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Are small-scale freshwater aquaculture farms in coastal areas of Ghana economically profitable?

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Abstract
Marine fish stocks in Ghana are in serious decline, while local demand for fish has outstripped supply due to a combination of factors led by over-fishing. To sustain per capita consumption of fish, the Government of Ghana has positioned aquaculture as one of its top priorities. Aquaculture is projected to meet the deficit in the country's fish requirements. However, there is paucity of information on the profitability of smallholder aquaculture farming practices to guide planning and investments in the sector. This study was carried out on 40 farms across all four coastal regions of Ghana namely Western, Central, Greater Accra, and Volta Regions to help address critical bottlenecks facing smallholder fish farming practices. Three profitability metrics, i.e., benefit-cost ratio (BCR), payback period (PBP), and return on investment (ROI) were used to assess profitability. Regression analysis between investments and revenue outputs revealed cost factors that were significant and positively influencing revenue generation from aquaculture farms. Average BCR for smallholder aquaculture farms for a 5-year period was estimated at 1.14. When disaggregated, tilapia profitability was higher (BCR = 1.16) compared to catfish (BCR = 1.11) but not significant. The results showed that both tilapia and catfish farming had positive returns on investment. However, in the long term, profitability from catfish was higher (ROI = 0.74) than tilapia farming (ROI = 0.73) but not significantly different. Tilapia farms recorded shorter payback time of 7 years when compared to catfish farms estimated at 9 years. This study calls for stronger commitment of government and stakeholders to address the issues of high cost of fish feed and access to fish fingerlings and markets, while improving specific on-farm management practices.

Keywords Catfish · Tilapia · Aquaculture · Profitability · Small-scale fish farming · Ghana

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Introduction

The importance of the fisheries sector, both capture fisheries and aquaculture, to food security and livelihoods of millions of people in sub-Saharan Africa cannot be over-emphasized. The sector employs more than 10 million people on the continent and is the only source of animal protein for one in five people (FAO 2016). Globally, fish products are among the most traded commodities, of which nearly 80% is sourced in the developing world (World Bank 2009). In Ghana, the contribution of the fisheries sector to food security and livelihoods is even more pronounced. Ghana is a major fish-consuming nation and fish is an important source of animal protein in local diets. With a production rate of 400,000 metric tons a year, fisheries products supply 60% of the animal protein consumed in the country and per capita fish consumption is 27 kg per year—more than double the world average (FAO 2016). The sector directly or indirectly supports the livelihoods of 2.2 million people (World Bank 2009).

However, throughout much of the developing world and especially in West Africa, local demand for fish has outstripped supply, and fish stocks are in serious decline due to a combination of factors led by over-fishing (Atta-Mills et al. 2004). Ghana presently imports about US$200 million worth of fish annually with marine fisheries production recorded to have declined significantly in recent years especially in the last two decades (MOFAD 2014). The country produces less than half of its fish requirement through domestic production. The country's marine fisheries are affected by seasonal upwelling that occurs in its coastal waters. Given the state and reality of rapidly declining marine fish stocks, attributed also to rampant illegal fishing activities including fish transshipment (Aheto et al. 2017; Debrah et al. 2018), aquaculture has been earmarked to address the situation, enhance food security, and reduce poverty (Food and Agriculture Organization 2014; Ministry of Fisheries and Aquaculture Development 2015).

Aquaculture in Ghana

Historically, aquaculture was introduced to Sub-Saharan Africa in the 1950s with the primary objective to improve nutrition in rural areas, generate additional income, diversify activities to reduce risk of crop failures, and create employment opportunities in rural areas (Hecht 2006). Since then, aquaculture in Africa has developed some setbacks including low innovation and intensification of production. Aquaculture was introduced in Ghana in 1953 but presently still remains largely undeveloped with an annual production of about 3257 tons (FAO 2016). The aquaculture sector in Ghana comprises largely of small-scale subsistence in contrast to a few intensive commercial fish farms.

Tilapia is the major species farmed, constituting over 80% of aquaculture production. The catfishes (*Clarias* sp., *Heterobranchus* sp.) and *Heterotis niloticus* account for the remaining 20% (FAO 2016). The preference of catfishes and tilapia as culture species is possibly due to the demand among the populace and the availability of knowledge on their culture due to extensive research carried out over the years. However, unlike freshwater aquaculture, mariculture in the country is not widely practiced; with only a few large-scale foreign-owned mariculture enterprises mainly shellfish farms along the coast. Research is still undergoing on competencies to culture marine shellfishes and finfishes in the country.

To sustain the per capita consumption of fish, the Government of Ghana has positioned aquaculture as one of the top priorities in the country's development agenda. The government has adopted aquaculture as an assured way of meeting the deficit in Ghana's fish requirements. In May 2018, the government launched "Aquaculture for food and jobs," a program, which is in response to growing concerns over Ghana's depleting fish stock and aimed at ensuring adequate supply of fish all year, while creating employment in coastal communities (MOFAD 2018).

Aquaculture can contribute to domestic fish production and offers important livelihood opportunities through their direct involvement in the production, processing, and sale of fish. Aquaculture farms, from the micro- to large-scale, bring affordable and nutritious food to markets and create farm income and employment opportunities throughout the value chain. According to the FAO (2016), aquaculture is the world's most rapidly growing food production subsector for the past three decades and currently generates more than half the fish destined for direct human consumption. Aquaculture is an investment option and like all important investments, this option could be profitable only if transformed into action, through comprehensive marketing and business planning.

Previous studies in Ghana have attempted to examine the food security, economic growth, and poverty reduction potential of aquaculture (Anane-Taabeah et al. 2011; Kassam 2014). However, only a handful of studies have examined the profitability of aquaculture (Asmah 2008; Ansah and Frimpong 2015). Therefore, there is paucity of information on its profitability in terms of returns on investment on both catfish (*Clarias* sp.) and tilapia (*Oreochromis* sp.) culture. According to Machaena and Moehl (2001), the lack of data relating to aquaculture economics poses major challenges because they are crucial in the selection of appropriate aquaculture production systems and efficient use of inputs. In many African countries, including Ghana, rural aquaculture lacks investment mainly because of the absence of quality economic data and analysis. According to Pillay (1994), there is a general perception that aquaculture is a high-risk activity involving risks higher than other food production industries such as poultry, pigs, and cattle rearing.

To this end, the study assessed the profitability of indigenous smallholder aquaculture farms in terms of their investments and production costs and explored the relationship between various costs incurred and gross revenue. The study also aimed at providing information on the socioeconomic conditions of selected smallholder aquaculture farms in coastal areas of Ghana that could contribute to improving smallholder aquaculture farming practices. It will also promote aquaculture policy development in the country.

Materials and methods

Study area

The study was undertaken in Ghana's coastal regions, comprising the Western, Central, Greater Accra, and Volta Regions (Fig. 1). The coastal regions of the country were selected primarily because the study sought to assess whether investments in aquaculture is a profitable alternative for coastal communities in the face of declining capture fisheries in the marine fisheries sector of Ghana. The four coastal regions occupies a land area of 57,562 km^2 which

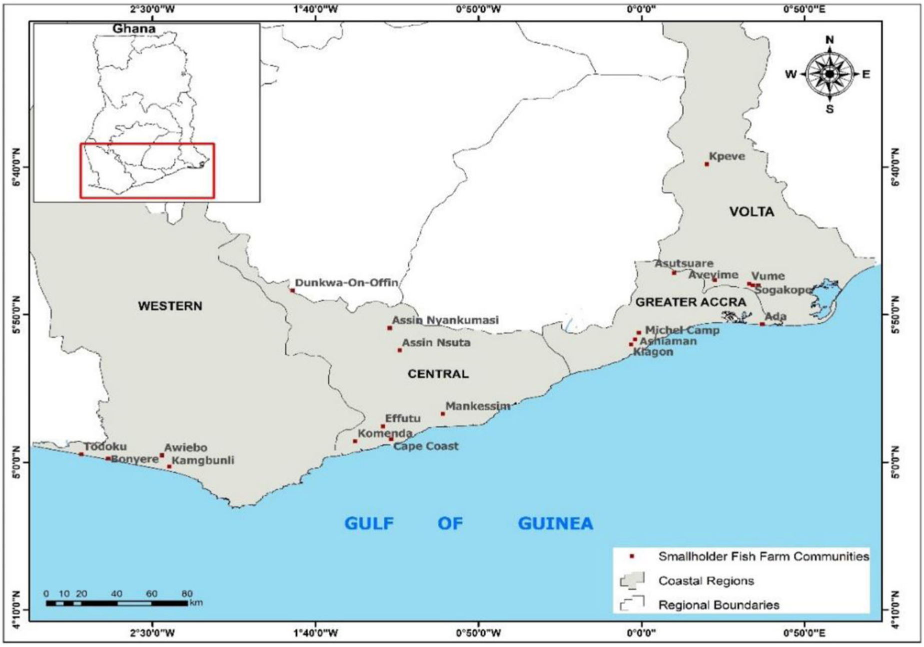

Fig. 1 Map of the sampling areas in coastal areas in Ghana (Source: Centre for Coastal Management, University of Cape Coast, 2018)

represents 24% of the total land cover of Ghana. According to the 2010 population and housing census, the total population of the study area is about 10.6 million, which is 43% of the total population of the country (Ghana Statistical Service 2012). The area is characterized by a large network of river systems, dynamic estuaries, and interaction between numerous freshwater bodies along a coastline of 550 km in length with a relatively narrow continental shelf.

Sampling and data collection

The study surveyed smallholder aquaculture farms following a documented list of small-scale aquaculture farm enterprises (characterized by low-asset base and low productivity of not more than 2 tons per year) obtained from the Ghana Fisheries Commission in March 2018. However, the exact number of aquaculture farms in all the regions is not known since some farmers do not register with the commission and some of those who did have retired their operations. Therefore, the list was further categorized into operational and non-operational farms. Structured questionnaires with open- and closed-ended questions and interview schedules were used to solicit primary data from operational aquaculture farms. The interview schedules sought to discover major challenges confronting farmers, giving them the opportunity to comment on their manner of operations personally whereas the questionnaire posed sought answers on issues that had been documented in literature (see Appendix II). Prior to the data collection, a pilot test was carried out to validate the suitability and appropriateness of the questions and expected responses from the respondents. Revision of the questionnaire in light of errors detected during the pilot surveys was subsequently carried out. To facilitate data collection, questionnaires were completed with the farm owner or manager, whichever was available, at the time of visit. Due to time and resource limitations, data was collected from 40 farms with the highest number of respondents from the Central Region (31.8%) and the least from Greater Accra Region (17.5%). The questionnaire sought to gather personal information on the farmers in relation to their social (including educational, marriage, and gender) and economic status, and a profile of the fish farm in relation to size, level of operation, species cultured, type of enclosures, cost of production, as well as the kinds of inputs and equipment used, type of culture system, and stocking densities. The study also acquired data on variable and fixed costs as well as revenue generated from the farms. These data enabled a calculation of the profit margins for both catfishes and tilapia investments over a 5-year period. The variable cost data included source and price of fingerings, feed type, quantity of feed, feeding per unit area, formulation of fertilizer, and cost of fertilizer components, as well as length of culture period, source of funding, and number and salaries of employed labor.

Research data analysis

All the data gathered were coded and entered in Microsoft Excel 2010 spreadsheets. Descriptive statistics and summary statistics of means, frequencies, and percentages were then used to show the socio- and economic characteristics of the farms. Social data was grouped using frequency distribution and percentages. Furthermore, regression analysis was employed to derive a relationship between feed intake and harvested fish weight.

For fish production, the regression equation used was:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + U \tag{1}$$

where

Y gross revenue realized from table size fish production (US$)
X_1 cost of juveniles stocked (US$)
X_2 cost of feed (US$)
X_3 cost of fertilizer components (US$)
X_4 cost of equipment used (US$)
X_5 marketing price per kilogram
X_6 pond size
U error term
b_0 intercept or constant
b_1 parameter estimates

The economic data was analyzed following the enterprise budget approach using income and expenses associated with the farming practices (Engle and Neira 2005). In this sense, cost/benefit index was used as a proxy to assess profitability of the aquaculture farms in their business ventures taking into account all the costs involved in the production (see Appendix). To assess the economic efficiency of the smallholder aquaculture farms, three profitability ratios were calculated: benefit-cost ratio (BCR), payback period (PBP), and return on investment (ROI) (Eqs. 2, 3, and 4, respectively).

The benefit-cost ratio (Mishan and Quah 2007) is an indicator, used in cost-benefit analysis that attempts to summarize the overall value for money of a project or proposal. Investments with a benefit-cost ratio greater than 1 have greater benefits than costs; hence, they have positive net benefits. The higher the ratio, the greater the benefits relative to the costs. This method helps to total up the equivalent money value of the benefits and costs involved in a particular project. Payback period is a financial metric for cash flow analysis that determines how long it takes for investments or actions to pay for themselves and how long it could take for incoming returns to cover costs. The smaller the payback time, the better. The payback period, however, does not take into account the time value of money. (Ardalan 2012). The ROI is the ratio of gains to cost and measures, per period, the rate of return on money invested in the aquaculture enterprise (Ardalan 2012). A positive ROI means that the investment gains compare favorably to the cost; hence, the larger the ROI, the better. These ratios were employed to understand the inputs of farmers and investors and their possible returns in the aquaculture venture.

The formula for the benefit-cost ratio used is stated below:

$$\mathrm{BCR} = \{\sum_{\mathrm{t}=1}^{n}(\mathrm{Bt}/(1-r)t\}/\sum_{\mathrm{t}=1}^{n}(\mathrm{Ct}/(1-r)t\} \tag{2}$$

where

t current time span of project (years)
Bt benefits derived from aquaculture farms
Ct operational costs in time (t)
n lifespan of project estimated to be 5 years
r 33.2% interest rate, which is the average rate at which agricultural loan is given to farmers by financial institutions as reported by the Bank of Ghana.

The formula for the payback period used is stated below:

$$\text{Payback period (years)} = \frac{\text{cash outlay(capital)}}{\text{average amount of net cash inflow}} \tag{3}$$

The formula for the return on investment (ROI) used is stated below:

$$\mathrm{ROI} = \frac{\text{annual net profit}}{\text{total capital investment}} \tag{4}$$

The annual depreciation of fixed asset, in this case, land, was estimated according to the formula:

$$\text{Annual depreciation} = \frac{\text{cost of capital asset–residual value}}{\text{useful life of the asset}} \tag{5}$$

where "capital asset" is average acreage of farm, and the useful life of the land is assumed to be 5 years. The residual value is estimated to be 20% of the original cost of capital asset.

From the point of view of analyzing profitability of smallholder aquaculture farms, the study is introducing the payback − ROI profitability matrix (Fig. 2). The basic idea of the management tool is the placement of the smallholder aquaculture farms in a bi-dimensional coordinate system, with their payback values reflected on the vertical axis and ROI values on the horizontal axis, and their grouping into four quadrants: "sleeping," "dogs," "stars," and "duds." If a farm falls in any particular quadrant, it is possible to estimate the profitability potential.

Results

Descriptive analysis

Descriptive analysis of socioeconomic characteristics of respondents shows that majority of aquaculture farmers are male (92%) and a greater number of the farmers are married (90%). All the farmers had some form of formal education with majority of the farmers (85%) being either primary or secondary school graduates (Table 1). The study shows that majority of aquaculture farms are sole proprietorship businesses (95%) ownership structure and only 5% have joint venture or partnership structure. Funding for aquaculture farms is mainly from personal savings or assets (93.0%) and credit from banks is very limited (2%). The average startup capital cost for land and construction works is about US$862.2 and US$2048, respectively, for an average farm size of about 3237.49 m^2; and the main operational costs of aquaculture farms are feed, labor, and fry costs.

Majority of farmers preferred feed from locally based foreign producers and fish fry is mostly purchased from private hatcheries. The average farm size (entire agricultural facility) is 3237.49 m^2 and the average number of ponds is three per farm. The data shows that the majority of farms have pond sizes below 500 m^2 (Fig. 3) and the average pond size of 652.5 m^2 per pond (Table 2). Minimum wage in Ghana is US$2.18, and mean labor charges recorded were US$402.4 per year. Figure 3 shows the frequency distribution of smallholder pond sizes.

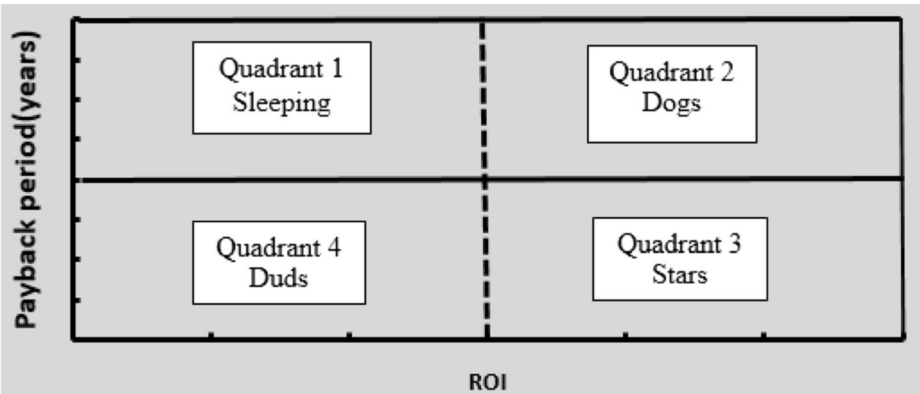

Fig. 2 Payback-ROI profitability matrix

Aquaculture farms are challenged by a number of issues, including high cost of feed, inadequate governmental support, low reliability of farmers to meet fish market demand, theft, poor record and book keeping, and the lack of technical skill and low adoption of technology (Fig. 4).

Most fish farmers reported cost of feed (30%) and inadequate governmental support (27%) as major drawbacks in their venture. Record keeping and marketing were also noted as key challenges in small farms reported by 7% and 10% of respondents, respectively. Theft was a minor issue and stated among the least concerns, constituting 3% of total respondents.

Table 1 Characteristics of smallholder aquaculture farmers and farms surveyed ($N = 40$)

	Frequency	Percentage (%)
Gender		
Male	37	92.5
Female	3	7.5
Total	40	100
Marital status		
Married	36	90
Single	4	10
Total	40	100
Education		
Primary level	17	42.5
Secondary level	17	42.5
Tertiary	6	15.0
Total	40	100
Ownership structure		
Sole proprietors	38	95
Partnerships	2	5
Total	40	100
Sources of finance		
Personal savings	37	92.5
Friends	2	5
Relatives	0	0
Bank loans	1	2.5
Total	40	100
Species farmed		
Tilapia	22	55
Catfish	18	45
Total	40	100
Source of fingerlings		
Government hatcheries	4	10
Private hatcheries	36	90
Total	40	100
Sources of feeds		
Purchase	39	97.5
Households waste	1	2.5
Total	40	100
Type of feed		
Agro-based	1	2.5
Imported	11	27.5
Locally based foreign producers	28	70
Total	40	100

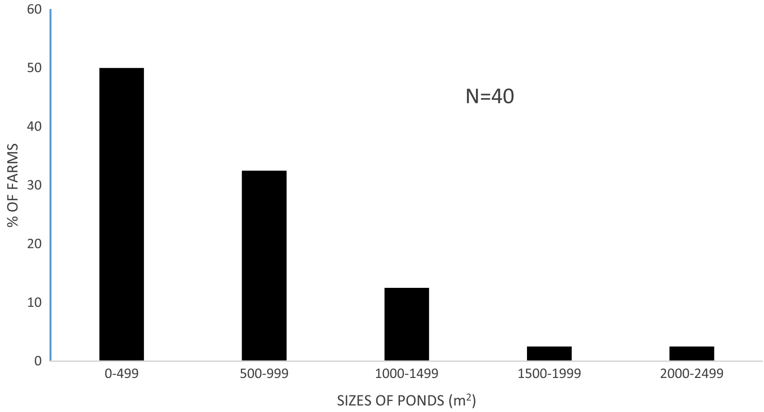

Fig. 3 Frequency distribution of ponds in smallholder farms

Feeds, pond sizes, and fish harvest weights

A regression analysis was carried out to examine key determinants of factors influencing fish production output in the study areas. An analysis of weight of feed and weight of total harvested fishes on the farms was used to derive an equation for the estimation of total fish weights at given weights of feed is presented in Fig. 5. The regression coefficient signifies a moderately strong but positive relation between the total weight of harvested fishes and the weight of feed. Thus, high amount or weight of feed (kg) utilized corresponds to increasing weight of total harvested fishes (kg). There is, however, the need for correct feeding and consideration of feed conversion ratio (FCR) and feeding time for optimum and maximum growth of cultured fishes. The average yearly total weight of harvested fish was 796.95 kg. Figure 6 shows a regression analysis of pond sizes, feed quantity, and total harvested fishes in kilograms per annum. The multiple regression result revealed that fish output is significantly determined by pond size and feed quantity. Farms with bigger pond sizes recorded higher weights of total harvested fishes whereas farms with lower pond sizes recorded low productivity (kg).

Table 2 Descriptive statistics of smallholder aquaculture farms surveyed (N = 40)

	Mean	SE
Cost of land at time of purchase (US$/acre)	862.2	132.4
Cost of construction (%)	2048.6	264.7
Machinery cost (US$/year)	29.7	2.9
Cost of lime (US$/year)	8.6	2.6
Cost of fertilizer per year (US$/year)	3.1	0.8
Cost of labor (US$/year)	402.4	109.9
Cost of feed (US$/year)	2181.4	167.4
Farm size (m^2)	3237.49	0.2
Number of ponds per farm	3	0.2
Pond sizes per farm (m^2)	652.5	73.4
Stocking rates per year	2	0
Stocking number	2115.4	305.3
Marketing price (US$/year)	2.5	0.02

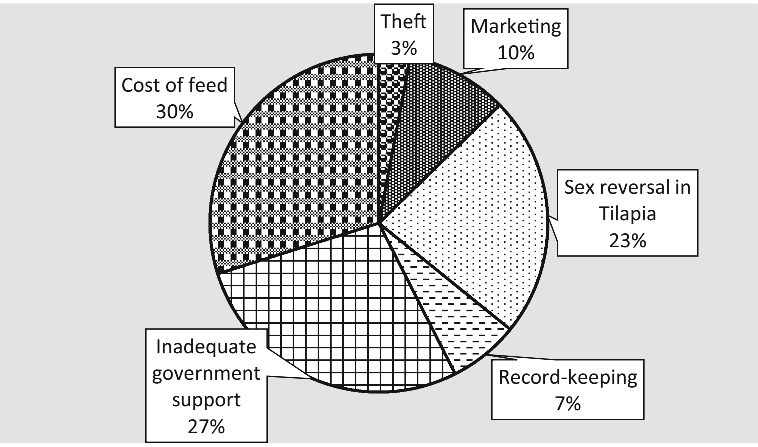

Fig. 4 Major challenges faced by small-holder farmers in coastal regions of Ghana

Table 3 shows the production function relationship between total costs of feed, amount spent on fertilization, size of ponds, cost of fingerlings, and the gross revenue derived from fish farming among the smallholder farms. All variables have a positive and significant relationship with gross revenue except fertilization, which is significantly negative. Cost of feed had a positive and significant regression coefficient. Hence, the more the amount expended on feed and fry, the more amount that will be realized from fish farms in the study area. The R^2 for the estimated regression implied that 84% of the variations in the revenue from sales of full fish is explained by the postulated explanatory variables.

Profitability Analysis

Tables 4, 5, and 6 shows the profitability of smallholder aquaculture farms using the benefit-cost ratio (BCR) for all smallholder, tilapia, and catfish farms, respectively. The average BCR for smallholder aquaculture farms for the 5-year period is 1.14. When disaggregated, tilapia profitability (BCR = 1.16) is higher than catfish (BCR = 1.11) but not significantly different. The BCR for the first year is low due to high initial costs of operation. In the first year, farmers

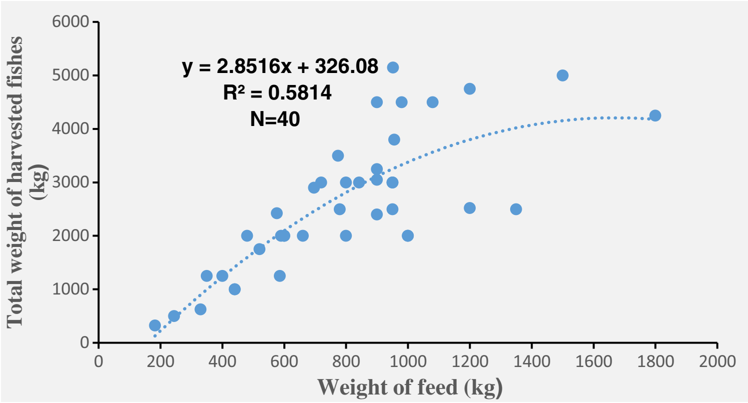

Fig. 5 Relationship between weight of feed and weight of total harvested fishes

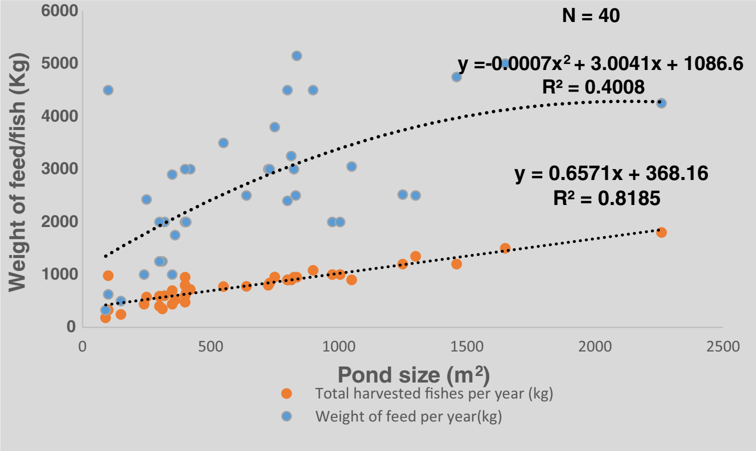

Fig. 6 Relationship between pond sizes, feed quantity, and farm production

incur more costs due to fixed expenses such as acquisition and construction of fish farming facilities and liming, as well as variable costs including cost of fingerlings, labor, fertilizers, and feed; hence, revenue generated is low and farmers run at a loss (Appendix I). However, BCR increases from the second year of production reaching 1.26 and 1.22 for tilapia and catfish aquaculture ventures, respectively; increasing steadily towards the fifth year of production. Generally, as net benefits increase and production costs are reduced, the yearly calculated BCR increases. Table 7 shows the profitability of smallholder aquaculture farms using the payback and return on investment metrics.

The results shows that both tilapia and catfish have positive return on investment. However, catfish profitability (ROI = 0.74) is higher than tilapia (ROI = 0.73) but not significantly different. The results also shows that tilapia (7 years) has a shorter payback time compared to catfish (9 years). This suggests that on the average, tilapia farmers are expected to make enough profit to pay for all costs incurred by the seventh year of production while the catfish farmers by the ninth year of production. This generally indicates that smallholder aquaculture farms in coastal areas of Ghana are generally profitable in the medium-term. The analysis further shows that, on average, a farm can take US$ 137.90 as the depreciation expense every year over the next five as shown in the analysis in Table 8.

A very useful representation emerges when the payback period and ROI profitability metrics are combined, drawing a matrix that arrays the smallholder aquaculture farms in four quadrants (Figs. 7 and 8). As shown, majority of smallholder aquaculture farms fall in

Table 3 Relationship between various costs incurred and gross revenue

Variables	Coefficients	*T* value
Intercept	–	–
Cost of feed per year	0.60	5.65
Fertilization	− 3.16	− 0.12
Pond sizes (m^2)	9.68	6.28
Fingerlings per year	0.42	1.55

R^2 = 0.84, Adjusted R (which takes into account sample size) 0.88, Significant at 95%

Table 4 Profitability of all smallholder farms ($N = 40$)

Year	Total cost of operations (US$)	Net benefit (US$)	Benefit cost ratio (BCR)
1	244,968.78	− 87,578.82	0.64
2	126,310.59	30,787.05	1.24
3	126,310.59	30,787.05	1.24
4	124,187.49	32,910.15	1.27
5	120,752.94	36,344.7	1.3

quadrant 3, which portray that most aquaculture farms have a low return on investment (ranging from 01 to 1.6) but shorter payback period less than 15 years.

Discussion

Socioeconomic profile

The study shows the dominance of men in aquaculture farming. This finding corroborates the study by Asmah (2008) who confirmed male dominance in aquaculture farming and attributed the low number of female ownership of farms to the fact that traditionally, men are deemed to be the heads of the household units in Ghana and farms owned and operated by a family are likely to be in the name of the head of the family. Ajayi and Fagbenro (2005) described fish farming as “a totem of masculinity.” Recent studies in Nigeria by Thompson and Mafimisebi (2014), as well as Adewuyi et al. (2010) also confirms that males were involved in fish aquaculture farming than females. The study also shows that majority of aquaculture farmers were married. According to Asmah (2008), over 70% of the non-commercial aquaculture farms in Ghana are owned by married men, but were however operated jointly with their wives and children who often took on the role of feeding, processing, and selling the fish after harvests.

The data showed that lack of capital in general is a major challenge for the development of aquaculture in coastal areas of Ghana. Aquaculture farming necessitates adequate capital which is necessary to create, maintain, and expand operations to increase efficiency. The study indicates that funding for aquaculture farms is mainly from personal savings. According to Varadi (2000), the aquaculture sector is characterized by being composed mainly of small, family-owned businesses of limited financial capacity. According to the FAO (2002), the most common external source of funding to provide capital for aquaculture ventures is borrowing, mainly from banks. Unfortunately, however, in the case of aquaculture, financial institutions play a minor role in the provision of loans for the procurement of investment capital so far. The

Table 5 Profitability of smallholder tilapia farms ($N = 22$)

Year	Total cost of operations (US$)	Net benefit (US$)	Benefit cost ratio (BCR)
1	130,814.3	− 41,688.57	0.68
2	70,441.35	18,392.01	1.26
3	70,441.35	18,392.01	1.26
4	64,863.75	18,291.21	1.28
5	67,051.95	21,781.41	1.32

Table 6 Profitability of smallholder catfish farms (N = 18)

Year	Total cost of operations (US$)	Net benefit (US$)	Benefit cost ratio (BCR)
1	114,154.5	− 45890.25	0.60
2	55,869.24	12395.04	1.22
3	55,869.24	12395.04	1.22
4	54,766.74	13497.54	1.24
5	53,700.99	14563.29	1.27

lack of capital remains one of the biggest barriers to aquaculture development in sub-Saharan Africa.

Furthermore, there is paucity of information regarding small-scale fish farming enterprises in Ghana. For instance, actual estimates of the potential economic value (i.e., the surplus of income over expenditure) in Ghana's aquaculture industry are either not available or readily accessible MOFAD (2011–2016) probably because the industry is largely in the hands of private sector operators who are, in most cases, not ready to divulge or share information of their business earnings, and justifiably so. In terms of the overall economy, fish farming has grown rapidly, spurred by high prices of tilapia, and the quickly expanding cage farming in the Volta Basin and the high level of government interest. Tilapias constituted over 90% of the total aquaculture harvest. Regardless, the cost of producing fish in Ghana is, however, alarming. The evidence available suggests that fish production costs are approaching or exceeding income over recent years. There is strong evidence to suggest that costs are increasing in fish farming enterprises and profitability remain increasingly dissipated (FAO, 2016).

The FAO (2002) indicated that four main factors impede access by aquaculture farmers to bank loans in sub-Saharan Africa. These are (1) banks perception that commercial aquaculture carries a particularly high risk of failure, (2) banks insistence on collateral, (3) high interest rates, and (4) lack of knowledge of how to prepare and present a loan application to a bank and what specific information the bank might require. Improved profitability of Ghana's small-scale aquaculture industry will, however, only be possible if the issue of access to loans is addressed.

The predominant form of ownership among small-scale ventures in Ghana is sole proprietorship which explains why sole proprietorship for aquaculture farms are preferred over joint ventures. Arguably, joint ventures enable partners to increase efficiency, reducing expenses by cutting back on fixed costs and eliminating redundant operations. The average monthly earnings by all paid employees in the agriculture, forestry, and fishing sector in Ghana is US$184 (Ghana Statistical Service 2016). Most of the labor supplied on the farms were hired to assist the farm owners in weeding, digging ponds, or harvesting. This accounted for the minimal amount spent on labor.

The percentage of farmers who cultured tilapia was found to be higher than that of catfish; more farmers in the Western Region cultured catfishes whereas more farmers in the Volta

Table 7 Payback period and return on investment for smallholder aquaculture farms

Species	Total capital (US$)	Average net cash inflow (US$)	Payback period (years)	Average ROI
Tilapia	130,814.30	19,214.16	7	0.73
Catfish	114,504.05	13,212.73	9	0.74

Table 8 Annual depreciation expense

Year	Original cost-residual value (US$)	Depreciation expense (US$)
1	689.80	137.90
2	689.80	137.90
3	689.80	137.90
4	689.80	137.90
5	689.80	137.90

Region cultured tilapia. Asmah (2008) identified a huge market potential for tilapia with a current supply deficit of 41,000 metric tons. However, choice of fishes for consumption among Ghanaians is dependent on ethnicity and religious prohibitions among others, thus, in some areas and among certain ethnic groups and religious factions, consuming a particular species of fish can be considered forbidden, and consumer acceptability greatly affects marketability which in turn determines profitability of a fish farming venture (Webber and Riordan 1976; Reay 1979). This assertion explains the farm distribution of catfish and tilapia farmers across the various regions. The average selling price per kilogram for tilapia and catfishes in Ghana is US$2.80 and on the average the length of culture period is twice per year.

Profitability analysis

The profitability analyses showed that smallholder aquaculture farms in coastal Ghana are profitable and financially viable with BCR ratios being greater than 1 from the second year of the investment and ROI being positive. The longest payback period is 9 years. An assumption of payback period is that risk is time-related (Drury 2001), such that the longer a project takes to pay itself, the greater the chances of failure. An aquaculture enterprise not profitable in 10 years is likely to be considered an unattractive investment opportunity because high-risk projects are expected to perform better and projects that can recoup their cost quickly are considered economically more attractive than those with long pay back periods (Atrill 2003).

According to Asmah (2008), main constraints affecting the profitability of small-scale farming were the relatively low prices of fish, high cost of feed, and the low levels of output which could be improved through better farming practices. Enhancing profitability of these

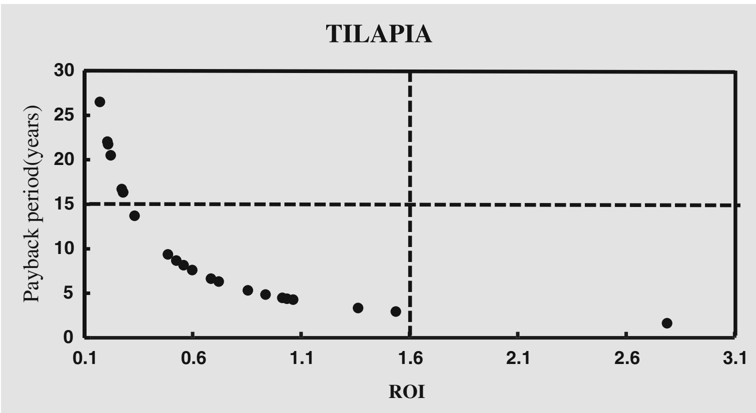

Fig. 7 Payback period-return on investment profitability matrix for tilapia

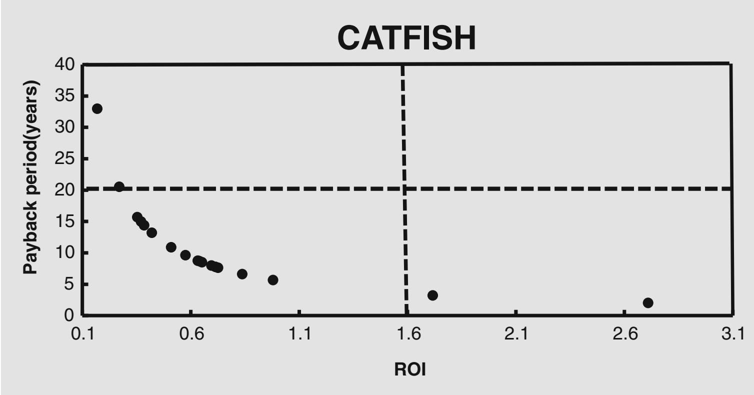

Fig. 8 Payback period-return on investment profitability matrix for catfish

farms may imply operating more efficiently and producing the quality of fish which will attract the right prices. By and large, high profitability would therefore mean that payback period must be generally lower with high return on investment (Fig. 2). For example, Engle and Valderrama (2004) indicated that avoidance of feed wastes saves cost and contributes to farm profitability. Therefore, for any business venture, the difference between incoming cash flows and outgoing cash flows will usually be close to the on-paper profit. However, just because a business is profitable does not mean that it is doing well. Indeed, a business can be profitable but have an incoming cash flow that is too low to sustain that profitability. Figures 7 and 8 compare the payback period to the return on investment for tilapia and catfish smallholder farms, respectively. Larger return on investment with corresponding lower payback periods increase profitability. The payback period can be reduced when small-scale fish farmers spread their investments across the years of their practice, increasing their scales of production as profits increase. The findings generally make the aquaculture venture unprofitable in the short term.

Major challenges faced by small-scale farmers

In Ghana, the cost of feed accounts for about 70% of total fish-farming production costs. Choice of feed for fish farming could greatly affect total productivity as shown in Fig. 3. Although some supplement with agro-by products such as groundnut and maize husk, most farmers prefer using commercial feed because it has higher nutritional value, the ability to float, and higher palatability although it is relatively very expensive. The fact that attention from investors, government agencies, and researchers has been lacking in the development of technologies to make locally produced feed competitive with those produced by foreigners has accounted to the high dependency on the latter, which has in turn increased the costs involved in aquaculture.

Consequently, all the farmers interviewed during the period of the research complained about the cost of extruded feed, as shown in Fig. 4. The limited access to agriculture loans, and the high interest rates of the few banks that offer loans, aggravate the production cost challenges of smallholder fish farmers forcing them to rely on their personal savings as capital. Therefore, establishing a loan system attractive for small-scale activities would make a boost of aquaculture more likely. Again, challenges with marketing of fish were recorded among 22.5% of the total sample. Marketing challenges could be due to distance of farm sites from local market, high charges from "middle-men" and lack of adequate transportation means to get goods to consumers. Also, 32.5% of farmers reported challenges with sex-reversed tilapia where sex-reversal was incomplete and affected production. The situation could be averted when quality fingerlings from accredited hatchery operators are purchased. Hence, the need to train more hatchery and nursery operators and to develop government-owned hatcheries close to aquaculture sites is paramount. Also, from Fig. 4, 7% of fish farmers had issues with record keeping where it was observed that records kept were poor and ignored certain relevant aspects of fish farming such as water quality assessments, stocking dates, and annual financial reports similar to challenges reported by Engle and Niera (2005). According to Machaena and Moehl (2001), inadequacy of governmental support activities had handicapped the orderly and rapid development of the aquaculture venture; as shown in Fig. 4, 27% of farmers confirmed that inadequate governmental support (financially, and provision of training and machinery) was an impediment on aquaculture production in Ghana. Theft, however, was a minor challenge faced by only 3% of the farmers; theft cases were not rampant because many of fish farmers lived on their farms.

Conclusion and recommendations

The study revealed that small-scale aquaculture fish production is profitable but with a longer-tern payback period. It was also found to be a male-dominated business in the study areas. In support of the nationwide agenda to improve aquaculture production, the government should provide training and technical support to small-scale fish farmers in the country through on-farm research and demonstrations. Again, the aquaculture for food and jobs agenda by the government should not only seek to improve production and create more employment among larger-scale fish farmers but also smallholder farms. There is also the need for increased research into locally produced feed from agro-by products in order to reduce production costs for smallholder farmers. In this regard, it is strongly recommended for such extended study to apply the production function approach to interrogate the issue of marginal returns on farmer investments. Also, it is important to note that effective management of farming operation requires that records be kept so managers can make informed decision affecting the profitability of their farms. Financial institutions require farming records as a basis to understand the feasibility of an investment and to give loans. To provide the needed financial support, credit providers, both formal and informal, should be educated as to the opportunities for investment in aquaculture and its potential profitability. These steps will encourage more people to go into aquaculture, to boost fish supply, increase food security, and bridge the high demand-supply gap of fish in Ghana.

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Ethical approval This article does not contain any studies with animals performed by any of the authors.

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Appendix

Section A: Farm details

1. Name of aquaculture farm……………………………………………………………………..

2. Area (size) of farm……………………………………………………………………………..

3. Location of farm: District……………………………………………………

- ☐ Greater Accra region
- ☐ Central region
- ☐ Western region
- ☐ Eastern region
- ☐ Volta region
- ☐ Ashanti region

4. What is the type of business ownership?

☐Sole proprietorship ☐Partnership ☐Foreign investors (if marked, proceed to 4b)

4b.i) Name of company………………………………… ii) Country of Origin………………………………………………..

5. What species do you culture?

☐Tilapia ☐Catfish ☐Shrimp ☐ other……………………………………………………………….

6. What kind of enclosure is used on the farm?

☐Earthen pond ☐Cage ☐Concrete tanks ☐ other……………………………….

7. What are the dimensions of the holding facilities?

i) …………………………… ii) ………………………. Iii)……………………

Section B (Variable costs)

1Fingerlings prod.	□ Farm	□ Not on farm		
2.Fingerlings source	□Gov. owned hatcheries	□Private hatcheries		
3.Sex Cultured	□All-male monosex	□Mixed sex	Polyculture	
4.Polyculture species	i)……………………………………	ii)………………………… …	iii)………………… ….	
5.Fingerlings prices	Per fingerling…………………… ….	Per pond/cage……………………..		
6.Area of ponds/cages	i)……………………………………	ii)………………………… ………	iii)………………… ….	
7.Average stocking density	………………………./m^2			
8.Average stocking weight	……………………..kg			
9.Feed type	□Pelleted	□Non-pelleted		
10. Feed source	□Locally from agro by-products	□Foreign based; imported	□LBFP*	
11.Average qt. per day	Feed quantity(per bag)	Protein quantity	Feed qt.(/ Kg)	cost per bag(Ghs)
•age 3 months & below	……………………………..	………………………… ….	…………………… ….	……………….
• age 3-6 months	……………………………	………………………… ……	…………………… ……..	……………….
•age 6months-1 year	……………………………….	………………………… ………	…………………… ……..	……………….
12.Costs of feed per cycle	……………………………… ……..			
13.Fertilization freq. per cycle	……………………………… ….			
14.Formulation of fertilizer	………………..…………..	………………..……… ……..	…………………… …..	Total costs per cycle
15.Prices of components	Cost……………………… ….	Cost…………………… …….	Cost……………… ………	…………………..
16.Length of culture period	……………………………… ……….			
17.Level of mechanized farming	□High	□Moderate	□Low	□ςερψ low
18.Avg size of harvested fish	………………………..cm	………………………… kg		
19.Avg qt. of total harvested fishes				
•Number	……………………………..			
•Weight	……………………………..			
20.Number of skilled labour	……………………………..	Salary…………………each		
21.Number of unskilled labour	…………………………….	Salary…………………each		
22.Number of security personnel	……………………………..	Salary…………………..each		
23.Pond/cage repair frequency	…………………………….			
24.Cost of repairs	……………………………..			
25.Source of funding	□Personal savings	□Loans from banks	□Family loan	□Φορειγν investors
26.Time at which loan was taken	……………………………….			
27.Interest on loan	……………………………… ……….			
28.Ready market	□Yes	□No	□Occassionally	
29.Preference for cultured species	□High	□Low	□Moderate	□ςερψ low
30.Marketing price at table size	……………………………GHS.			

LBFP* means Locally Based Foreign Producers

SECTION C(Fixed costs)

1.Total farm area	……………………….acres

Section C (Fixed costs)

1.Total farm area	……………………….acres
2.Price of 1 acre of land	……………………….GHS
3.Area of individual ponds	i)……………………
	ii)…………………....
	iii)…………………..
	iv)…………………..
4. Machines for digging?	□Yes
	□No
5.Price of rented machinery per hr	…………………….GHS
6.Operation hrs per day	………………………….
7.Duration of work	…………………………
8.Operator's charge	…………………………
9. Manual excavation?	□Yes
	□No
10.Number of labourers	………………………..
11.Hours of work per day	………………………….
12.Total number of work days	…………………………
13.Each labourer's charge	…………………………GHS
14.Liming cost	…………………………GHS
CAGE	
15.Cost of 1 vol. of space	
16.Initial licences and costs	
i)……………………………	i)……………………………
ii)……………………………	ii)…………………………..
iii)……………………………	iii)…………………………
iv)…………………………	iv)………………………..
17.Licence renewal charges	
i)……………………………….	i)…………………………
ii)……………………………	ii)………………………
iii)…………………………	iii)…………………………

iv)……………………………	iv)……………………………	
18.Cost of one cage	………………………………	
19.Cost of setup of 1 cage	………………………………	
20.Additional costs involved		
21.Machinery costs		
• Weeding (mowers, cutlasses etc.)	………………………..	
• Harvesting (Gears, scoop nets etc.)	…………………………..	
• Others (buckets, feeding aids etc.)	…………………………..	
22.Source of water	………………………………	
23. Payments on water?	……………………../month	
ADDITIONAL VARIABLE COSTS	Monthly	**Per cycle**
•Electricity	…………………………...	**………………**
•Health and veterinary	…………………………….	………………
•Inspection/advisory services	……………………………..	………………
•Transportation of fishes to markets	………………………………	………………
•Transportation of fingerlings to farm*	………………………………	………………
•Packaging of fishes to market	………………………………	………………

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