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Evaluation of Pond Management Regimes of Fish Farmers: the Case Study in Tolon Fisheries Zone, Ghana

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Abstract

During the last decade, capture fisheries production from capture fisheries has been on the decline. Fish farming has been preferred as an alternative to meet fish requirements. This study was therefore conducted to evaluate the effect of different pond management regimes on water quality parameters and the resultant effect on the production and profitability of fish farming in the Northern Region, Ghana. A total of 10 fish farmers were selected randomly for the study of pond management regimes and 5 fish ponds were chosen purposively for the water quality and profitability analyses. The study revealed that the highest concentration of fish farmers (50%) was in the Tamale Metropolis. The dominant type of fish holding facility was tank (70%) whiles pond constitutes 30%. The study revealed that 56% of the fish farmers use pelleted feed whiles 22% use both pelleted and powdered feed. The results also revealed that 60% use pipe-borne water for fish farming while 40% of the fish farmers had a dam as a source of water. The study indicated a positive relationship between feeding frequency and the concentration of dissolved oxygen.

Keywords: *Water Quality; Net Profit; Pond Management Regimes; Tolon Fishery zone*

1.0 Introduction

The growing global demand for fish is currently the highest on record with a significant contribution to global food security. (FAO,2018).

Global production from Fisheries, aquaculture and food fish supply is currently the highest on record while the global per capita fish consumption rises over 20kiligram annually and remains very significant for global food security FAO (2018a). The world's total fish production for 2018 was 179 million tonnes of which capture production from inland waters increased to 12 million tonnes.

The importance of the fisheries sector to the socio-economic development of Ghana cannot be overemphasized. The agriculture, forestry and fishery sectors of Ghana made a contribution with an added value of about 17 percent to the gross domestic product (GDP) in 2019 (Sasu, 2021). Despite the potential of the fisheries sector in the country, fish production has been experiencing a consistent decline over the years (Ofori *et al.*, 2010). It has been observed that there is a general decline in the capture per unit of effort (CPUE) over the years, and a similar reduction in fish abundance in Ghanaian waters (Nunoo and Asiedu, 2013). Capture fisheries are consistently declining with increasing demand for fish worldwide with Ghana not being an exception. Several conservations and management plans have been put in place for sustainable exploitation of this natural resource including fish farming as an alternative (Tidwell, 2001). These include Ghana Fisheries Management Plan (2015-2016), Fisheries (Amendment) Regulations (2015), etc. the National Aquaculture code of Practice and guidelines and the Co-management policy for fisheries sector 2020.

Aquaculture is the rearing of aquatic animals (including fish) or cultivating aquatic plants for food (Ahmed, 1992) (reference?). This term is mostly used interchangeably with fish farming, which is also known as pisciculture, that is raising fish commercially in ponds, tanks, cages or other enclosures for food. Fish farming is an alternative means of meeting the ever-increasing demand for fish and a means of creating employment (Tidewell, 2001). For example, in China, farmed fish production exceeds capture fisheries (Xianping, 2017). Fish farming was introduced in Ghana at Lawra in Northern Ghana (Hiheglo, 2008). However, this gained more prominence in the southern part of the country. In recent times, most people who invest in fish farming in the Tolon zone fold out after a short period. Worthy of note is the Tolon zone, aquaculture practice has been in an alarmingly declining state due to poor management practice in the region. Most fish farms have collapsed due to the poor management of ponds. However, this study investigated the reasons for the poor operation of fish farms in tolon zone of the Northern region.

2.0 Methodology

2.1 Study Area

The Fisheries Commission in the Northern region has divided the region into four (4) operational areas (namely Tolon, Savelugu, Nanumba, and Yendi Zones). The study was conducted in the Tolon zone which comprises of four administrative districts namely: Kumbugu, Sagnarigu, Tamale and Tolon districts (Fig. 1). Tolon covers a total land area of 2,389 km2and it is located in the central part of the Northern Region lying between latitude 9.4309° N, 1.0646° W (GSS, 2012).

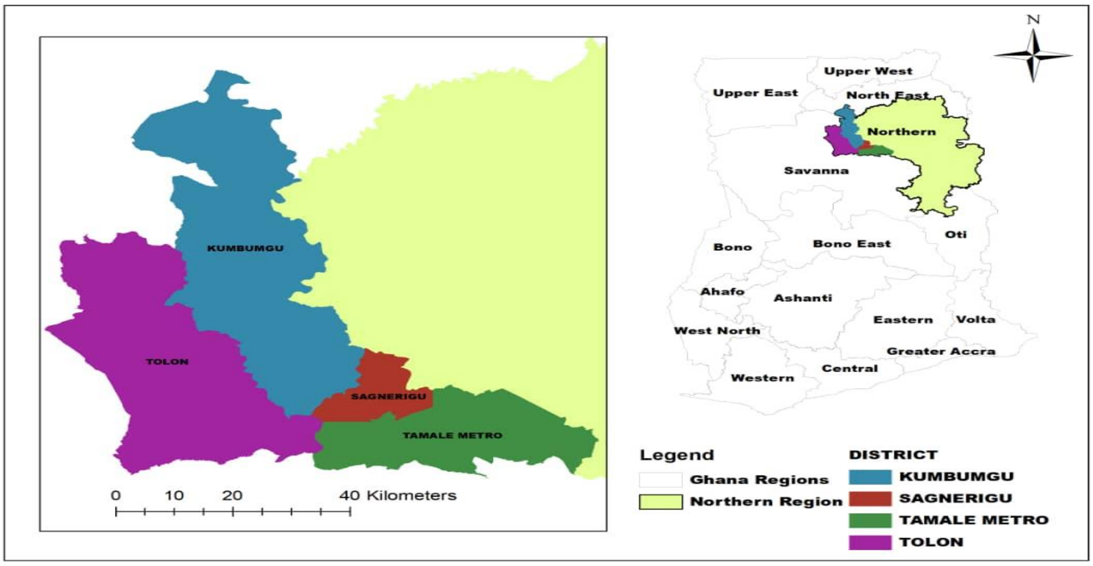

Figure 1: Map of the Study Area

2.2 Data Collection

Self-administered questionnaires were used to collect data from ten (10) fish farmers representing 95% of the total fish farmers in the district. The purposive sampling method was employed in identifying fish farmers. The questionnaire was divided into three (3) sections; demographic characteristics of fish farmers, pond management and profitability of the fish business. Secondary data on fish farmers in the zone were collected from the zonal Fisheries Directorate to support the research.

2.2.1 Water quality assessment

Water quality parameters (dissolved oxygen, pH, water temperature, turbidity, conductivity and ammonia) were measured in situ using a multi-parameter probe, Hydro kit (H2000) portable electronic water testing kit. The water quality was measured bi-weekly between March-May, 2020.

2.3 Data Analysis

The data was analyzed using the Statistical Package for the Social Sciences (SPSS 25.0) to obtain frequencies and percentages. Microsoft Excel 2010 was used to calculate the means of the various water quality parameters measured. The profitability of fish farming was analyzed using the equation: Y=QP-C (Howard & Matheson, 2005)

where Y=profit, Q=production, P=price received and C=cost of production and marketing.

Results

3.1 Demographic Characteristics of Fish Farmers

As indicated in Table 1, 80% of the total respondents were males whereas 20% were females. The age distribution of respondents indicated that 40% of the fish farmers were between the ages of 60 years and above and 10% of the fish farmers were between the ages of 51-60 years. In terms of educational background, 70% of the total respondents had tertiary education whiles 30% had secondary education (Table 1).

Table 1: Demographic Characteristics of Fish Farmers

Demographics	Percentage (%)
Gender	
Male	80
Female	20
Total	100
Age Group	
31-40	30
41-50	20
51-60	10
60+	40
Total	100
Education Level	
Tertiary	70
Secondary	30
Total	100

3.2 Fish feed and feeding methods

From Table 2, 56% of the fish farmers use pelleted feed whiles 22% of the respondents use both pellets and powdered feed. 56% of the fish farmers fed their fish twice daily whiles 22% of each of the respondents fed their fish once and thrice.

Table 2: Fish feed and feeding methods

Variable	Parameter	Percentage (%)
Type of feed	Pellet	56%
	Powder	22%
	Both	22%
	Total	100%
Feeding frequency per day	Once	22%
	Twice	56%
	Thrice	22%
	Total	100%

3.3 Source of Water, Water Quality, Water Quality Parameters and Management

The results revealed that 60% of the fish farmers use pipe-borne water for fish farming whiles 40% of the fish farmers had a dam as a source of water (Table 3). The average dissolved oxygen was 7.34mg/l, ammonia had an average of 0.22mg/l and an average pH of 7.34 (Table 3). The various fish farms had an average conductivity of 228.48µs/cm and an average turbidity of 23.75cm.

As indicated in Table 4, there was a significant difference between the conductivity of farm one and farms two, three, four and five. Also, there was a significant difference between farm two and farm three, four and five. Finally, there was a significant difference between farm three and farm four. Apart from the temperature which was just a little lower than the optimum level, 29-300C the rest of the water quality parameters were within the optimum ranges (Table 4)

Table 3: Source of Water and Water Quality Management

Variable	Parameters	Percentages (%)
Water source	Pipe	60%
	Dam	40%
	Total	100%
Variable	Parameters	Averages
Water Quality Management	Dissolved oxygen (mg/l)	7.34
	Ammonia (mg/l)	0.22
	pH	7.34
	Conductivity(µs/cm)	228.48
	Turbidity (cm)	23.75

Table 4: Means of Water Quality Parameters

Water quality parameter	Farms				
	1	2	3	4	5
Temperature (0C)	25.18±2.86ab	24.75±2.75a	28.23±0.52bc	28.63±0.52c	28.08±0.38bc
Dissolved Oxygen (mg/l)	5.83±0.49b	5.03±0.49a	7.34±0.39d	6.42±0.43bc	6.73±0.43cd
Turbidity (cm)	25.5±1c	22.7±0.53ab	23.75±1.76bc	21.5±1.87a	23.4±1.24ab
Ammonia (mg/l)	0.48±0.11bc	0.51±0.09c	0.22±0.02a	0.39±0.08bc	0.39±0.13b
pH	7.82±0.08b	7.82±0.08b	7.34±0.39a	6.88±0.12a	6.88±0.34a
Conductivity (µs/l)	269.83±4044d	264.67±3.27c	228.48±0.32a	238.65±0.96b	232.21±1.98a

Mean with the same letter are not significantly different at $P<0.05$

3.4 Type of Holding Facility and Management

The study revealed that 70% of the fish farmers culture their fish in concrete tanks whiles 30% of the fish farmers use earthen ponds (Table 5). In terms of management, 60% of the fish farmers applied lime to their holding facilities twice per production cycle whiles 40% of the fish farmers applied lime once in a production cycle. As indicated in (Table 5); 57% of fish farmers did fertilizer application once per production cycle whiles 43% of the fish farmers did fertilizer application twice per production cycle.

Table 5: Type of Holding Facility and Management

Variables	Parameters	Percentages (%)
Types of Holding Facility	Tank	70%
	Pond	30%
	Total	100%
Facility Management	Frequency of Liming	
	Once	40%
	Twice	60%
	Total	100%
	Frequency of Fertilizer Application	
	Once	57%
	Twice	43%
	Total	100%

3.5 Effect of Feeding Frequency on Dissolved Oxygen

The study indicated a positive relationship between feeding frequency and the concentration of dissolved oxygen; the farmer with a concrete tank who fed his fish twice with supplementary feed had the least concentration of dissolved oxygen and the highest concentration by the farmer with an earthen pond who fed his fish twice, each with half of the daily ration of supplementary feed with a weak strength of 0.33 (Figure 2).

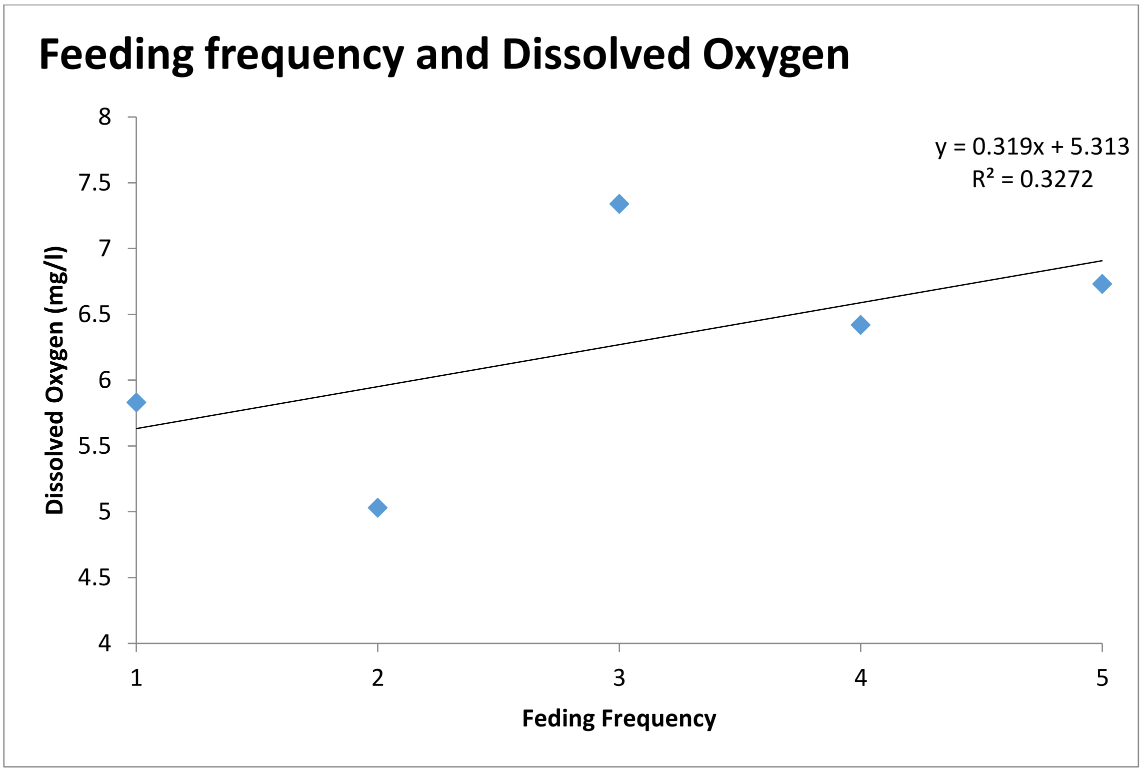

Figure 2: Effect of feeding frequency on dissolved oxygen

3.6 Cost of production, Net Profit and Profitability of Fish Farming in the Tolon District

In table 6, the major variable costs per production cycle were fingerlings, feed, lime and water. The fixed cost was the depreciated cost of pond/tank construction. The cost of feed per production cycle was the highest variable cost followed by the cost of fingerlings; the two variable costs represented 78.90% of the total variable cost. The depreciated cost of construction of the pond was the only item incurred under fixed cost.

The cost of feed per production cycle was recorded highest while, this was followed by the variable cost incurred for the purchase of fish seeds. These costs were extremely higher than those of the other variable cost items. This culminated in the high cost of total variable cost. The holding facility was the only item incurred under the fixed cost during the production cycle.

The study revealed that the mean cost of production in the zone was GH₵ 8,198.00 with average revenue of GH₵ 11,041.62 yielding an average net profit of GH₵ 2,843.62 (Table 6).

As indicated in (Table 7), the average net profit from fish farming in the Tolon district ranges from GH₵ 243.88 to 11,747.48.

Table 6: Cost of production

Item	Mean amount (GH₵)
Variable cost item	
Fingerlings	1,142.60
Feed	5,225.03
Fertilizer	17.50
Lime	195.00
Water	280.00
Labour	230.00
Security	280.00
Administration	700.00
Total variable cost	8,070.13
Fixed cost items	
Cost of holding facility	127.87
Total fixed cost	127.87
Total cost	8,198.00

Table 7: Net profit of fish farming in the Tolon zone

Total Revenue (GH₵)	Total cost (GH₵)	Net profit (GH₵)
11,041.62	8,198.00	2,843.62

Table 8: Average profitability of farmers

Farm	Revenue(GHS)	Cost (GHS)	Average Net Profit (GHS)	Average net profit per square meter (GHS)	Average cost per square meter (GHS)
1	1,048.00	804.12	243.88	4.88	20.96
2	2,390.40	2,009.26	381.14	3.97	24.90
3	940.50	635.00	305.50	4.07	12.54
4	13,878.00	9,936.88	3,941.12	6.57	23.13
5	35,616.00	23,868.52	11,747.48	9.79	29.68

4.0 Discussion

Males dominated the fish farming activities whiles females were the least represented in this study. This is because, in Ghana, males are mostly into aquaculture than women due to the physical nature of the activities involved. This conforms to Githukia *et al.,* (2020) who stated that gender participation at different levels of the value chain in aquaculture with female representation is very low compared to males. Githukia *et al.,* (2020) further explained that gender-based constraints affecting involvement in aquaculture include access to productive resources and start-up capital and discriminatory gender norms which limit women's participation and financial returns. The age distribution of respondents indicated that 40% of the fish farmers were between the ages of 60 and above years and only 10% of the fish farmers were between the ages of 51-60 years. The findings contradict Githukia *et al.,* (2020) who highlighted that, the mean age of the fish farmers was 49.3 years. The outcome of the study indicates the majority of fish farmers had tertiary and secondary level of education; this conforms to Ole-Moiyoi (2017) who explained that fish farmers with education backgrounds had basic knowledge on matters related to fish culture and marketing. Moreover, they understand the basic information on extension service delivery to update themselves with essential knowledge on technical and entrepreneurial skills (Obiero *et al.,* 2019).

Fish feed and feeding regimes is very essential in aquaculture production; the study highlighted that 56% of the fish farmers use pellet feed whiles 22% of the respondents uses both pellet and powdered feed. This finding conforms to Dauda *et al.,* (2014) who indicated that most fish farmers in Katsina State, Nigeria feed their fish with pelleted feeds and they relied on commercial or imported feeds. According to Asiedu and Henneh (2016), the growth and maintenance of the health of fish largely depend on the quality of protein in the feed. They further explained that protein ensures the formation and activity of important enzymes and hormones in a fish. According to the study conducted, 60% of the fish farmers resulted to pipe water for fish farming whiles 40% of the fish farmers had a dam as a source of water in the Tolon district. The outcome contradicts Akinwole *et al.,* (2014) who reported that deep well were the most abundant primary source of water for fish farming Ibarapa area of Oyo State, Nigeria. The outcome also contradicts the findings of Asiedu and Henneh (2016) who stated that fish farmers are coping with the impact of climate change by digging wells to top up water levels, and planting of trees around ponds to reduce evaporation.

However, the study also revealed that 70% of the fish farmers cultured their fish in concrete tanks while 30% of the fish farmers cultured their fish in earthen ponds. The results of this study are contrary to Akinwole and Akinnove (2012) who reported that earthen pond remained the most commonly used fish culturing facility in Nigeria. However, the outcome of this study conforms to Adeongun *et al.,* (2007) who highlighted that, concrete tanks were the most commonly used fish culturing facility in Lagos State, Nigeria. Water quality parameters of the various fish farms were examined; apart from water temperature which was just a little lower than the optimum level, the rest of the water quality parameters were within the optimum ranges for fish farming. The findings conform to Asiedu and Henneh (2016) who stated that the mean values recorded for water parameters were within the range of required water quality for tilapia farming. Asiedu and Henneh (2016) further explained that for good health and growth of fish depends on suitable water conditions. According to Boyed (2012); water quality is critical factor in fish farming or any aquatic organism, optimal water quality varies by the type of species and must be measured to promote growth and survival of the fish.

The study revealed a weak positive relationship between feeding frequency and concentration of dissolved oxygen with tanks that were fed twice daily. Such tanks had the least concentration of dissolved oxygen (5.03±0.49) mg/l whilst the earthen ponds which were fed thrice daily had the highest concentration of dissolved oxygen (6.73±0.43)mg/l. This was in accordance with Cerezo *et al.,* (2004), who discovered that there was a significant difference ($P<0.05$) between earthen ponds and concrete tanks in that fish in earthen ponds consumed more feed and the rate of decomposition of uneaten feed was faster than that in of concrete tanks. Consequently, there was a high amount of dissolved oxygen in the earthen ponds than in the concrete tanks. This was also in agreement with the result of Njoku *et al.,* (2015) who reported the same trend in earthen and concrete tanks holding facilities for fish.

The study highlighted fish farming to be profitable in the Tolon district with an average net profit of two thousand eight hundred and forty three Ghana cedis sixty two pesewas (GHS 2,843.62). This was in concordance with the report of Adewuyi *et al.*, (2010). They reiterated that fish farming is profitable in Nigeria. Moreover, net profit is affected by variable costs, cost of fish feed and fingerlings. This results from the non-availability of fish feed distribution outlets, inadequate quality fingerlings, high transportation and high cost of purchase of fish seeds and fish feeds to Tolon district. Similar findings were reported by Wesonga, (2018) who emphasized the high costs of purchase and high cost of transporting fish seeds and fish feeds to some fish farms in some remote settlements in Kenya.

Conclusion

In conclusion, farmers in Tolon zone do not have adequate technical advice on pond management practices. Furthermore, the poor management practices affected the physicochemical parameters of the ponds in Tolon zone. It could be concluded that water quality parameters influenced the net profitability of fish farming in the zone. More so, the cost of fish farming affected the net profit of the enterprise in Tolon zone.

It is therefore recommended that the Ministry of Fisheries and Aquaculture Development, Ghana should embark on frequent aquaculture extension education to educate fish farmers in Talon district and Ghana as a whole; this will enhance fish farmers' technical skills and knowledge on aquaculture management practices. This will also further enhance United Nations Sustainable Development Goals (SDG 1: "End poverty in all its forms everywhere" and SDG 2: "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture").

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