FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Aquaculture in troubled climate: Farmers’ perception of climate change and their adaptation

Bercie Asiedu, Jenyo-Oni Adetola and Isaac Odame Kissi

Cogent Food & Agriculture (2017), 3: 1296400
Aquaculture in troubled climate: Farmers’ perception of climate change and their adaptation

Berchie Asiedu1*, Jenyo-Oni Adetola2 and Isaac Odame Kissi1

Abstract: Aquaculture is one of the fastest growing industries in the fisheries sector of Ghana, serving as a source of protein, food security, employment creation, economic growth and poverty reduction strategy. The aim of this paper is to assess the awareness level and perception as well as adaptation strategies adopted by small scale aquafarmers on climate change. Climatological data, namely, temperature, rainfall and relative humidity were collected for the period 1989–2015 from the Ghana Meteorological Agency and analysed to determine the trends. The study adopted stratification and simple random sampling technique in obtaining 40 respondents (aquafarmers and other stakeholders) from the Sunyani Aquaculture Zone through questionnaires administration. The analysis of the data utilised descriptive statistics. Findings of this study indicate that there have been significant changes in temperature, rainfall and relative humidity patterns. Aquafarmers have considerable knowledge on climate change from sources such as radio (36%), schools (24%) and television (20%). A number of adaptation strategies are employed by aquafarmers to deal with climate change, including, water management, construction of bore-holes, sitting farms close to water bodies, adjusting fish stocking time, and creation of embankment to avoid floods. Aquaculture extension education should be carried out regularly to enhance aquafarmers adaptation responses to the existing and potential negative impacts of climate change which is a threat to aquaculture production and sustainable livelihood.

ABOUT THE AUTHORS
We, the authors through the Department for International Development (DfID) under the Climate Impact Research Capacity and Leadership Enhancement (CIRCLE) programme (Cohort 2) are working on the impacts of climate change in the small-scale aquaculture industry of Ghana. This programme mainly focuses on training a postdoctoral fellow. It also has a side component of training undergraduate students on data collection, analysis and interpretation. This work is a joint research between the University of Energy and Natural Resources, Sunyani-Ghana and the University of Ibadan, Nigeria.

In addition to climate change research, our research interests include fisheries, diversity of coastal wetlands, food security and safety and economics of small-scale fisheries.

PUBLIC INTEREST STATEMENT
Fish provides micronutrients and food security to millions of people globally, especially people in developing countries. Fish stocks in the wild have been depleted. The alternative has been fish farming (aquaculture). The aquaculture industry is being confronted with challenges such as feed, fingerlings and in particular climate change. Livelihoods of small scale aquafarmers are also increasingly under threat of climate change.

In this paper, we report aquafarmers perceptions about climate change in Sunyani Aquaculture Zone of Brong Ahafo region of Ghana. Our findings demonstrate that farmers are aware of climate change from various sources and have clear opinions about changes in temperature and rainfall as indicators of climate change which compares well with scientific data. Therefore, documenting their viewpoints can be used as an important source of information in developing bottom-up adaptation strategies since they reflect concerns at the local levels.
1. Introduction

Climate Change is a global issue because it affects all countries in the world. Climate change refers to “a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer” (UNFCCC, 2011). In a broader sense, climate change consists of changes in temperature, rainfall pattern, humidity, sea level, greenhouse gases (GHG), continental drifts, deviation in the Earth’s orbit, activities of man (Yazdi & Shakouri, 2010) which interact with each other to exist as a unit entity.

Changes in weather patterns, namely rainfall, relative humidity, winds, temperature and light intensity and period have undoubtedly affected agricultural production systems including fisheries and aquaculture (Figure 1). Climate change has both direct and indirect influence on fisheries and aquaculture. The direct implications of climate change are on physiology and behaviour of the fish that affect growth, reproduction, mortality and distribution (Allison et al., 2009; IFAD, 2014; Yazdi & Shakouri, 2010). The indirect impact affects the productivity, structure and composition of the ecosystem in which the fish depend on for food (Yazdi & Shakouri, 2010). Changes in biophysical characteristics of the aquatic environment and frequent occurrence of extreme events will have significant effects on the ecosystems that support fish (Essam & Uraguch, 2013).

Consequently, any increase or decrease in the temperature of the fish habitat would have a significant influence on general metabolism and hence the rate of growth and therefore total production, reproduction, seasonality and even possibly reproductive efficacy (e.g. relative fecundity, number of spawnings (Wood & McDonald, 1997), increased susceptibility to diseases and toxicants (Ficke, Myrick, & Hansen, 2007). The lower and upper lethal temperature and the optimal temperature range for fish species differ widely, therefore, climate change induced temperature variations are bound to have an impact on spatial distribution of species specific aquaculture activities.

With declining fish stocks in the wild and health complications associated with consumption of meat, the consumption of aquaculture products is on the increase (Asiedu, Pierre, & Yolaine, 2015; FAO, 2016). Aquaculture is one of the fastest growing animal food producing sectors offering employment and food security to the ever increasing human populace in Ghana. According to FAO (2008),
the average contribution of aquaculture to the global per capita fish available for human consump-
tion rose from 14% in 1986, to 30% in 1996 and to 47% in 2006, targeting 50% in the next few years
serving as a means of food security and income generation for many engaged in it. Global aquacul-
ture production is estimated at 73.8 million tonnes, with Africa contributing 2.32% (1,710.9 thousand
tonnes) to this figure (FAO, 2016). Aquaculture production in Ghana has increased from 5,000 tonnes
in 2000 to 38,547 tonnes currently (FAO, 2017; Ministry of Fisheries and Aquaculture Development
(MoFAD), 2015), with annual per capita fish consumption of 28 kg.

Aquaculture production systems in Ghana can be in the form of earthen ponds, tanks, cages, pens
and raceways depending on the culture system being adopted, and can also be in the freshwater
and marine environs. Intensive aquaculture can be witnessed in Ghana on the Volta Lake which
extends close to 40% of Ghana and has a total surface area of 8,482 km² in the form of cage culture
system with other important water bodies including Lake Bosomtwe (49 km²), Weija (37 km²) and
Kpong reservoir (36.5 km²) (Asiedu et al., 2015; FAO, 1999; Freeman, 1974). Compared to dugout
ponds which is semi-intensive or extensive culture system observed, all contributing to farmed fish
production in Ghana (Table 1).

There are a lot of constraints to the expansion of aquaculture in Ghana. These include lack of ade-
quate supply of seed, lack of quality fish seed, lack of suitable feed and weak extension support.
There are also problems of inadequate credit and lack of organised markets. Shortage of trained
staff and less motivated practitioners are also of much concern (Hiheglo, 2008).

Aquaculture in Ghana is mainly based on Nile tilapia, Oreochromis niloticus and the African catfish,
Clarias gariepinus of which tilapia forms about 80% of aquaculture production (Asiedu, Asase,
Iddrisu, & Ayisi, 2016; FAO, 2005). In 2013, the Ministry of Fisheries and Aquaculture Development
(MoFAD) launched the Ghana National Aquaculture Development Plan (GNADP) (2012–2016). The
goal of the Plan is to improve the practice, management and development of aquaculture as a viable
business. This is to increase the production of cultured fish from 27,000 mt in 2012 to 100,000 mt by
2016 (Fisheries Commission, 2012).

| Region    | Pond production | Cage production | Others (dugouts, reservoirs) |
|-----------|-----------------|-----------------|-----------------------------|
|           | No. of ponds | Total surface area (ha) | Production (mt) | No. of cages | Vol. (m³) | Production (mt) |                  |
| Greater Accra | 275.00 | 75.00 | 158.05 | 350.00 | 43,750.00 | 1,531.25 | – |
| Ashanti    | 1,205.00 | 150.63 | 384.68 | 39.00 | 4,875.00 | 20.00 | – |
| Northern   | 90.00 | 2.85 | 1.23 | – | – | – | 450.90 |
| Eastern    | 292.00 | 30.23 | 75.58 | 1,473.00 | 179,222.50 | 19,768.38 | – |
| Brong Ahafo | 1,393.00 | 64.66 | 260.00 | – | – | – | – |
| Western    | 644.00 | 82.80 | 207.00 | 3.00 | 225.00 | 7.88 | – |
| Upper East | 49.00 | 13.39 | 34.70 | – | – | – | 599.34 |
| Upper West | 17.00 | 0.80 | 0.00 | 10.00 | 1,000.00 | 1.97 | 380.30 |
| Volta      | 247.00 | 98.32 | 282.72 | 416.00 | 50,900.00 | 2,919.02 | – |
| Central    | 537.00 | 184.92 | 367.54 | – | – | – | – |
| Total      | 4,749.00 | 703.66 | 1,771.56 | 2,278.00 | 279,972.50 | 24,248.50 | 1,430.54 |

Production 2012–27,450.56 mt

Source: Ministry of Fisheries and Aquaculture Development [MoFAD] (2013).
Some other priorities of the GNADP are as follows; Zoning of the Volta Lake which is being undertaken by the Water Resources Commission is expected to be completed within one year for expansion of aquaculture industry, support the establishment of modern hatcheries and feed mills by the private sector in the form of technical advice and tax waivers, support the fish breeding research programme being implemented by the Water Research Institute for example, as at October, 2013, a total of 84 million fingerlings had been produced out of an estimated 100 million fingerlings targeted for 2013 and to establish a Central laboratory at Tema for diagnosis of diseases and testing quality of food fish (Ghana Civil Service, 2013).

The aquaculture sector faces constraints with regards to climate change beside its enormous contributions (IFAD, 2014). Livelihoods depending on fishery are the first to be impacted especially small scale farmers by climate change (IFAD, 2014). Small aquafarmers do not possess adequate resources (technological, financial and human) to deal with the impacts of climate change.

Climate change is greatly affecting aquaculture operations as a result of fluctuations in rainfall and temperature distribution globally. However, when it comes to the Sunyani Aquaculture Zone (SAZ) of Ghana, there is no known data as far as small scale aquaculture is concerned. According to literature, climate change has influence on aquaculture and since SAZ which falls with the Brong-Ahafo Region has the highest number of ponds in Ghana, there is the need to assess the perception and adaptation measures adopted to mitigate climate change by fish farmers in SAZ. In fact, no study has been carried out in the studied area on aquafarmers’ perception and adaptation on climate change.

Therefore, this study looked at the question “What do small scale fish farmers know about climate change and what are they doing about its impacts”? The overall aim of this paper is to assess the awareness level of small scale fish farmers on climate change within the SAZ of Ghana. Specifically, the paper seeks to:

- Determine climate (temperature, rainfall and relative humidity) trends and patterns between 1989 and 2015.
- Find out fish farmers knowledge on climate change.
- Find out relevant stakeholders (e.g. government institutions, traders, associations) knowledge on climate change.
- Find out fish farmers’ adaption strategies on climate change.

2. Materials and methods

2.1. Study area

The study was conducted within the SAZ according to Ghana’s MoFAD operational areas classification (Figure 2). SAZ falls within the Brong-Ahafo region of Ghana which has the highest number of earthen ponds (29%) in the country and aquaculture production of 260 mt. SAZ comprises three political administrative districts, namely, Sunyani Municipal (SM), Sunyani West District (SWD) and Berekum District (BD). The study area also has major water bodies, example; River Tano, Sunyani river, streams and ground water for fish farming, as well as a number of aquaculture inputs dealers such as feeds, veterinary drugs, pipes, etc. The regional office of Ghana Meteorological Agency and MoFAD are also located within the SAZ.

2.2. Population and sampling method

SAZ formed the population of the survey. The region is categorized into zones for data collection purposes by the Regional Fisheries Commission1 Office. Using stratified sampling technique, the respondents were grouped into fish farmers and stakeholders. Simple random sampling was adopted in selecting the respondents so as to avoid bias.
A total number of 25 fish farmers (representing 75%) in SAZ were selected randomly out of 32 operational fish farmers for the survey. Strata and random sampling technique was adopted in selecting 15 representatives for stakeholders based on institution (Educational, Traders, Entertainment centres, Pond diggers association and Fisheries Commission). Five respondents from educational institutions ($n = 5$), three respondents from fish traders ($n = 3$), three respondents from entertainment centres ($n = 3$), two respondents from pond diggers association ($n = 2$) and another two respondents from the Fisheries Commission ($n = 2$).

2.3. Desktop studies
Desktop survey of relevant literature was carried out during the course of the study period to provide information on the research to form the background and context. Additionally, desktop studies on climate change indicators, namely, temperature, rainfall and relative humidity were also analysed from the year 1989–2015 based on data obtained from the Ghana Meteorological Agency office.

2.4. Design of the questionnaire
The goal of the study was to gather statistical data about fish farmers and other stakeholders perception and adaption on climate change in small scale aquaculture and how it affects their production and living conditions. The questionnaire for the study was constructed in two folds targeting fish farmers and stakeholders.

The questionnaire for fish farmers comprises six sections. Section One dealt with demographic data. Section Two focused on knowledge of climate change whilst Section Three dealt with perception or understanding of climate change. Section Four dealt with challenges in production, productivity, market and sales whereas Section Five looked at income and food security. And finally, Section Six dealt with expectation of fish farmers on mitigation and adaptation measures to climate change.

Stakeholders questionnaires were also made of six sections. Section One focused on demographic information whilsts Section Two dealt with awareness and understanding of climate change. Section Three looked at existence and causes of climate change at present time whereas Section Four dealt with perceived threat from climate change. Section Five dealt with seriousness of climate change compared to other issues whilsts Section Six focused on requirement for action on climate change (both at national and personal level).
The questionnaires were designed in simple English language that could be easily understood by respondents.

2.5. Data collection procedure

In total, forty (40) questionnaires were administered comprising 25 for fish farmers and 15 for stakeholders within SAZ. The samples selected were representative and this was done using simple random and stratification techniques.

Statistical data from the Fisheries Commission and reconnaissance survey of the SAZ helped in the stratification and distribution of the questionnaires between the small scale fish farmers and other stakeholders. To evaluate the impact of climate change on small scale aquaculture, the perception and adaptation of both fishers and relevant stakeholders were considered thereby resulting in the stratification of the sample size for a representative data collection and interpretation.

The questionnaires were given to respondents for them to tick and in some cases write briefly. In areas where the respondent cannot read nor write, the questionnaire was administered in the form of interview where respondent answered questions asked by the interviewer from the designed questionnaire. Five questionnaires were administered every week for eight weeks to cover the sample size of forty (40). Statistics of fish mortalities were obtained from farmer’s records. The period of data collection was between January 2016 and June 2016.

2.7. Data analysis and estimation of error of respondents

Using descriptive statistics, the data was analysed in terms of frequency distribution, percentage, mean and standard deviation using Microsoft Excel (2010) edition. The analysed data was presented using tables, frequencies, figures and percentages.

Estimation of error of respondents was done using 95% Confidence to estimate 5% errors from respondents.

3. Results

3.1. Parameters of climate change

The temperature distribution over the twenty-six (26) year period shows patterns of unstable temperature (Figure 3). The highest average annual temperature was in the year 2003 which was 27.9°C while the lowest average annual temperature was 23.3°C in 1989. Between 2012 and 2015, there have been a gradual rise in the temperature. From 1989 to 2015, the annual average temperature has been hovering around 24 and 26°C.

![Figure 3. Average annual temperature distribution (1989–2015).](image)

\[
y = 0.048x + 25.451 \\
R^2 = 0.1748
\]
The rainfall pattern for the period was also not stable with wide variations (Figure 4). The highest average annual rainfall recorded was 133 mm in 2007 whiles the lowest average was 78 mm in 1998. Between 1989 and 1999 the average annual rainfall was 99 mm; 110 mm between 2000 and 2010. The average annual rainfall between 2011 and 2015 was 116 mm. Over the last five years (between 2010 and 2015), the annual rainfall has decreased by close to 10% (from 128 to 116 mm).

Figure 5 shows the relative humidity distribution for the period 1989–2015. The relative humidity readings for the period exhibited variations. The lowest relative humidity reading was 65.3% in 2007 and the highest was 89.5% in 1989. Since 1992, the moisture content of the atmosphere has witnessed reduction in percentage (roughly 21%) till 2015. It slightly picked up in 1997 to around 83.6% but come down after that year.

The correlation between rainfall and temperature is shown in Figure 6. The correlation is negative. As the amount of rainfall increases, the temperature decreases. Rainfall and temperature are the two most important climatic factors that affect aquaculture operations in Ghana.
3.2. Knowledge, perception and awareness of climate change

From the data gathered, 100% of the respondents have heard or read something about climate change from different sources. The source with highest representation was radio having 36% with internet sources having the least (0%). Considering causes of climate change, 64% said it was as a result of environmental pollution due to human activities, 24% attributed it to natural causes whiles 12% attributed it to both environmental pollution and natural causes. This shows the different levels of understanding regarding climate change but the most important thing is their awareness of its occurrence (Table 2).

| Variable                        | Frequency | (%) |
|---------------------------------|-----------|-----|
| Knowledge of climate change     |           |     |
| Yes                             | 25        | 100 |
| No                              | 0         | 0   |
| Total                           | 25        | 100 |
| Source of information           |           |     |
| Television                      | 5         | 20  |
| Radio                           | 9         | 36  |
| Newspaper                       | 2         | 8   |
| Internet                        | 0         | 0   |
| Friend                          | 3         | 12  |
| School                          | 6         | 24  |
| Total                           | 25        | 100 |
| Changes observed in weather a result of:|     |     |
| Environmental pollution         | 16        | 64  |
| Natural causes                  | 6         | 24  |
| Both                            | 3         | 12  |
| Total                           | 25        | 100 |
However, responses from the survey on stability of the weather condition indicated that 64% strongly disagree, 32% disagree, and 4% not sure. Additionally, 72% respondents strongly agree that weather is getting hotter and rains becoming unpredictable over the years. Similarly, 60% respondents strongly agree with unpredictable weather and 0% was not sure (Figure 7).

3.3. Challenges in productivity, market and physical structures

With regards to fish mortality recorded as a result of bad weather, 28% of farmers agreed and 48% disagree. The percentage representations for not sure (12%), disagree (48%) and strongly disagree (4%) comprises respondents who have not experienced mortality at their farms due to bad weather, but rather because of poor handling of fish and poor management practices (Figure 8).
On the impacts of climate change on farm physical structure, the most important climatic factors are flood and storm (Figure 9). Drought, low rainfall and high temperature are relatively of less importance and pose little threat to farm structures. This indicates that severe flood and storm have the potential to destroy most small scale aquaculture establishments. Aquaculture operations cannot afford to make such losses.

3.4. Stakeholders expectations and adaptation strategies

The expectations from individuals and the State in dealing with climate change is presented in Table 3. More than half (64%) of the respondents strongly agreed that individuals should be encouraged to reduce the incidence of climate change. 72% of the respondents also supported the concept that government should also embark on measures to ensure that climate change effects are reduced and also allocate reforestation programme for institutions or individuals degrading the environment (Table 3). With regards to adaptation strategies to cope with the impacts of climate change, 32% planted trees around ponds to serve as shade to reduce evaporation, 20% raised the banks of ponds to prevent loss of fish when there is heavy rainfall that could result in flooding, 16% dug bore hole near ponds to serve as a water source during the dry and low rainfall seasons, 12% constructed

Table 3. Expectations from individuals and State

| Variable                                           | 1   | 2   | 3   | 4   | 5   |
|----------------------------------------------------|-----|-----|-----|-----|-----|
| Everybody should do their best to reduce climate change | 16  | 9   | 0   | 0   | 0   |
|                                                   | 64% | 36% | 0%  | 0%  | 0%  |
| The State should take steps to implement projects and measures to minimize the effects of climate change | 18  | 7   | 0   | 0   | 0   |
|                                                   | 72% | 28% | 0%  | 0%  | 0%  |

Notes: The responses were based on a scale of: 1 = Strongly agree, 2 = Agree, 3 = Not sure, 4 = Disagree, 5 = Strongly disagree; The values indicate the number of respondents and the % indicate the percentile representative of the total respondents.
ponds close to water bodies and stocked favourable species whereas 8\% adjusted stocking time to meet rainy season (Figure 10).

3.5. Problems of aquaculture

The small scale aquaculture industry of Ghana faces a number of problems (Figure 11). 32\% of the respondents indicated infrastructure such as a poor road and communication networks, 20\% indicated lack of aquaculture education and training, 8\% indicated climate change, 8\% indicated market and 32\% indicated storage and processing. Though, not as high as the lack of aquaculture education and training, considering the percentage attributed to climate change by respondents, climate change still poses a considerable threat to the sustainable development of the aquaculture industry of Ghana, in the nearby future.
4. Discussion
This study provides important insights into perception and understanding of climate change in the small scale aquaculture industry of Ghana. The variations in temperature cannot be attributed to a particular cause but rather several causes, including GHG emissions from fossil fuel combustion in energy generation, to meet Ghana’s energy deficit, transport and industry, deforestation and intensive agriculture. Ghana’s carbon dioxide (CO₂) emissions (metric tons per capita) is 0.6 which is less than the world average of 4.06 (World Bank, 2016). Countries all over the world are being urged to put measures in place to reduce GHG emissions. Ghana is working around this task by reducing seasonal biomass clearing from farming, aquaculture, grazing land, mining, settlement, among others (Ghana’s initial national communication under the United Nations Framework Convention on Climate Change, MEST, 2001).

With rapid annual population growth rate of 2.7% in Ghana (National Population Council, 2011) the resulting effect are deforestation, intensive agriculture and continuous pressure on the limited natural resources particularly land and water resources. The consequential impact is either direct or indirect on the small scale aquaculture as long-established (IPCC, 2007; Roessig, Woodley, Cech, & Hansen, 2004; Wood & McDonald, 1997). A temperature change of 1°C is significant in the case of aquaculture production. These variations affect physiology, growth, and metabolism of farmed fish which in turn alter growth and prolong production, thereby, affecting the profit of fish farmers. The constant rise in temperature over the last few years means that farmers have to put measures in place to deal with temperature upsurge. A rise in temperature is not all that bad since high temperature is also useful during fish processing (specifically during fish drying. However, high temperature can also lead to fish spoilage, thus, bringing economic loss to the farmer. Temperature thus becomes critical in the aquaculture value chain (from production to consumption).

Aquafarmers in Ghana depend mainly on rainfall for their operations. The rainfall pattern was not stable and will continue to change. The unpredictability trend observed in the rainfall pattern will affect water availability ranging from droughts and to flood, water quality and mortality in the small scale aquaculture as confirmed in other studies and reports (Diersing, 2009; IPCC, 2007; Oloruntade & Oguntunde, 2009). Increased in rainfall will lead to an increase in the flow rate of water bodies with the possibility of reducing the salinity of the ponds since there is movement of water in and out. Decreased in rainfall will seriously affect fish production since aquaculture depends mainly on the availability of water.

Fish farmers in Ghana do not keep records of rainfall. This makes it difficult to know when to start production. Water quality and quantity are critical factors in fish production. There should be improvement in the sharing of rainfall information with aquafarmers to aid them in planning of their farming activities.

Dissimilarities in relative humidity distribution show how dry or moist the air is at a specific temperature and place. This phenomenon is influence by rainfall and temperature. Relative humidity forms part of the main factors required to determine pond water temperature. Increase in temperature and reduction in rainfall will result in increased evaporation and cloud cover (IPCC, 2007). This affects rain formation and delays rainfall.

Considering multi climatic data in aquaculture is advisable rather than single data. Temperature and rainfall are useful when it comes to the aquaculture production (that is, culturing of fish from fingerlings stage to adult stage) whiles relative humidity is useful in post-harvest practices such as drying. In developing countries, such as Ghana, fish drying plays an important role in making sure that fish is available all year round thereby ensuring food security and sustainable livelihood of thousands of fish processors.

The understanding level of climate change differs from person to person both scientific knowledge and personal experience or traditional knowledge within the studied area. Whether it is a natural
phenomenon or anthropogenic, the awareness and acceptance of its existence is important for planning purposes and finding ways to adjust to the effects associated with it. This conforms to (Adebayo, 2012; Apata, Samuel, & Adeola, 2009; Maddison, 2006) that, educated and experienced farmers have more knowledge and information about climate change. Documenting farmers’ viewpoints can be used as an important source of information in developing bottom-up adaptation strategies since they reflect concerns at the local levels.

With low literacy among farmers, putting climate change information in the newspapers and the internet will not be efficient (the source of information was 8 and 0% for newspapers and internet, respectively). On the other hand, the source of information from radio was 36%. Leaders, experts and aqua farmed practitioners should work together to develop a comprehensive action plan in dealing with climate change information in the aquaculture industry of Ghana.

The problem facing the aquaculture industry of Ghana is multi-faceted ranging from lack of training and extension services, market, storage, processing and climate change. Irrespective of the weight respondents attached to climate change, the impact of climate change turns to be severe. A single incidence of drought or flood for instance can wipe out a whole production stock and collapse farmers’ investment.

Fish production stands to suffer as a result of fish mortalities due to the impacts of climate change. In developing countries such as Ghana where food insecurity and malnutrition are high, threats of climate change will affect the country ability to achieve the targets of the Sustainable Development Goals (SDGs), especially, Goals 1, 2 and 12 (that is, no poverty, zero hunger and responsible consumption and production).

Climate change is expected to continue. Adaptation is thus critical in dealing with climate change by the small scale aquafarmer in Ghana. With small scale farmers without any form of insurance cover to deal with the effects of climate change, particularly, with floods and storms, improving the adaptive capacity of farmers becomes critical. Several coping mechanisms were adapted to mitigate the effects of climate change. Planting of trees to control strong wind and also to provide shade was practiced the most together with rising of dyke to avoid flooding and constructing bore hole to supply water during dry season. But these strategies were implemented after a few effects had been witnessed. Generally, adaptation responses of fishers to climate change impacts is scarce (Belhabib, Lam, & Cheung, 2016). Farmers adapting to climate change will go a long way to increase fish production which will eventually decrease the amount of money been spent annually on fish importation to Ghana (around US$120 million in 2014) (MoFAD, 2015) and ultimately improve the contributions of the aquaculture sector to Ghana’s economy.

5. Conclusion
Climate change poses threat to fish production in Ghana. The study confirms that, though fisher folks were aware of the phenomenon, their knowledge about the impacts of climate change differs. The farmers indicated relying mostly on radio broadcast buttressed with personal experience in most cases rather than any other form of extension or source of information. There is the need therefore, for a multi-media enlightenment campaign and education on the effects and possible adaptation strategies of climate change, to reach all fish farmers, using the available extension structures on ground by all stakeholders. In terms of policy implications, the Fisheries Commission of Ghana should also develop policy on climate change and aquaculture in order to realise and sustain the benefits of aquaculture.
Acknowledgement
We would like to thank all fish farmers who voluntarily shared their knowledge and records with us. The kind assistance given by the Regional Office of the Fisheries Commission is greatly appreciated.

Funding
This research is supported by funding from the Department for International Development (DFID) under the Climate Impact Research Capacity and Leadership Enhancement (CIRCLE) programme.

Competing Interests
The authors declare no competing interest.

Author details
Berchie Asiedu1
E-mail: berchiasiedu@yahoo.com
ORCID ID: http://orcid.org/0000-0002-9879-718X
Jenyo-Oni Adetola2
E-mail: jentolaoni@yahoo.com
Isaac Odame Kissi2
E-mail: kisii_isaac99@yahoo.com
1 Department of Fisheries & Water Resources, University of Energy and Natural Resources, P.O. Box 214, Sunyani, Ghana.
2 Department of Aquaculture & Fisheries Management, University of Ibadan, Ibadan, Oyo State, Nigeria.

Citation information
Cite this article as: Aquaculture in troubled climate: Farmers’ perception of climate change and their adaptation, Berchie Asiedu, Jenyo-Oni Adetola & Isaac Odame Kissi, Cogent Food & Agriculture (2017), 3: 1296400.

Notes
1. Regional Fisheries Commission the Government of Ghana agency responsible for regulating fisheries and aquaculture operations in Ghana.
2. Bad weather: an incidence of too high or low rainfall, drought, high temperature and strong storms (Source: from farmers’ interview).

Cover image
Source: Author (Bercbie Asiedu).

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