



**FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE**

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# Prospects and sustainability of aquaculture development in Ghana, West Africa

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**Abstract:** Fish is the most preferred and widely consumed animal protein in Ghana, with annual per capita consumption estimated at 26 kg compared with the global average of 20 kg. The fisheries sector of Ghana provides livelihood support to 2.4 million people and contribute 1.5% to the nation's gross domestic product. Recent increase in fish production is attributed to aquaculture and culture-based fisheries. However, the aquaculture sector is facing a challenge of sustainability. This study was aimed at identifying and examining the prospects of sustainable aquaculture development in Ghana using the Sunyani Fisheries Zone as a case study. Specifically, the following questions were asked: what are the important factors for aquaculture development for both the operational and non-operational farmer? What are the climatological and environmental factors that pose threat to aquaculture development? To what extent does water, human and financial resources affect the sustainability of aquaculture development in Ghana? The methods employed for data collection were; farm survey and interviews with aquafarmers, document analysis, and fish farm observation. Data was analyzed using descriptive statistics. The results indicate that market establishment, affordability of feed and funding for farmers are the important areas for aquaculture growth. Changing weather patterns and related disasters like floods, droughts, and erosions have negatively impacted on the aquaculture industry and, have reduced its production and profitability. Poor

### ABOUT THE AUTHOR



Berchie Asiedu

Berchie Asiedu completed his PhD in Fisheries Science at the University of Ghana. He had his postdoctoral research fellowship at the Department of Aquaculture and Fisheries Management of the University of Ibadan, Nigeria under the Climate Impact Research Capacity and Leadership Enhancement (CIRCLE) programme funded by the Department for International Development (DfID). He is a Lecturer and Researcher at the Department of Fisheries and Water Resources, University of Energy and Natural Resources, Ghana. The major research interest of Asiedu and his co-authors are aquaculture, fisheries, coastal management, ocean acidification, climate change, food safety and economics of small-scale fisheries.

### PUBLIC INTEREST STATEMENT

Fish is an important protein and food source globally and plays a vital role in healthy human development. Wild fish stocks are declining in spite of the world's effort to feed the ever increasing population. Aquaculture is identified as a cost-effective solution, optimizing fish production and protecting natural stocks. The sustainability of aquaculture in Ghana is threatened, with farm abandonment being a major observation.

This paper reports on the prospects and sustainability of aquaculture development in Ghana using the Sunyani Aquaculture Zone as a case study. Our findings present; reliable market, fish feed, and funds for farmers as the major constraints to fish farmers. Changes in weather conditions and related disasters like; floods, droughts erratic rains and high temperatures are contributing greatly to the problem. These threaten the livelihood of fish farming households, as well as food and nutrition security of the general public.

pond effluent management also poses an ecological threat through introduction of non-native species. It is recommended that Policy makers, Fisheries Commission, Environmental Protection Agency and other relevant stakeholders should give urgent attention to the constraints in order to sustain the industry of Ghana.

**Subjects:** Agricultural Development; Fisheries Science; Agriculture and Food; Biodiversity & Conservation

**Keywords:** aquaculture; climate change; fisheries; food insecurity; sustainability; production

## 1. Introduction

### 1.1. Importance of fisheries in Ghana

Fish is the most preferred and widely consumed animal protein in Ghana. The per capita fish consumption is estimated at 26 kg which is higher than the world's average (20 kg) and Africa's average (10 kg) (FAO, 2014, 2016). The fishery sector plays important role in the livelihoods support and economy growth of Ghana. An estimated 80% of total domestic fish production is consumed locally, constituting about 60% of total animal protein intake (Asiedu, Failler, & Yolaine, 2015; Ministry of Fisheries and Aquaculture Development [MoFAD], 2015). The contribution of fisheries to livelihoods and food security increased from 2.2 to 2.4 million people between 2011 and 2015 (MoFAD, 2015). The sector generates US\$ 1 billion revenue yearly (MoFAD, 2011). Foreign exchange earnings from fisheries increased from US\$ 165.7 million in 2010 to US\$ 309.7 million in 2015, with a corresponding increase in the overall fish production by volume of 9.3% between 2010 and 2015 (MoFAD, 2011, 2016). The inland fisheries and aquaculture contribute 30% to total fish production. The Ghanaian fisheries contribute about 1.5% to the GDP annually with GDP growth rate of 5% (Ghana Statistical Service [GSS], 2015), and very important in the development of coastal poor populations. The fisheries in Ghana is very valuable. The economic potential stands at 30–60% of fishery revenue or at least US\$ 300 million per year (MoFAD, 2011).

The socio-economic benefits of the fisheries is underdeveloped at the time when capture fisheries is taking a downward trend globally, with Ghana not exempted. Ghana's capture fisheries production decreased from 431 thousand tonnes in 2008 to 375 thousand tonnes in 2014 (MoFAD, 2013, 2015). Poverty incidence still remains high (87%) in the fishing communities (Asiedu, Nunoo, Ofori-Danson, Sarpong, & Sumaila, 2013) with about 24% of children suffering from chronic malnutrition (stunting) (Ghana Statistical Service (GSS), 2014). Fish is an important source of omega 3 fatty acids, protein, vitamins (A, B<sub>12</sub>, D and E), calcium, iodine, iron, selenium and zinc which are often lacking or under-represented in most human diets. Ghana is working assiduously to meet the target of the United Nations Sustainable Development Goals (specifically, SDG 2: zero hunger) by increasing aquaculture production. The capture fishery sector in Ghana has reached a low-level equilibrium that provides little prospects and thus, inhibits socio-economic development dramatically (Ghana Business News [GBN], 2015). Domestic production has increased from 444,000 tonnes in 2011 to 451,000 tonnes in (the last 5 years). But the country's annual fish requirement is estimated to be above 1 million tonnes, indicating a shortfall of more than 55% (MoFAD, 2016; Rurangwa, Agyakwah, Boon, & Bolman, 2015). In 2015, Ghana imported 180,801 tonnes of fish valued at US\$ 154,019,585 to supplement consumption (MoFAD, 2016). The revenue of coastal fishery has dropped by 40% over the past decade (GBN, 2015). The major consequences of this trend will be increasing poverty, food, and job insecurity, hunger, and undernourishment.

### 1.2. The need for sustainable aquaculture development

Hunger and malnutrition remain a challenge to human development in most parts of the world including Ghana. The demand for food and nutrition is growing exponentially in Ghana. About 50% of child deaths in Ghana is attributable to malnourishment (Ghana News Agency, 2015). About 29% of children in homes are underweight and, 17% extremely underweight (AmeriCares, 2014). Recent

increase in fish production is accredited to aquaculture and culture-based fisheries. An effective remedy is to strengthen these two systems without compromising environmental safety. However, aquaculture is facing a challenge of sustainable development. Sustainable aquaculture can lead to an increase in fish production.

### 1.3. Objective of the study

To ensure the effective growth of the Ghanaian aquaculture sector, it is vital to identify current and potential future threats to aquaculture development. This study, therefore, aims at identifying and examining the prospects of sustainable aquaculture development in Ghana. The following questions are asked: what are the important factors for aquaculture development for both the operational and non-operational farmer? What are the climatological and environmental factors that pose threat to aquaculture development? To what extent does water, human and financial resources affect the sustainability of aquaculture development in Ghana? It also recommends some measures to be taken to ensure sustainable development of the aquaculture sector of Ghana.

## 2. Materials and methods

### 2.1. Study area

#### 2.1.1. Selection criteria

Cluster, random, and purposive sampling techniques were employed for the study. Four aquaculture clusters (regions) were identified in Ghana. The clusters included; Ashanti, Brong-Ahafo, Eastern, and Volta regions. These four regions account for about 86% of aquaculture production (27, 450.56 tonnes) (MoFAD, 2013). As used here, a cluster refers to a region with an estimated pond fish production of <250 tonnes from Ministry of Fisheries and Aquaculture Development 2013 aquaculture production data. The clusters were numbered; 1, 2, 3, and 4. Numbers were assigned on the basis of their alphabetic arrangement, where Ashanti (1), BA (2), Eastern (3) and Volta (4) (Table 1). Using random generator software (GraphPad, 2016), one cluster (Cluster 2: Brong Ahafo) was randomly selected for the survey. Fisheries zones (districts) within the cluster were considered sub-clusters. Information from the Fisheries Commission<sup>1</sup> indicates that majority of farms are located in the Sunyani Fisheries Zone (Sunyani Municipality-Figure 1) (Francis Barnes, personal communication, 2016). The Sunyani Municipality also record the highest fish production (5,100 kg) in the region (MoFA, 2010). Thus, it was selected purposively based on its outmost contribution to aquaculture production in the region.

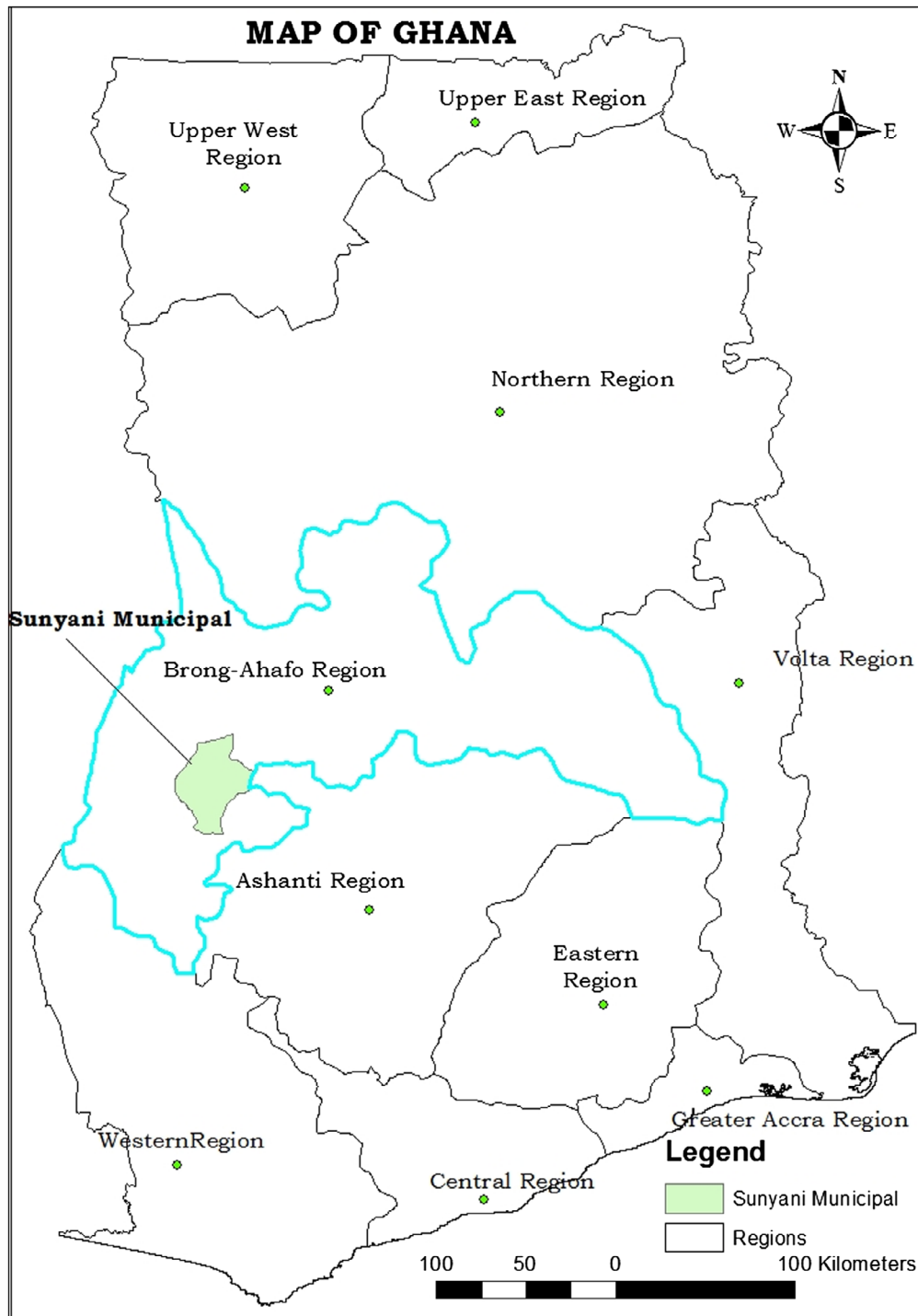
#### 2.2. Data collection: Farm survey and interview with aquafarmers

Farm register was obtained from the regional Fisheries Commission for the selection of farms to be interviewed. From a register of 46 farms, 29 were operational and 17 were non-operational. Farms were numbered and the random number generator software (GraphPad, 2016) was used to randomly select 15 farms from each category. The respondents for the survey were either farm managers or farm owners for the operational farms group, and farm owners only for non-operational farms. Farmer in this study refers to either farm manager or farm owner. Operational farms in this study are farms in production whilst non-operational are farms abandoned.

**Table 1. Clusters with assigned number and region**

Cluster number	Region
1	Ashanti
2	Brong Ahafo
3	Eastern
4	Volta

Figure 1. Map of Ghana showing Sunyani Municipality.



A questionnaire-based interview was used for data collection at the field level. The questionnaires were prepared in English language and translated into the local language (Twi) to respondents for them to give their responses.

Before questionnaire administration, a pilot test was carried out on five of each category, to validate and check the reliability of the questions. The necessary changes were subsequently made to the questionnaires.

Both open and closed-ended questions were used. The questionnaires were focused on two broad areas; prospects of aquaculture (include: challenges facing operational farms, reasons why some farms are non-operational, aquaculture growth in the area) and aquaculture sustainability (include: aquaculture capacity, farm management, financial, human and water resources for aquaculture development, recording keeping, effluent management, impacts of seasonal change on aquaculture and weather related threats).

### 2.3. Data collection: Document analysis

Official documents and scientific publications were consulted as secondary data sources to obtain information on fish demand, fish production, exports, imports, malnutrition figures, aquaculture growth and its sustainability. Fish farmers' information was also obtained from the Brong-Ahafo regional Fisheries Commission, which included number of fish farms, locations and contact numbers of farmers in the Sunyani Municipality (study area). Document findings were used as a guide in designing questionnaire for field data collection and farmers information for sample selection and farm accessibility.

### 2.4. Data collection: Observation

Observation of farm location, the topography of farm area and design of production systems was done. Water supply systems, inlet, and outlets were also observed. The sustainability of a farm is in part dependent on its location, design of production systems, the ease of water transportation and inputs supply.

### 2.5. Data analysis

Quantitative and qualitative data collected from the survey were entered into Microsoft Excel (2013) and analyzed using descriptive statistics such as arithmetic means, proportions, and percentages. Qualitative data was coded and analyzed using descriptive statistics or analyzed qualitatively. All interviews were transcribed and stored to wait for the analysis of the surveys. Variables for analysis included the; challenges, opportunities, and sustainability.

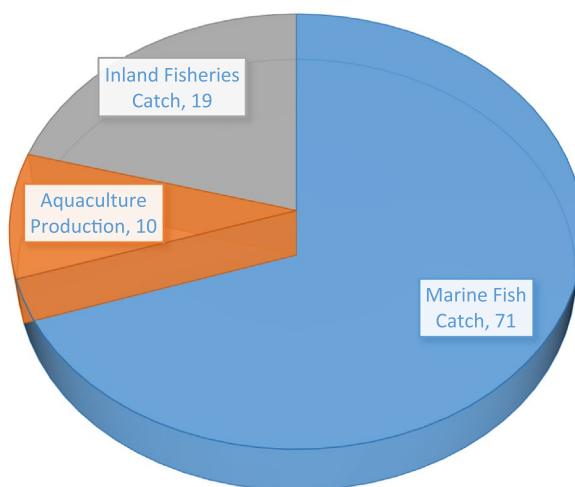
## 3. Results

### 3.1. Prospects of aquaculture in Ghana

The contribution of the aquaculture sector to total fish production in Ghana is presented in Figure 2. Aquaculture production comes from cages (90%), ponds and tanks (5.4%) with dugouts, reservoirs, and dams making the remaining 4.6%. Aquaculture production in 2015 was 44,610 tonnes.

**Figure 2. Percentage contribution of marine, inland, and aquaculture sub-sector to total fish production.**

Source: Ministry of Fisheries and Aquaculture Development (2016).

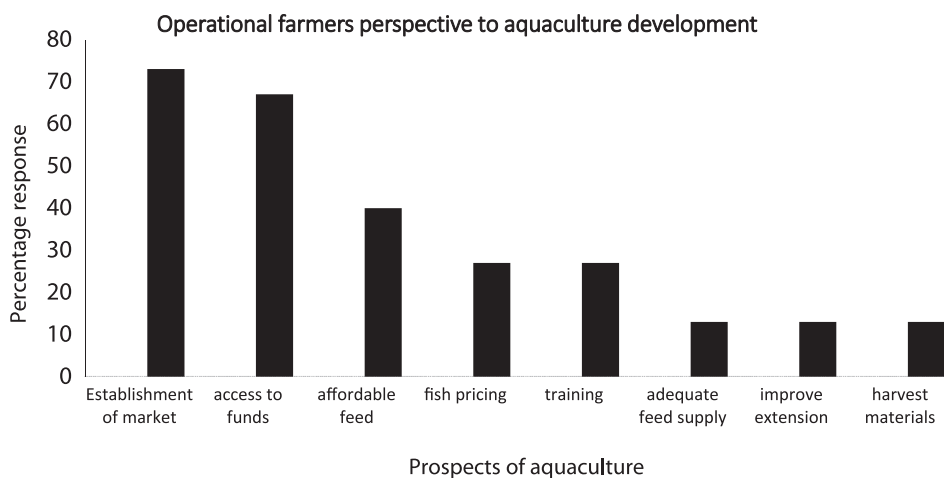


From the interview conducted, majority of farms, 93% of non-operational farms and 73% of operational farms, proposed market establishment as the most vital way forward (Figures 3 and 4). Whilst access to funds was the next important solution to operational farms (67%), affordable feed (86.7%) was the second important solution from non-operational farms standpoint. Funding (access to funds) for farmers took the third position with 80% of NOF. To the operational farms, affordable feed was the third important area to farmers (40%). Adequate feed supply, improve extension and harvesting materials were on the same scale, 13% each in Figure 3. Training and fish pricing had the same percentage, 27% of farmers, in Figure 3. Improvement in extension was the least (13%) according to NOF (Figure 4).

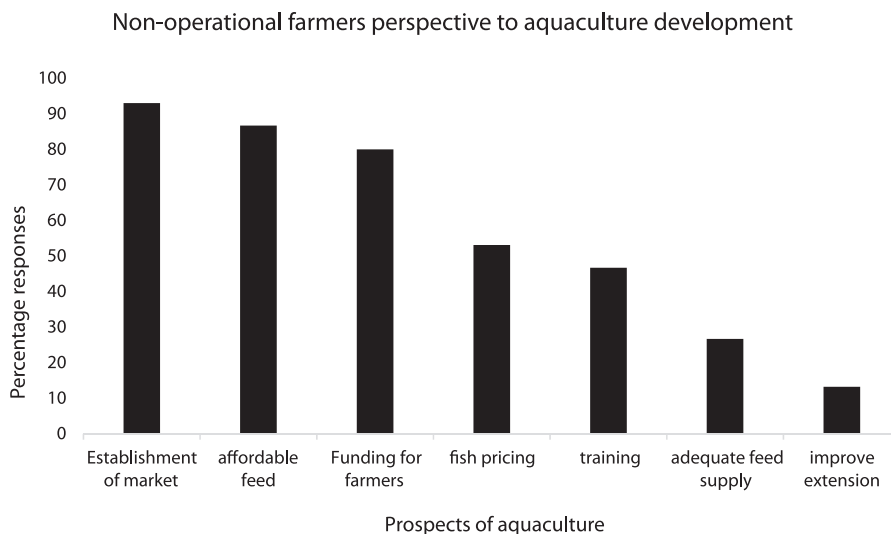
### 3.2. Sustainability of aquaculture in Ghana

The sustainability of aquaculture was linked to the availability of water and financial resources, human capacity, farm record keeping, management of farm effluent and impacts of seasonal change on aquaculture development. Impacts of seasonal changes like increasing atmospheric temperature, incidence of flood, erosion, drought and other observable factors were considered threats to sustainable aquaculture development.

**Figure 3. Operational farms perspective areas to aquaculture development.**



**Figure 4. Non-operational farms perspective areas of aquaculture development.**



### 3.2.1. Water resources for pond aquaculture

Aquaculture depends on natural water for production. It is therefore important for farmers to have adequate, reliable, and quality water supply on sustainability basis. The results from the study revealed that 93.3% of operational farms had reliable water supply. Only 6.7% operational farms did not have reliable water source. Most farms (75%) from the survey rely on streams as their water source (Table 2).

### 3.2.2. Financial resources for aquaculture development

In order to fully exploit aquaculture to meet the national fish deficit, it is crucial to understand financial resources available to fish farmers and aquaculture development. Results from the study showed that no farmer had access to loans. The majority of farms, 65.6%, were self-financed and 19.2% depend on sales revenue. Only 10.1% of farmers rely on government support (Table 3).

### 3.2.3. Farm record keeping

Recording farm activities is an effective and efficient managerial tool. The survey identified that 80% of farmers keep record in books whilst 20% do not keep records at all. This, therefore, makes it easier to monitor the gains and losses of the aquaculture enterprise (Table 4).

### 3.2.4. Pond effluent management

Effluent from ponds if not manage with caution before discharge may alter the conditions of receiving ecosystems and may result in loss of biological integrity of the wild stock. The study revealed that all farmers drain effluents away without consideration of the receiving environment (Table 5). With such trend, the Ghanaian aquaculture may cause undesirable environmental consequences. These in

**Table 2. Waters resources available to fish farmers in the Sunyani Municipality**

Reliable water source	Frequency	Percentage (%)
Stream	12	75.0
Rainfall	0	0.0
River basin	1	6.25
Wells	1	6.25
Underground water	2	12.5

Source: Field Survey (2016) (Authors).

**Table 3. Financial Mechanisms for sustainability of farmers in the Sunyani Municipality**

Sustainability mechanisms	Frequency	Percentage (%)
Self-financing	13	65
Project support	0	0.0
Government support	2	10
Group contribution	1	5.0
Sales revenue	4	20
Loan from other	0	0.0

Source: Field Survey (2016) (Authors).

**Table 4. Farm record keeping systems**

System	Frequency	Percentage (%)
Book	12	80.0
Computer	0	0.0
None	3	20.0

Source: Field Survey (2016) (Authors).



**Table 5. Management of pond farm effluent**

Effluent control	Frequency	Percentage (%)
Treatment	0	0.0
Drain	15	100.0
Evaporation	0	0.0
Others	0	0.0

Source: Field Survey (2016) (Authors).

part include fouling of terrestrial habitats and changing physico-chemical conditions of receiving streams, rivers, and other ecosystems. None of the farmers had an idea of such dangers (Table 5).

### 3.2.5. Climatological threats to aquaculture

Increasing global temperature due to the presence of heat-trapping gases like methane and carbon dioxide have resulted in sea level rise, intrusion of salt water into inland waters and aquifers and heating surface waters in extreme condition. Notable consequences of such changes are inundation of low lying areas, erosion, strong winds, and drought at higher temperatures and prolonged rains. The results obtained showed that 42% of operational farms experience flood, 32% experience erosion and 11% experience drought. Only 16% of farms indicated that they do not experience any of the natural disasters presented in Table 6.

### 3.2.6. Human resource for aquaculture development

Knowledge in farming practices and technology is very important in the expansion of the fish farming industry in Ghana. Farmers' knowledge in aquaculture was then obtained to determine human capacity available for the sector's development. The results showed majority, 40%, of farmers have had training in fish farming, 20% farm management, 16% in pond/cage construction and 12% for general aquaculture practice. Only 6 farmers representing 12% of NOF and OF had no training in any of the areas (Table 7).

**Table 6. Impacts of seasonal climate change on farms**

Natural disaster	Frequency	Percentage (%)
Flood	8	42.00
Erosion	6	32.00
Drought	2	11.00
None	3	16.00

Source: Field Survey (2016) (Authors).

**Table 7. Human capacity for aquaculture development**

Aquaculture capacity	Frequency	Percentage (%)
Fish farming	20	40.0
Farm management	10	20.0
Pond/cage construction	8	16.0
General aquaculture practice	6	12.0
None	6	12.0

Source: Field Survey (2016) (Authors).

#### 4. Discussion

Aquaculture holds the key in addressing food insecurity, malnutrition, unemployment, hunger and economic growth in Ghana. Farmed tilapia is currently improving the livelihoods and protein needs of both fish farming households and consumers, and at the same time creating economic opportunities in Ghana despite the challenges. Currently, Ghanaians have developed strong preference for cultured tilapia and available market exists for all sizes of tilapia locally (Asiedu et al., 2015).

The population of Ghana is currently estimated at 28.9 million with an annual growth rate of 2.5% (GSS, 2017). Protein needs of the population must be met. Aquaculture is one of the cheapest means to meet the protein and other essential nutrients needs (such as omega 3 fatty acids, vitamins, calcium, zinc and other minerals). In addition to ensuring food security, aquaculture offers opportunity to a large section of the population both in urban and rural communities, thereby ensuring poverty (25.6%) reduction.

From Figures 3 and 4, market establishment, affordability of feed and funding for farmers are areas for the future development of aquaculture from both operational and non-operational farms perspectives. In confirmation to the findings of Hiheglo (2008) and Rurangwa et al. (2015), this study presents lack of access to funds, high cost of feed, and lack organized market as the major challenges to the aquaculture sector development. The prospects of the aquaculture sector is also restrained both in market availability and competition with substitute products from the EU (Bostock, Lane, Hough, & Yamamoto, 2016). A similar study by Asiedu et al. (2015) indicated that improving market for farm fish products can make the Ghanaian aquaculture competitive.

Anane-Taabeah, Frimpong, Amisah, and Agbo (2010) indicated lack of access to funds and weak extension as a major challenge to cage aquaculture development in Ghana. A survey by Mbogo (2010) found out that most farmers (88%) financed themselves in order to sustain their farms and, only 16% of farmers receive government support. In agreement, results from Table 3 indicate that 65.6% farmers are self-financed and no farmer had access to loans. Only 10.1% of respondents had support from the government. This is part of the reasons why access to funds was important to both operational and non-operational farms (Figures 3 and 4). These multiple factors is leading to high cost of production and farm abandonment which poses threat to food security in the studied area and the nation at large. It is often difficult for the aquafarmer to obtain loan from financial institutions which is often associated with long and complex processes.

The growing population has undoubtedly exerted pressure on food production and supply systems. Increasing competition for water for aquaculture are driving intensification that sometimes push the limits of ecosystems to absorb impacts and thus increase the risk of catastrophic failure (Brummett, 2013). And not only is the world concerned about meeting present and future nutritional demands but also more cautious on the need to safeguard the environment. Sustainable aquaculture practices must not be detrimental to the need for a safety environment. All operational farms (100%) in the survey drained pond effluent away without any treatment. Pond effluent if not properly managed may result in nutrient pollution, biological pollution, and water pollution. Aquaculture can be the cause of the introduction (whether intentional or accidental) of non-native species from one area to another (Economidis, Dimitriou, Pagoni, Michaloudi, & Natsis, 2000) if biosecurity measures are not properly enforced. There are high risks of escapees of aquatic organisms when pond effluents are drained way, but these are controlled through the use of filters (Aquafish Collaborative Research Support Program, 2009). Hence, current farm management in Ghana is not reasonable to ensure environmental health. This is evident in Table 7, where only 20% of farmers had training in farm management.

The integrity of wild fish stock is very important for any sustainable aquaculture. Treatment of pond effluents and control of stock loss to floods is very key to prevent the introduction of new species into aquatic ecosystems. From Table 6, 42% of farms experience floods and 32% farms experience pond erosion. A major consequence will be loss of stock to floods and broken pond dikes due to severe erosion. The economic impacts of climate change in aquaculture cannot be push on the sideline. To the fish farmer, this will imply huge economic loss, reduction of revenue and damage to production systems.

And to the environmentalist, it means dispersal of non-native species into natural ecosystems which may lead to undesirable ecological consequences like inbreeding, loss of native stock and diseases.

One of the environmental issue that is currently confronting Ghana is the menace of illegal small-scale mining locally known as “galamsey”. A large portion of the populace both in the rural and urban areas depend on this activity for a living. To reduce the populace dependency on this illegal activity, alternative livelihood is key. Aquaculture will be one of the best options, thereby, helping to manage water and other natural resources sustainably. With brighter prospects of aquaculture development, the populace should be trained so that they can take up aquaculture as a livelihood.

## 5. Conclusions and recommendations

The prospects and sustainability of aquaculture was carried out purposely to identify key constraining factors to sustainable aquaculture development. For effective development of aquaculture in Ghana, it is important to identify key constraining factors limiting farmers’ ability to optimize production. Farmers’ perspectives on aquaculture development highlight major challenges limiting their economic and production potential. The effects of the changing climate were given prominent consideration during the study. The study reveals that market establishment, funding for farmers and affordable feed are the major bottlenecks to improving production and profitability of aquaculture in Ghana. Future development interventions will require finding comprehensive solutions to, or removing such constrains simultaneously.

The current pond effluent management is detrimental to the environmental. All farmers drain effluents away with no regards to the receiving environment. Such practice compromises healthy environment and biodiversity. It is therefore necessary to enforce licensing of aquaculture establishment and monitoring of the environmental impacts of aquaculture operations by the relevant environmental agencies.

Changes in weather patterns and related disasters have led to serious economic losses in fish farms, loss of fish stock to floods, droughts, and damage of pond dike by erosion. Adaptive strategies should be well-designed for farmers to overcome seasonal production losses to floods, pond breakages, droughts and water shortages. Fish loss through floods and pond effluents imply dispersal of cultured species into wild waters. Aquaculture is sustainable if the total farm operations ensure reasonable economic and social gains with least detrimental impacts on the environment.

Posterity of the Ghanaian aquaculture should focus immediately on building a resilient and vibrant market for farm fish products, probably through value addition; ensure affordability of feed, and improve funding for farmers to ensure increase in production and related socio-economic benefits. To cope with changes in weather patterns and related detrimental impacts, suitable site selection, proper planning of production systems, water storage facilities and more awareness on climate change are required in the long-term. Although the majority of farmers have undergone some training in fish farming, it is very important to focus more on farm management, general aquaculture practice, and construction of production systems. The sustainability of a fish farm depends on how it is efficiently managed and respect for the code of good practice. Efficient farm management will help promote fish production and environmental safety.

To reduce food insecurity, hunger, and malnutrition, as well as ensures economic growth, the government should make a strong political commitment to promote aquaculture in a sustainable manner. Currently, Ghana imports 180,801 tonnes of fish (valued at US\$ 154,019,585) to supplement consumption. The country self-sufficiency in fish production is less than 50%. Poverty which stands at 25.6% will be reduced if aquaculture is promoted. Over, 50% of farmers have also had some training in aquaculture. The Government should also as much as possible adhere to its vision of accelerating development of a private sector-led aquaculture to enable the sector to contribute significantly to fish food and nutritional security, employment generation, increased incomes,

economic growth and poverty reduction as enshrined in the Ghana National Aquaculture Development Plan (GNADP).

Policy makers, Fisheries Commission, Environmental Protection Agency, training institutions and other relevant stakeholder should give attention to these multi-challenging factors when making policies, planning and undertaking their programmes.

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#### Competing Interests

The authors declare no competing interest.

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#### Note

1. Fisheries Commission is the government body responsible for regulating fisheries and aquaculture activities in Ghana.

#### Cover image

African catfish (*Clarias gariepinus*) in an aquaculture system (earthen pond).

Source: Authors.

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