3.31
Operating profit	1.99	3.75	0.68	0.01	1.38	1.57
Fixed costs						
Equipment depreciation	0.19	0.05	0.02	0.03	0.03	0.12
Ponds/pens depreciation	0.07	0.1	0.08	0.01	0.05	0.24
Opportunity cost of land	0.29	0.41	0.39	1.19	0.5	0.04
Interest on investment	0.12	0.12	0.06	0.02	0.27	0.82
Total fixed cost (TFC)	0.67	0.69	0.55	1.25	0.85	1.21
Total costs (TC)	2.15	2.65	2.07	2.96	2.64	4.52
Net returns	1.32	3.06	0.13	−1.23	0.53	0.36

US\$ 1.0 = GH ¢ 1.14 (2008).

23.6% for pond and the cost of labour was second for pen culture at 27.8% of variable costs (Table 3).

The costs of production among other things are dependent on the culture techniques used and the costs of inputs to the production process (Atrill 2003). At the technical level, the ability to produce at a low enough cost is determined primarily by species, location and feed (Hishamunda 2004). Average costs, revenues and returns of production are presented in Table 3.

For pond culture, the total cost in Volta Region was the highest, with the lowest coming from the Greater Accra Region (Table 3). Between pond and pen systems, however, total cost for pen was higher than for ponds (Table 3). Therefore, it is cheaper to produce per meter squared of pond than pen. This supports the theory that pen culture is capital-intensive.

Profitability

Profitability is the primary goal of all business ventures. Without profit, the business will not survive in the long-run. So measuring current and past profitability and projecting future profitability is very important (Hofstrand 2006**)**. Performance indicators used to assess profitability include net returns, average price and production, break-even price and yield, return to capital and management and return to land, capital and management, and rate of return to capital invested and rate of return to total investment.

Net returns. Net returns above total cost (net profit) by definition is the gross revenue less total production cost (including interest and depreciation on capital employed); a positive value implies profitability and potential viability, a negative value implies non-profitability and the unlikelihood of continuing unless revenues increase and/or costs decrease (Asmah 2008). The positive operating profit for pond farmers from all the regions indicates that it is profitable to operate in the short-term (Table 3). All variable costs of production are covered (Engle & Neira 2005). The operating profit and net returns for pen farmers are also positive and higher than that for ponds, on the average (Table 3). Net returns per m^2 were highest in the Western Region (US$ 3.06). FAO (2005) also obtained higher returns for farmers in the Western Region, but obtained negative returns for Central Region. Results from the Central Region, however, show a positive net return. It can therefore be inferred that that since FAO (2005) study, culture in the region is improving.

Between pond and pen culture in the Volta Region, pen yielded a positive net return, whereas that of pond was negative at US$ 0.36 and US$ -1.23 m^{-2} respectively (Table 3). This shows that even though pen culture is more capital-intensive, it produces higher profits. The positive net returns above total cost (net profit), observed in all regions except Volta, indicate that aquaculture in these regions, given the prices and costs used in this budget, is profitable even in the longer term. The mean value of fish produced (m^{-2}) was US$ 3.18 and US$ 4.88 for pond and pen respectively (Table 3). Comparing this value with the total cost of production, (i.e. US$ 2.64 and US$ 4.52 for pond and pen respectively) shows that on the whole, pond and pen aquaculture respectively were profitable in Ghana.

Break-even analysis. Break-even prices and yields offer additional insights into the overall feasibility of the operation. Break-even price above total variable cost and total cost is used to assess profitability of fish sold in the short-run and long-run respectively. Break-even yield above total variable cost and total cost is used to assess profitability of fish produced in the short-run and long-run respectively. An aquaculture venture will be profitable as long as the price (kg^{-1}) sold or yield (m^{-2}) is above these estimates (Engle & Neira 2005).

From Table 4, Greater Accra and Western Regions had estimates of break-even price lower than their average prices. This means that it is profitable in the short-term and long-term to produce here. Volta region had estimates higher than the average price, making it unprofitable to produce in both the short-term and long-term. Results from Central region, however, indicate that production in the short-run is profitable; but in the long-run, it will be unprofitable (Table 4). Taking pond culture on a whole, break-even price above total variable cost and total cost were US$ 1.17 and GH¢ 1.72 kg^{-1}, which were 37.4% and 7.7% lower than prevailing average market prices (Table 4). Pen culture also had break-even price above total variable cost and total cost being US$ 1.37 and GH¢ 1.87 kg^{-1}, which were 35.1% and 11.4% lower than prevailing average market prices (Table 4). These figures imply that pond and pen culture can significantly absorb price changes and still achieve profitability (Boonchuwong *et al.* 2007).

As long as production per meter squared is above estimates of break-even yield, it is profitable to produce in the short-run and long-run. At this level of production, there is enough production to cover both all variables and all fixed costs. Comparing the estimates with average production per m^2, for pond and pen culture, gave similar results as that for break-even price discussed above (Table 4).

Returns and rate of return to capital, land and investment. Returns and rates of return were positive for pond farmers in all the all regions except Volta region (Table 4). Return and rates of returns were highest in Western Region. This was expected because of the higher intensity of culture in the region, i.e. more investment in fixed and operating capital per square meter. Pen farmers show positive returns, which are higher than pond culture, except for rate of return to total investment. This is the same for both systems in the Volta Region.

Role of pond farm size. Farm size was hypothesized to play an important role in farm profitability and ultimate success. Pond farm, because of the higher numbers as opposed to pen farms are used in the assessment of profitability. Farms were classified as small- (1000 m^{-2} and less), medium- (between 1001 and 3000 m^{-2}) and large- (more than 3001 m^{-2}) scales (Table 5). The highest average yield and price were obtained by large-scale farmers.

Variable costs made up 81%, 71% and 62% of total costs observed for small-, medium- and

Table 4 Performance indicators for pond and pen farmers

	Pond					Pen
	Greater Accra	Western	Central	Volta	Av. total	Volta
Performance indicators	*N* = 6	*N* = 38	*N* = 19	*N* = 11	*N* = 74	*N* = 13
Average production (kg m^{-2})	1.68	2.60	1.04	0.82	1.54	2.42
Average price (US\$ kg^{-1})	1.92	2.07	1.69	1.78	1.86	2.11
Break-even price (kg^{-1} sold)						
Above TVC	0.88	0.76	1.46	2.28	1.17	1.37
Above TC	1.28	1.02	1.99	3.79	1.72	1.87
Break-even yield (US\$ kg^{-1})						
Above TVC	0.77	0.95	0.90	1.05	0.96	1.57
Above TC	1.12	1.28	1.23	1.75	1.42	2.14
Return to capital and management	1.450	3.190	0.190	−1.210	0.810	1.180
Return to land, capital and management	1.740	3.600	0.580	−0.020	1.310	1.220
Rate of return to capital invested (%)	67	120	9	−41	31	26
Rate of return to total investment (%)	81	136	28	−1	50	27

large-scale operations respectively. Opportunity cost for family labour and cost of hired labour contributed the most to variable costs for small- and medium-, large-scale operations respectively. This was followed by cost of feed, for all the three scales of operation. Results for small-scale operations were comparable to studies done in Uganda and other Sub-Saharan African countries, on small-scale aquaculture production, that showed a higher percentage of 93% and 98.06% respectively (Hyuha, Bukenya, Twinamasiko & Molnar 2011).

Operating profits and net returns were positive for medium- and large-scale farmers, whereas small-scale producers recorded negative values. This implies that under the present conditions, small-scale operations are not economically viable (Wattanutchariya & Panayotou 1982; Engle & Neira 2005). A comparison of the total gross receipts and total costs further buttressed the unprofitability of small-scale operations.

Break-even prices and yields are higher than the average price and yield of small-scale farms, which further suggest that it is not profitable to produce in both the short- and long-terms. Medium-scale operations are profitable in the short-run only based on estimates of break-even price and yield (Table 5). Large-scale operations are, however, very profitable (Table 5).

Returns and rates of returns were also positive for medium- and large-scale operations, with large-scale having the highest returns. Those for small-scale are negative, further implying that economically, such operations are non-viable.

Table 5 Profitability indicators for small-, medium- and large-scale pond farmers

	Small	Medium	Large
Profitability indicators	*N* = 36	*N* = 20	*N* = 18
Average production (kg m^{-2})	1.80	1.31	2.83
Average price (US\$ kg^{-1})	1.88	1.94	1.97
Total gross receipts (US\$ m^{-2})	5.11	3.04	5.13
Total variable costs (TVC) (US\$ m^{-2})	8.11	1.84	1.36
Operating profit (US\$ m^{-2})	−3.01	1.20	3.77
Total fixed cost (TFC) (US\$ m^{-2})	1.89	0.76	0.84
Total costs (TC) (US\$ m^{-2})	10.00	2.59	2.20
Net returns (US\$ m^{-2})	−4.90	0.44	2.92
Break-even price (kg^{-1} sold)			
Above TVC	4.51	1.40	0.48
Above TC	5.56	1.98	0.78
Break-even yield (US\$ kg^{-1})			
Above TVC	4.32	0.95	0.69
Above TC	5.32	1.34	1.12
Return to capital and management	−4.74	0.57	3.03
Return to land, capital and management	−3.37	1.06	3.59
Rate of return to capital invested (%)	−70	26	162
Rate of return to total investment (%)	−34	41	163

US\$ 1.0 = GH ¢ 1.14 (2008).

Constraints to aquaculture production

The farmers reported a number of constraints that they face in their operations. The foremost was lack of capital (mostly the lack of credit facilities and the difficulties in assessing loans mostly for expansion), which was reported by 30% of the respondents. Fish farming is a capital-intensive enterprise, thus requiring big capital investment for reasonable profit to be made (Ugwumba & Chukwuji 2010). Fish predators came in at second, with 21% response. The predators were mostly birds, catfish in the ponds especially, and other wild animals. Some farmers had therefore covered their ponds with wire mesh to keep predators away. Poaching was reported by 15% of the respondents. This was most serious in pen farming. Other constraints listed were expensive feeds (4%), lack of ready market for harvested fish (4%) and the fewer number of extension personnel that the farmers relied on for proper training and information.

Conclusion and recommendations

Aquaculture presents an alternative to meeting the global demand for high-quality protein. In Ghana, it is a viable industry with high investment gains. Results show that the industry is typically male-oriented and most farmers are well into their productive years. Pond culture has been around longer than pen culture. However, both are viable means of production. Ponds were generally larger than pens. Farmers used various feeds and mostly used either full-time labourers or relied on family labour. The costs and returns for the different regions were calculated and compared. It was found that, on average, pond farmers made a net profit of about GH¢ 0.63 m^{-2}. On a regional basis, the Western region was by far the most profitable region. Comparing pond to pen profits, pond was by far more profitable. However, pens were only in the Volta Region and a comparison of the two systems indicated that pens were more profitable. Performance indicators of profitability for pond and pen aquaculture pointed out that it was profitable to produce on the average in the whole study area. By regions, however, the Western region was still the most profitable. Small-scale pond operations were found to be economically non-viable under the present situation. Large-scale operations are the most profitable, which was expected. The main constraints affecting production were lack of capital, fish predators and poaching.

Based on the results of the study, it is recommended that as pen farming is a relatively new production method, it should be the focus of future research. Fish farming was recognized as typically male-dominated with most of the farmers well into their productive years. More programmes should therefore be targeted at females and most especially the young ones to bring them into aquaculture for its continued growth. Most of the fish farmers had little or no access to finance. The government should therefore assist farmers, especially those with small farms and little experience to overcome the problems of high operating capital and insufficient knowledge. Extension services to farmers should be strengthened, to provide adequate training for the fish farmers. Finally, most farmers did not keep records, making it difficult to assess their progress. There should therefore be more training on record keeping. Also, record keeping must be a prerequisite for getting accepted into a fish farmers' association.

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