

## Research Article

# Estimating Profit Efficiency of Artisanal Fishing in the Pru District of the Brong-Ahafo Region, Ghana

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Received 26 February 2017; Accepted 26 November 2017; Published 21 December 2017

Academic Editor: Claus A. Soerensen

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This study evaluated the profit efficiency of artisanal fishing in the Pru District of Ghana by explicitly computing profit efficiency level, identifying the sources of profit inefficiency, and examining the constraints of artisanal fisheries. Cross-sectional data was obtained from 120 small-scale fishing households using semistructured questionnaire. The stochastic profit frontier model was used to compute profit efficiency level and identify the determinants of profit inefficiency while Garrett ranking technique was used to rank the constraints. The average profit efficiency level was 81.66% which implies that about 82% of the prospective maximum profit was gained due to production efficiency. That is, only 18% of the potential profit was lost due to the fishers' inefficiency. Also, the age of the household head and household size increase the inefficiency level while experience in artisanal fishing tends to decrease the inefficiency level. From the Garrett ranking, access to credit facility to fully operate the small-scale fishing business was ranked as the most pressing issue followed by unstable prices while perishability was ranked last among the constraints. The study, therefore, recommends that group formation should be encouraged to enable easy access to loans and contract sales to boost profitability.

## 1. Introduction

Fish is a source of high quality and cheap animal protein essential to balancing diet. According to the World Bank [1], the primary source of animal protein for more than 50% of the world's population is fish. Globally, most of the total fish supply is obtained from marine and inland capture fisheries, and the remainder is derived from aquaculture. Both marine fish and aquaculture play a vital role in the global supply of fish. In 2006, there was a total of 110 million tonnes world production of fish out of which 47% came from aquaculture [2]. In Africa, 5% of the total population obtain their source of livelihood from fisheries industry.

Ghana has a lot of lakes, lagoons, and rivers for fish production [3, 4]. The Volta river basin (including Volta lake, the largest man-made lake in Africa and the second largest in the world) dominates the country's riverine systems [5]. The Volta lake has attracted several migrant artisanal fisheries and

settlers. The country is also blessed with a marine coastline of about 550 kilometers which stretches from Aflao in the eastern part of the country to Half-Assini in the western part. These two water bodies (i.e., Volta lake and the coast) serve as a main source of fish, which is used in the production of meals and medicines for both human and animal consumption [6]. Artisanal fisheries form a significant contribution towards food security, income, and employment in many Ghanaian households. Artisanal fishing is a traditional or subsistence fishing comprising small-scale, low-technology, and low-capital fishing practices undertaken by individual fishing households (based on the definition of artisanal fishing, the study, therefore, used artisans and small-scale fishers interchangeably). Most of these artisans are of coastal, island, or inland ethnic groups. The artisan fishing uses traditional fishing technology such as rod and tackle, cast nets, and small traditional fishing boats. Artisanal fishing is less intensive and stressful than the modern industrial fishing techniques.

According to Tetteh [7], the small-scale subsector of Ghana's fisheries provides about 30,000 people with employment. In 2012, the fisheries subsector contributed approximately 1.5% to the country's agricultural Gross Domestic Product (GDP) [8, 9].

Despite the above-mentioned natural potentials and significance of fish industry in the country, the sector faces some challenges that militate against its growth. These include perishability of fresh fish and lack of information about the management of the industry by these artisans [10]. For instance, small-scale fishers may not have the financial management skill to adequately manage their resources to optimize their revenue. According to Bank of Ghana Report [11] on the Fishery industry in 2008, fish production declined severely from 6% of the GDP in 1993 to 3.9% in 2006. Ghana imports fish to supplement its consumption demand, particularly in the lean season, albeit, Ghana is a fishing country. An integral aspect of fish production is fish marketing which ensures that the right commodity is available at the right time, price, and place [12]. Over the years, governments have implemented intervention programmes such as subsidizing the cost of outboard motors and fuel cost towards improving productivity growth and an efficiency of the artisanal fisheries as well as increasing per capita income of the indigenous fishermen. However, the outcomes have been below expectation, due to poor implementation, monitoring, and evaluation of the intervention programmes. Further, the marketing of fish is characterized mainly by the problems of seasonality, perishability, and poor storage. The seasonality of fish makes it abundant at certain periods of the year (July to August) during which there is glut leading to high supply over demand forcing fishermen to sell at a "give-away" price. Fish has been highly perishable after harvesting as it requires proper preservation and storage to increase its shelf life [13]. This negatively affects profit efficiency of the artisanal fishers and also serves as a disincentive for people to go into fishing and its related businesses. At other periods of the year (January to February), there is a great scarcity of fish leading to high prices. Addressing these obstacles through empirical evidence is a necessary step towards attaining self-sufficiency in the Ghanaian fishing industry. Estimating profit efficiency provides a mean to capture farm level production specialization that allows higher incomes reserved by farms through the production of differentiated output to compensate for higher cost incurred [14].

Moreover, most studies in efficiency have not looked at the artisanal fishing subsector, especially in the study area. In the Pru District of Ghana where most households are into artisanal fishing and food security of great concern, the sustainability of the fishing business cannot be achieved without economic viability. The study, therefore, investigates the profit efficiency among artisanal fishers in the Pru District of Ghana by estimating their profit efficiency levels, identifying the sources of profit inefficiency and assessing some of the constraints of artisanal fishing.

## 2. Methodology

*2.1. Study Area, Data, and Sampling Technique.* The study was conducted in the Pru District which is geographically located in the Brong-Ahafo region of Ghana, and its capital is Yeji.

The population is mainly rural with their primarily economic activity being agriculture. Due to the presence of the Volta lake in the district, fishing is a significant activity that employs the majority of the people (fishers, fishmongers, cold store operators, among others). Primary data collected from small-scale fishing households was used for the study. The data consisted of fishermen's sociodemographic characteristics, inputs and outputs of fishing, the cost of fishing, and prices of fish, among others. A semistructured questionnaire was used to collect data through personal interviews. The communities well known for fishing activities were taken from the Fisheries Department under the Ministry of Food and Agriculture [MoFA], Ghana. Six villages were randomly selected, and twenty respondents were chosen from each community giving a total sample size of 120.

*2.2. Analytical Framework.* Sociodemographic characteristics were reported using descriptive statistics such as frequencies, percentages, and averages. The data was examined using stochastic profit frontier model and Garrett ranking technique.

*2.2.1. Theoretical Framework of Stochastic Frontier Model.* Over the past three decades, the two main components of production efficiency, technical and allocative, have been analysed in literature. However, both measures can be merged into one system, where more efficient estimates can be obtained by the simultaneous estimation of the system [15]. The technical efficiency component is mostly measured using the famous frontier production function [16]. However, [17] argues that frontier production approach to measuring efficiency may not be appropriate when production units face different prices and have different resource endowment. Hence, stochastic profit efficiency function is used to estimate efficiency directly [18]. The stochastic profit frontier combines the concepts of both technical and allocative efficiency, and, therefore, any errors in the production are assumed to be translated into lower profits [19]. Profit efficiency refers to the ability of an artisanal fisher to achieve highest possible benefit or gain, given the prices of inputs and levels of fixed factors used in fishing. In this case, the small-scale fishers are assumed to choose a combination of variable inputs and outputs that maximize profit subject to technology constraint. Artisans who fall below the frontier or do not operate on the frontier are not profit-efficient. This model assumes that factors outside the artisans control can also affect profit levels estimated against a random term which is a component of the composite error. The stochastic profit frontier model was used to determine the profit efficiency of artisanal fishing in the Pru District. The study applies the Battese and Coelli [20] procedure by postulating a profit function assumed to behave in a manner consistent with the concept of the stochastic frontier model [21, 22].

The stochastic profit frontier model is specified as

$$\begin{aligned}\pi_j &= f(P_{ij}, Z_{kj}) \exp e_i \\ e_i &= v_i - u_i,\end{aligned}\tag{1}$$

where  $\pi_j$  is the normalized profit (gross margin) of the  $j$ th fisherman,  $P_{ij}$  is the price of the normalized variable input,

$Z_{kj}$  is the level of fixed factor in fishing, and  $e_i$  is the error term.  $v_i$  is the symmetric error term and assumed to be an independently and identically distributed two-sided error term representing the random effects, measurement errors, omitted explanatory variables, and statistical noise;  $u_i$  is the one-sided error term. The profit efficiency of the  $i$ th artisanal fisher can be expressed as the ratio of the observed profit ( $\pi_i$ ) to the predicted maximum profit ( $\pi_{\max}$ ) and specified as

$$\begin{aligned}\pi_e &= \frac{\pi_i}{\pi_{\max}} \\ &= \frac{f(P_{ij}, X_{ij}, \beta_i) \cdot \exp(v_i - u_i)}{f(P_{ij}, X_{ij}, \beta_i) \cdot \exp(v_i)} \quad (2) \\ &= \exp(-u_i)\end{aligned}$$

Profit inefficiency =  $1 - \pi$ ,

where  $\pi_e$  is the profit efficiency,  $\pi_i$  is observed profit, and  $\pi_{\max}$  is the maximum (potential) profit. The profit efficiency ranges between zero [0] and one [1]. That is,  $0 < \pi_e < 1$ . The parameters of the stochastic profit frontier function were estimated by the maximum likelihood function using STATA 13. The maximum likelihood estimates of the stochastic profit frontier model provide the estimates of  $\beta$  and gamma ( $\gamma$ ), where gamma explains the variation of the total profit from the frontier profit. The gamma estimate is specified as  $\gamma = \sigma_u^2 / \sigma^2$ .

Here  $\gamma$  lies between zero and one ( $0 \leq \gamma \leq 1$ ) and represents the share of the inefficiency in the overall residual variance. The gamma values ranging between zero (0) and one (1) indicate the presence of profit inefficiency. A value of 1 indicates a deterministic frontier while that of zero suggests the absence of inefficiency. Thus, such absence of inefficiency favours the use of the average response model estimation due to the absence of the inefficiency effect term ( $\mu_i$ ).  $\sigma_u^2$  is the variance of the error term associated with the profit inefficiency effects, and that associated with random noise factor is  $\sigma_v^2$ .  $\sigma^2$  represents the overall variance of the model and the three are related as  $\sigma^2 = \sigma_u^2 + \sigma_v^2$  [23].

The main hypothesis tested in this study is whether or not there exists profit inefficiency in the operations of the sampled artisanal fishers in the study area. The null and the alternate hypotheses are stated as

$H_0$ : absence of profit inefficiency,

$H_A$ : presence of profit inefficiency.

The hypotheses above were tested with the generalized likelihood ratio test ( $\lambda$ ) which can be expressed as

$$LR = -2 \ln \left[ \frac{H_0}{H_A} \right]. \quad (3)$$

The generalized likelihood ratio (LR) has a mixed chi-square distribution set at a level of  $\alpha\%$  significance and  $K + 1$  degrees of freedom, where  $K$  is the number of variables included in the inefficiency model [24].  $H_0$  is the model under the null hypothesis that there is no inefficiency ( $\gamma = 0$ ) while  $H_A$  is an alternate hypothesis that profit inefficiency exists ( $\gamma = 0$ ).

**2.2.2. Empirical Model.** The study employed the Cobb-Douglas production function due to its flexibility and its popularity. It also meets the requirements of being self-dual; thus, it allows an examination of economic efficiency [22]. The study used the model of [25] to specify the stochastic profit frontier with the inefficiency components where all the parameters were estimated together in a single step maximum likelihood estimation. The frontier model for estimating profit efficiency of artisanal fish catch is specified as

$$\begin{aligned}\ln \pi_j &= \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 \\ &+ \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 \\ &+ u_i - v_i,\end{aligned} \quad (4)$$

where  $\pi$  is normalized profit. (For the normalized profit, the gross margin is divided by the market price of the fish output. The gross margin is the difference between the total revenue and the total variable cost considering the inclusion of some fixed cost as explanatory variables in the profit equation [24].)  $X_{1i}$  is the cost of maintenance,  $X_{2i}$  is cost of storage,  $X_{3i}$  is the price of labour,  $X_{4i}$  is the price of needle,  $X_{5i}$  is size of rope,  $X_{6i}$  is the price of paddle, and  $X_{7i}$  is the cost of the boat.  $u_i$  is characteristic of artisanal fishers related to fishing and  $v_i$  is error term. The profit efficiency of the  $i$ th farmer is given by  $\exp(-u_i)$  [5, 6], where

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4, \quad (5)$$

where  $Z_1$  denotes the age of fisherman,  $Z_2$  denotes fishing experience,  $Z_3$  denotes educational level, and  $Z_4$  denotes household size.

**2.2.3. Garrett Ranking Technique.** The Garrett ranking technique was used to rank constraints that militate against the activities of fishermen. The fishermen were allowed to rank constraints which were converted into score value using the formula for Garrett ranking technique as specified below:

$$\begin{aligned}\text{Percentage Position of Constraint} \\ &= 100 \cdot \frac{(R_{ij} - 0.5)}{N_j},\end{aligned} \quad (6)$$

where  $R_{ij}$  is rank of constraint = the  $i$ th constraint by the  $j$ th artisan.  $N_j$  is number of constraints ranked by  $j$ th fishers. The percentage position calculated using the above formula was converted into scores using Garrett's table. The scores of each constraint were added to each constraint from which total values and mean values of the scores were computed.

### 3. Empirical Results and Discussions

**3.1. Demographic Characteristics of Respondents.** The entire 120 respondents interviewed are males (Table 1). This may be due to the nature of fishing. Fishing involves physical strength and thus is undertaken by men while females are mainly engaged in the processing and marketing. Fishing in the Pru District is primarily dominated by the age group 31–40 years representing about 39% of the total sample size. This

TABLE 1: Demographic characteristics of the artisanal fishers in Pru District.

Variable	Category	Frequency	Percentage (%)
Age	21–30	21	17.5
	31–40	39	32.5
	41–50	32	26.7
	51–60	19	15.8
	>60	9	7.5
Marital status	Married	91	75.8
	Single	29	24.2
Formal education	No formal education	52	43.3
	Primary/junior high	52	43.2
	Senior high school	16	13.3
	Tertiary education	0	0
Experience	1–5	13	10.8
	6–10	31	25.8
	11–15	36	30
	16–20	21	17.5
	>20	19	15.8
Household size	1–5	47	39.2
	6–10	61	50.8
	>10	12	10
Off-farm activities	Off-farm	34	28.33
	Nonfarm	86	71.67

Source: field survey, January 2015.

is closely followed by the age group 41–50 years representing about 26.7%. There is no fisher below 20 years while 7.5% are above 60 years; thus, the aged are somehow engaged in fishing. The majority (75.8%) of the artisanal fishers are married. In the Ghanaian fishing communities, the entire family mostly engage in the business with the males going to the sea while the females participate in the marketing and processing. Table 1 also reveals that out of the 120 respondents sampled, those without formal education are 43.3% and those with basic/primary education are also 43.3%. Also, 16 respondents representing 13.3% had up to senior high school education while none of them had a tertiary education. Tijani et al. [26] and Hyuha [27] indicated that the acquisition of higher education improves the quality of labour and also the probability of adopting new techniques. The majority (68.3%) of the fishermen are Christians while Muslims and Traditionalists recorded 11.7% and 17.5%, respectively.

The remaining 2.5% belong to other religions. The mean household size is 9.13. Hence, on the average about 9 people live in a household and depend on the household head for their livelihoods. The size and composition of a household influence the magnitude of fishing activities of the household. This is because most fishermen use family labour. Apart from fishing, 28.3% of the fishermen engage in other economic activities such as rearing of farm animals, construction, crop farming, fetish priesthood, lottery, mechanic, and petty trading. The remaining 71.7% are solely engaged in fishing. Additionally, the minimum years of experience in fishing are 3 years while the maximum is 36 years. The mean year of experience is 16.59 years. This means that fishers have long-term experience in fishing.

TABLE 2: Estimated coefficients of the stochastic profit frontier model for fishermen.

Variable	Coefficient	Std. error
Cost of maintenance	-0.0229	0.0873
Cost of storage	0.1240**	0.0579
Price of labour	0.4360***	0.1171
Price of needle	-0.0369	0.1721
Price of rope	0.7944***	0.2601
Price of paddle	-1.7706**	0.8511
Price of boat	0.5884***	0.1097
Variance parameters		0.0342
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.2646***	
$\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$	0.7891***	
LR test of the one-sided error	48.37	

Source: field survey, January 2015. \* \* \* and \*\* denote significance levels at 1% and 5%, respectively.

3.2. Maximum Likelihood Estimates of the Stochastic Profit Frontier. The factors influencing profit of inland fishing in the study area are presented in Table 2. The estimated sigma-squared ( $\sigma^2$ ) was about 0.26 and statistically significant at one percent level indicating the correctness and a good fit of the distributional assumption of the composite error term.  $\sigma^2$  also suggests that the profit efficiency equation can explain the profit with regard to each decision making unit as well as the profit of the frontier function [25]. The gamma value which estimates the deviation of the observed profit from the frontier profit is approximately 0.79. This suggests

TABLE 3: Determinants of profit inefficiency of inland fishing in Pru District.

Variable	Coefficient	Standard error
Age of the household	0.0777*	0.0471
Household size	0.2345*	0.1251
Educational level	-0.0534	0.0849
Number of years in inland fishing	-0.1038**	0.0525
Constant	-5.8251	3.1210
<i>Mean profit efficiency</i>	<i>0.8166</i>	
<i>Minimum profit efficiency</i>	<i>0.3498</i>	
<i>Maximum profit efficiency</i>	<i>0.9519</i>	
<i>Number of observations</i>	<i>120</i>	

Source: field survey, January 2015. \*\* and \* denote significance levels at 5% and 10%, respectively.

that the most substantial proportion of the variation in the total profit could be ascribed to the use of inputs and other managerial practices. Nevertheless, the stochastic noise such as unfavourable weather conditions and data measurement errors contribute a relatively smaller proportion of the deviation from the potential profit. Further, the value of the generalized likelihood ratio test (LR) was 48.37 with 5 degrees of freedom being at 1% level of significance. (The critical value of gamma ( $\gamma$ ) was obtained from the table of Kodde and Palm [28].) This indicates that the null hypothesis of no inefficiency effects in the profit frontier function is rejected in favour of the alternate hypothesis and that the traditional average response function (Ordinary Least Squares [OLS]) is not a good representation of the dataset. Hence, the stochastic frontier function is most appropriate for the dataset. The coefficients of the factors are estimates of the profit function maximum likelihood and are interpreted as direct elasticities since they were normalized. From the results, the cost of storage, the price of labour, the price of rope, and price of the boat are significant and positively signed while the price of the paddle is significant and negatively signed. The estimated coefficients of the mean profit with respect to the cost of storage, the price of labour, the price of rope, and the price of the boat are 0.124, 0.436, 0.794, and 0.588, respectively. This implies that, for a 10% increase in the cost incurred in the cost of storage, the hiring of labour, and purchase of rope and boat, the profit is increased by 1.24%, 4.36%, 7.94%, and 5.88%, respectively, holding other variables constant. However, a 10% increase in the price of a paddle reduces the profit by 17.71%.

**3.3. Determinants of Profit Inefficiency.** Table 3 shows the profit efficiency levels and determinants of profits inefficiency. From the table, an average measure of profit efficiency of 81.66% was recorded. This means that fishermen are losing about 18% of their potential profits as a result of the inefficiencies. This finding is consistent with that of Itam et al. [29] who obtained a mean efficiency of 89% among fishermen in the Cross River State, Nigeria. Meanwhile, Penda et al. [30] found a lower efficiency level (61.9%) among fishermen. Age was significant at 10% and had a positive sign. It is important to note that the positive coefficient in the inefficiency model signifies an increase in profit inefficiency while a negative

TABLE 4: Constraints ranked by the artisanal fishers in Pru District.

Constraint	Percent position of constraint	Mean score	Rank
Finance (access to credit)	8.791667	76	1st
Unstable prices	14.99702735	70	2nd
Storm	16.16124	69	3rd
Seasonality of fishing	20.26771	66	4th
Perishability	31.97589	59	5th

Source: authors' computations.

coefficient leads to a decrease in profit inefficiency. This is because the value of the inefficiency term ( $\mu_i$ ) would be larger as the firm is far below the profit frontier [31]. As the age of fishermen increases, the efficiency level reduces or the inefficiency level increases. Fishing is an activity involving physical strength; therefore the relatively young and energetic fishers are more likely to have higher efficiency. Nevertheless, the positive sign of age contradicts the findings of Tsue et al., [18], Olayiwola [32], and Kareem et al. [33]. Household size was also significant at 10% and had a positive coefficient. This implies that, as the household size increases, the profit efficiency level reduces and vice versa.

However, Itam et al. [29] and Kareem et al. [33] found that family size has a negative effect on the inefficiency levels of small-scale fishers. The level of experience measured by the number of years in inland fishing had a negative sign and is significant at 5%. As the experience level of the artisanal fishers increases, profit efficiency level increases. This means that the more experienced artisanal fishers have higher levels of efficiency than the less experienced ones. This is expected because experience correlates positively with techniques of inland fishing for efficient operations and profit maximization. This is consistent with the works of Olayiwola [32], Kolawole [34], and Adeleke [35] who established that farming experience has a positive effect on the efficiency of fish output. However, Itam et al. [29] and Kareem et al. [33] reported a positive relationship between the level of experience and profit inefficiency.

**3.4. Constraints of Inland Fishing in the Study Area.** Artisanal fishers interviewed in the study area ranked some constraints that militate against their activities. The summary of the ranking is presented in Table 4. From the ranking, the respondents ranked *finance* (access to credit) as their topmost constraint. Similarly, other authors [29] ranked unavailability of credit as the second most pressing need of the artisans. Fishing like any other economic activity involves cost such as labour, fuel, maintenance, storage, and other variable inputs. Most of the fishers interviewed indicated that they face challenges with obtaining adequate funds to undertake fishing activities and this adversely affects their profit level significantly. Thus, more than half (about 55.5%) of the respondents suggested that access to credit would be a critical intervention. The unstable price of fish was ranked as the second most important constraint with a mean score of 70.

Similarly, Itam et al. [29] ranked unfavourable prices of fish (among ten constraints) as the fourth most pressing need

of the fishers. Fishing like any other agricultural activity is seasonal. Therefore, during the peak season, surpluses lead to a drastic reduction in prices. Conversely, during the lean season, shortages lead to high prices of the commodity. This makes their income/profit level unstable. As a result, respondents suggested a price ceiling policy and contract sales for fish. Seasonality was ranked as a fourth pressing issue with a mean score of 66. The storm was ranked third with a mean score of 69. Fishermen, especially those who use canoes without technology (outboard motor), mentioned that the storm is a threat to their lives since they cannot come to the shores as early as those with the technology when there is a storm. Fish like any other agricultural commodity is highly perishable. Though perishability is a pressing constraint, it was ranked last (5th) among the five limitations because they can sell almost all the fish they harvest in a day. The wholesalers, retailers, and processors come to the shore to purchase directly; hence, fishers do less or no storage.

#### 4. Conclusions and Recommendations

This study applied the stochastic profit frontier to a sample of small-scale fishing households to estimate the level of profit efficiency and identify sources of profit inefficiency using Pru District as a case study. The study concluded that the average measure of profit efficiency is 81.66%, suggesting that about 82% of prospective maximum profit was gained due to production efficiency. Artisanal fishers are as a result losing 18% of their potential profit due to inefficiency. Predictably, the study revealed that the benefit of small-scale fishers could be increased through the reduction of input prices. Profit efficiency can, therefore, be improved through educational training programmes geared towards the improvement of technical and managerial skill of the fishers. Also, the age of the household head and household size increase the profit inefficiency level while experience decreases inefficiency level. From the Garrett ranking, access to credit was ranked as the most pressing issue followed by unstable prices while perishability was ranked as the least among the constraints. The study, therefore, recommends that micro-policies oriented towards easy access to credit are crucial to boosting fish production in Pru District in particular and Ghana in general. Contract sales in the fishing industry are highly recommended since it has the potential to create an accessible market for the fisherman and minimize perishability as well as increasing the profit levels. The wide variation in the output price between the major and lean season is a critical area to be tackled. This suggests that focusing on skill and managerial development of the fishers alone may not produce the desired results. Long-term infrastructural development such as storage facilities (e.g., establishment of cold store in the fishing communities) is particularly important to assure these small-scale fishers that if market surpluses are experienced during the main season, the output could be stored in safer places for the next season. This could ensure steady prices throughout the year and that artisans could be sure of having relatively stable income and minimize hunger particularly in the lean season. Finally, the Ministry of Fisheries, Ghana, should consider subsidizing some of the inputs to boost productivity.

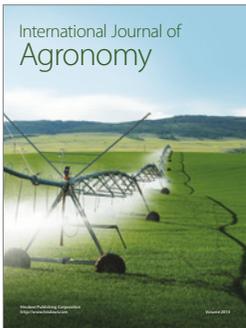
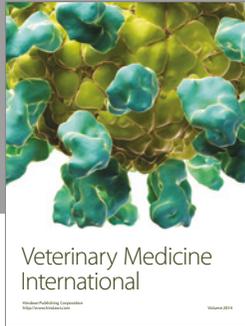
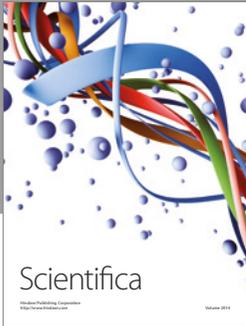
#### Conflicts of Interest

The authors declare that they have no conflicts of interest.

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