The impact of climate change on household food security in the Bongo District of the Upper East Region of Ghana

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ABSTRACT

The study determined the impact of climate change on household food security, investigated awareness level and identified coping strategies used to mitigate negative impact of climate change in the Bongo District with emphasis on women. It was a cross-sectional survey conducted in four purposively selected farming communities in the District in the Upper East Region of Ghana. A sample size of 246 women participated in the study. Using a structured questionnaire, data were collected on socio-demographic characteristics of the participants, awareness of climate change, food consumption patterns, coping strategies and household food security. Data on rainfall and temperature for the past 30 years period in the District were obtained from the Ghana Meteorological Service. Crop yields data over a period of 21 years in the District was also obtained from the Ministry of Food and Agriculture (MOFA). The results revealed that rainfall in the Bongo District has been decreasing at - 0.3 mm per annum and maximum temperature has been increasing at 0.005 °C. More than half (62.6%) of the participants were aware of climate change in their communities. Majority (89.4%) of the participants reduced the quality and quantity of diets as coping strategy method during food shortage periods and almost all (97.2%) of the households were food insecure. Participants who reported to have observed decrease in rainfall were more likely to be food insecure (OR = 3.96; CI = 0.56 – 27.81). Participants were aware of climate change and employed reduction in the quality and quantity of diet as coping mechanism. Almost all households were food insecure. There is the need to intensify climate resistant agriculture technology such as irrigation methods to offset the negative impact of climate change on food security in the District.

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Introduction

The alterations in the climate globally is negatively impacting on living conditions of people such as drinking water, food and the air inhaled (WHO, 2014). The negative effect of the changing climate on food crop production and other livelihoods exists and is very real (ACF, 2014). Extreme weather events have more than doubled compared to earlier decades, carrying in its wake major disasters that affect the main drivers of food security (ACF, 2014). The interaction between the human environment and weather extremities such as high temperatures, floods and drought, lead to disasters (Field, 2012). Increase in temperature is shown to reduce crop yields whilst variations in precipitation could have an impact on both crop quality and quantity (WFP, 2012). These alterations in the weather conditions are seen as an important "hunger-risk multiplier" (FAO, 2015). According to ACF (2014), climate change has led to increased food scarcity resulting in an overwhelming 842 million people suffering from hunger. Many forecasts of

the climate change impact show that these conditions could get worse because major staple crop production is already affected (ACF, 2014).

The climate change challenge of Africa is worst because most of its economic activity is agriculture based which rely heavily on natural resources such as rivers and the rain, which are affected by the changes in the weather (GPJ, 2013). In Ghana, report from the Ghana Agriculture Workers Union (GAWU) indicates that Ghana is already experiencing the impact of the weather extremes as there are extended drier and hotter days during the dry seasons and more floods during the raining reasons (GAWU, 2012). Northern Ghana is the most susceptible to the erratic weather pattern caused by climatic alterations than the other regions in the country owing to its drier and poorer nature and by reason that majority of its people are involved in subsistence agriculture (Darko & Atazona, 2013), in four farming communities in the Bongo District of the Upper East Region of Ghana. According to Ghana Statistical Service, about 90 percent of Bongo's population are into food crop farming (GSS,2010). The study was conducted to determine the impact of climate change on household food security in the Bongo District.

Materials and methods

Four farming communities (Anaafobiisi, Bogrigo, Gurigo and Gowrie) in the Bongo District of the Upper East Region of Ghana were purposively selected using cross-sectional survey. Apart from the primary occupation (farming) the population of women in these communities was considered. The study involved 246 women who were actively involved in food crop farming. Women were eligible to participate if they had been residing in the selected communities for at least 5 years. In Anafobiisi and Borigo, 62 participants were selected in each community. 61 participants were selected in Gurigo and Gowrie, respectively. Each community was divided into three strata due to the dispersed nature of the dwelling houses. The number of participants for each community was divided among the three strata. Stratified simple random sampling was used in selecting the households. A semi-structured questionnaire was used to obtain data on socio - demographic characteristics, awareness of climate change, household food consumption pattern in relation to climate change, coping strategies to offset the negative impact of climate change and household food security.

Data was collected from January to the second week of February, 2016, which was not farming season in the Upper East. The interviews were conducted from 8 a.m. till about 4 p.m. A 30–years' retrospective climate change data was collected from Ghana Meteorological Service Department on temperature and rainfall patterns in the study area. Also a 21– years' retrospective data on crop yields within the research location was collected from the Ministry of Food and Agriculture (MOFA), Upper East Region for trend analysis.

Data analysis

Data was analysed using SPSS version 20 (Statistical Package for Social Sciences). Means and standard deviations were generated for continuous variables and frequencies, for categorical variables.

Awareness: Data on awareness was analysed by creating two main categories namely adequate and inadequate awareness on climate change. A score of two was assigned to a Yes answer and zero to a No answer.

Coping strategy: Information collected were analysed by regrouping the list of coping strategies into three categories as;

i. Quality and quantity
ii. Aid and emergency
iii. Saving cost

Household food security data: Household Food Insecurity Access Scale (HFIAS) version 3 by FANTA III was used in categorizing the Household Food Security data. The four (4)

categories used according to the prevalence scale of HFIAS, were Food Secure, Mildly Food Insecure, Moderately Food Insecure and Severely Food Insecure. Binary logistic regression was used to determine the impact of rainfall and temperature and other variables on household food security.

Changes in household food consumption patterns: Pearson chi square was used to analyse the association between specific food crops that were consumed less by study participants and the reasons given as climate change effects on same crops.

Climate change and crop yields data: The means of climate change variables, rainfall and temperature, were used to plot time series graphs together with crop yields data to determine their trends and the impact of rainfall and temperature on crop yields in the Bongo district over 20 years' period.

Results

Background characteristics of respondents

Total number of 246 women were involved in the study. The minimum age of the women was 17 years whilst the maximum was 50 years. Majority (86.2%) of the women were married or cohabiting and more than a quarter of them (39.8%) had no formal education. Majority of the women were predominant farmers (73.2%). The mean monthly income of the women was GH₵ 42.8 ($10.2) with a maximum income of GH₵ 500.00 ($119.0). About 17.6 % had no income.

Awareness of climate change in the study area

More than half of the respondents (62.6%) were adequately aware of climate change in the study area. However, more than a quarter (37.4%) in the inadequate category were not aware of climate change. Table 1 profiles awareness level of participants and the changes observed in climatic variables over the years. Participants were also asked whether they have observed any changes over time in rainfall and temperature patterns and the type of change they have observed. Approximately 89.4 percent observed decreasing rainfall. On temperature, majority (84.7%) said it has been increasing over the past 5 years. Various causes of climate change were mentioned by the participants (Table 1). About 36.2 percent attributed the cause to cutting of trees, whiles 31.7 percent ascribed it to burning of bushes. About a quarter of the respondents (25.2%) had no knowledge of the causes of climate change.

TABLE 1

Level of awareness and observed changes in climate variables (N=246)

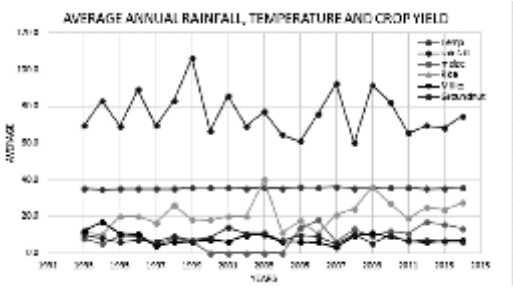
Variables	*n (%)*
Awareness	
Adequate	154 (62.6)
Inadequate	92 (37.4)
Changes observed in rainfall	
Yes	236 (95.9)
No	10 (4.1)
Types of change (N = 236)	
Increasing rainfall	25 (10.6)
Reduced rainfall	211(89.4)
Changes observed in temperature	
Yes	209 (85)
No	37 (15)
Types of change (N = 209)	
Increasing temperature	177 (84.7)
Reducing temperature	32 (15.3)
Causes of climate change in the study area	
Cutting of trees	89 (36.2)
Bush burning	78 (31.7)
I don't know	62 (25.2)
Poor rains	7 (2.8)

Impact of climate variables on food crop yields in the Bongo District

Some of the major crops grown in the district included millet, maize, rice, sorghum, groundnut and cowpea. The climate variables that impacted on food crops grown in the District were decreasing rainfall and maximum temperature. Changes in maximum temperature in relation to crop yield was marginal (Fig. 1) over the past 30 years, but rainfall variability affected crop yield considerably over the same period. In 1999, when average rainfall increased to about 108 mm, the yield of rice increased from 1.8 ton/ha to about 2.5 ton/ha. Over the same period, millet yield doubled from 0.4 ton/ha to about 0.8 ton/ha. The yield of groundnut also increased from about 0.5 ton/ha to about 1ton/ha, whereas the yield of maize more than doubled from 0.4 ton/ha to about 0.9 ton/ha.

However, as mean rainfall decreased sharply in 2011 from about 90 mm to about 62 mm, the yield of rice dropped with a difference of a 0.9 ton/ha. Rice yield decreased from 2.8 ton/ha to about 1.9 ton/ha. Millet yield were halved from 1 ton/ha to about 0.5 ton/ha over the same period. Groundnut yield dropped to almost half from 0.8 ton/ha to about 0.5 ton/ha. Maize yield also decreased from 1 ton/ha to about 0.7 ton/ha thus

a difference of 0.3 ton/ha. Again, when average rainfall decreased from about 65mm in 2012 to about 63mm in 2013, all the crops experienced decrease in yield. Rice dropped from 2.5 ton/ha to about 2.2 ton/ha. The yield of maize decreased from 1.8 ton/ha to about 1.6 ton/ha, while millet and groundnut also experienced decreases.



The values of crop yields were multiplied by 10 before plotting to enable their values fit on the same graph with the climate variables (temperature and rainfall).

Fig. 1. Relationship between climate variables and crop yields.

Changes in household food consumption patterns in relation to climate change

Participants were asked whether they no longer consumed or consumed in lesser quantities some food crops as a result of climate change impact. About a half (57.3%) of the participants responded yes to both questions while (42.7%) said no, they still consume food crops, and in their normal quantities. Those who said yes to both questions were further asked to mention the specific food crops that were affected by the impact of the changing climate and in which way climate change has affected these food crops. Using Pearson chi square, a significant association was observed between reasons given as climate change effects on the food crops and the specific crops mentioned to be affected with a significant p-value of 0.001 as shown in Fig. 2.

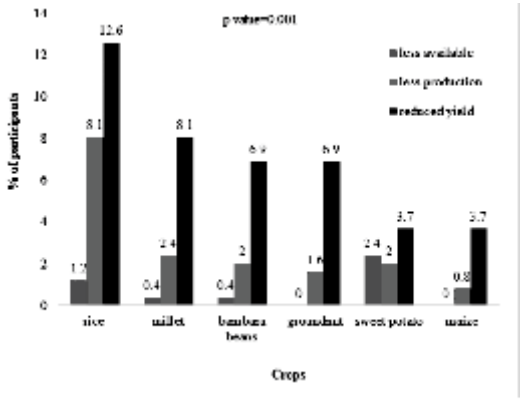


Fig. 2. Association between reasons given for consuming less quantity of some food crops and the specific food crops in relation to climate change.

Household food security and coping strategies

Based on the household food insecurity access scale (HFIAS), only 0.8 percent, representing two households, were food secure. Almost all the households were severely food insecure (Table 2), and almost all the respondents (89.4%) said the coping strategy they would employ during food shortage is reducing the quality and quantity of diet. About 10 percent indicated depending on aid and emergency.

TABLE 2
Household food security and coping strategies adopted (N = 246)

Variable	*n (%)*
Household food security	
Food Secure	2 (0.8)
Moderately Food Insecure	5 (2)
Mildly Food Insecure	0 (0)
Severely Food Insecure	239 (97.2)
Coping strategies	
Reduced quality and quantity	220 (89.4)
Aid and Emergency	24 (9.8)
Saving Cost	7 (0.8)

Determinants of household food insecurity among the participants

From the binary logistic regression model in Table 3, participants who reported experiencing decrease in rainfall were 3.96 more likely to be food insecure. Participants with no formal education were 4.54 more likely to be food insecure. Larger household sizes were highly correlated with food insecurity with the odds ratio of 3:11 compared to smaller household sizes.

TABLE 3

Adjusted and unadjusted odds ratios of rainfall and temperature impact on household food insecurity

Variables	*Food insecurity*	
	Unadjusted OR (95% CI)	*Adjusted OR (95% CI)*
Maternal age		
17-24	1	1
25-30	1.24 (1.03- 1.51)	1.90 (0.96- 1.59)
31-34	0.31 (0.56- 1.69)	0.13 (0.02- 1.02)
≥35	1.92 (0.19- 19.13)	1.50 (1.21- 1.87)
Education		
Educated	1	1
No education	9.31 (0.81- 107. 04)	4.54 (0.53- 39.01)
Household size		
<7	1	1
≥7	5.12 (3.25- 8.07)	3.11 (1.76- 5.50)
Income		
<Ghc20	1.16 (0.99- 1.36)	1.09 (0.22- 5.32)
≥Ghc20	1	1
Number of under 5[3]		
≤ 2	1	1
≥3	2.57 (2.12- 3.13)	1.51 (1.12- 2.05)
Decreasing Rainfall[1]		
Yes	4.67 (0.99- 21.82)	3.96 (0.56- 27.81)
Increasing Temperature[2]		
Yes	1.96 (0.34-11.31)	1.02 (0.12- 9.83)

Binary logistic regression adjusting for the other factors shown in the table

Food security was a reference variable

[1] *Perceived decreased rainfall*

[2] *Perceived increasing temperature*

[3] *Number of under five-year-old children in each household*

Discussion

Using rainfall and temperature variability over a period of 30 years as a proxy for climate change in the District revealed there was a - 0.3 mm decrease in rainfall per annum and 0.005 °C increase in maximum temperature. The decreasing trend in the rainfall pattern observed is consistent with the findings documented in the *Ghana Policy Journal* (GPJ, 2013) which stated that there has been drastic variations in the rainfall patterns after the 1960's. Ghana experienced high rainfall during 1960s after which it drastically reduced in the later part of 1970s and early 1980s. This resulted in the low level of rainfall observed in the country between 1960 and 2006 with mean decline of 2.3 mm (GPJ, 2013). Ghana's average yearly temperature is predicted to rise by 1.03.0 °C by the end of 2060s, and 1.55.2 °C by 2090s, with warming drastically increasing in the northern regions than the coastal regions (GPJ, 2013).

Another research conducted explained that northern Ghana is the most susceptible to the erratic weather pattern caused by climatic alterations than the other regions in the country owing to its drier and poorer nature (Darko & Atazona, 2013). This could be a possible reason for the trends observed in the rainfall patterns and in the maximum temperature over the years in the Bongo District which inevitably impacts food security negatively.

Awareness of changes in the atmospheric variables greatly impact on how farmers handle climatic threats and opportunities. The accuracy of their knowledge on these matters and their responses to the climatic threat is important in shaping their adaptation alternatives, the

methods to be employed and the adaption outcomes (Pauw, 2013). A study conducted in Kenya indicated that awareness of climate change especially among rural Kenyans is low (Mutimba *et al.*, 2010). About 44 percent of Kenyans, whose livelihood are dependent on the weather patterns, have no knowledge on the climate variability and any alternatives to mitigate its impact (Mutimba *et al.*, 2010). Contrary to this finding, the level of awareness of climate change among the study participants in this study was high. More than half (62.6 %) of the participants in the households surveyed were aware of the changing climate in the various communities.

Climate change threats on livelihoods and agriculture production have made indigenous people to develop knowledge and skills to help them sustain life in the changing environment. These coping strategies enable them to modify the detrimental effect of the changing climate on livelihoods and life (UNSCN, 2010). Investigation into the coping strategies employed by participants in this study showed that majority (87.4%) reduced the quality and quantity of their diet during periods of shortage of food. This finding is similar to results of many studies, such as the study by the United Nation's Standing Committee on Nutrition, which found out that weather associated threats consistently push households to adapt to some negative coping mechanisms such as decreasing the quantity and quality of meals, decreasing health and education expenditures in order to acquire food and the sale of vital personal assets (UNSCN, 2010; Field, 2012). Also a study conducted in Uganda showed that reduced crop yields resulting from erratic rainfall have limited peoples' access to sufficient food hence some families eat once a day and in food scarcity situations women reduce their own food so as to feed their children and men (MRFCJ, 2013).

Similarly, several coping strategies including reduction in the number of meals per day adopted by families in the Upper East Region during food shortage periods was revealed by Quaye in 2008. About 97 percent reduced number of meals served per day, whiles 71.3 percent sold their fowls to purchase food (Quaye, 2008). The type of coping strategies adopted by the participants reflects their socio-economic status. The mean monthly income of participants was GH₵43.00, which is less than $11.00 per month. This low- income status could be as a result of the nature of their occupation where more than half (73.2%) of the women were peasant farmers. This implies that most of the participants would not be able to afford a wide variety of nutritious food.

Observations from this study showed that as rainfall decreased, the yields of some of the crops decreased as well. For instance, in 2011 when mean rainfall decreased from about 90 mm to about 62 mm, the yield of rice dropped with a difference of a 0.9 ton/ha. Rice yield decreased from 2.8 ton/ha to about 1.9 ton/ha, millet yield was halved from 1 ton/ha to about 0.5 ton/ha over the same period (Fig. 1). This could explain why about a half (57.3%) of the participants consumed less of these crops over the previous five years. In addition, chi-square analysis (Fig. 2) between specific crops whose consumption was reducing among the households and reasons given for the reduction shows a significant association ($P = 0.001$).

This reduction in crop yields could also be the reason for the choice of the most frequent coping strategies adopted by majority of the participants (reduction in quality and quantity of diet) since their main meals are prepared from millet, maize and groundnut and these are less available due to low yields. This is consistent with the findings of the World Food Programme (2012) and Springmann *et al.,* (2016). According to these results, weather variability could have effect on calorie consumption through its impact on food security most especially from drought. The cumulative effect is change in dietary diversity and decrease in food consumption with persisting adverse impact on stunting.

Food insecurity is one of the greatest difficulties that the continent of Africa faces. According to World Food Programme, majority of the food insecure people reside in the poorest and low areas of Asia, Latin America and Africa, where anthropogenic conditions and the changing climate will most likely worsen the current danger to food security (WFP, 2012). Results from this study shows that almost all (97.2%) of the households were food insecure. Majority (89.4%) perceived that rainfall over the past 5 years has been decreasing, while 84.7 percent of the participants also perceived increasing temperature of the same period.

Similarly, data from Ghana Meteorological Agency (GMet) on rainfall and temperature from 1986 to 2015 has confirmed the perceptions of the participants as rainfall variability was decreasing at – 0.3 mm and maximum temperature increasing marginally at 0.005 °C per annum. These climate variables are the major determinants of food crop production hence food security and could explain why greater number of the households were food insecure. The findings complement what Rosegrant *et al*., (*2008*) stated in their study. They reported that the number of most food insecure will rise up to 170 million people by 2080 in Africa due to the changing climate alone (Rosegrant *et al.*, 2008). Statistics in Ghana also show that 2 million of the population are at risk of becoming food insecure and majority of these people are situated in Northern, Upper East and Upper West regions (Ahwoi, 2011).

Further analysis to assess the impact of climate change on food insecurity among the households showed that those who experienced decreased rainfall were more likely to be food insecure (OR = 3.96; CI = 0.56 – 27.81). The explanations for this could be that these people might have had low crop yields already due to the impact of the weather, hence, may not have sufficient food available for consumption. Other associated factors to household food insecurity were the educational level of the participants, the number of household members and women who were 35 years and above (Table 3). The odds of women who were 35 years and above were 1.5 times more likely to be food insecure (OR = 1.5; CI = 1.21- 1.87; *P = 0.05*).

The relationship between no formal education and food insecurity could be due to their inability to access or apply information on appropriate farming technology which could help improve their crop yields leading to low yields, hence, they are more food insecure. With low crop yields, larger household sizes are faced with the challenge of food availability which could translate into reduction in the quantity of food for consumption hence food insecurity. At 35 years and above, the strength of women for active farming could have reduced making them unable to cultivate food crops on a large scale. This, coupled with extreme weather conditions, such as decreasing rainfall and increasing temperature, could have resulted in having less crop yields and consequently become food insecure. In accordance with a report by WFP, climate change through its extreme weather events such as drought, floods and increase temperatures may prolong growing seasons of crops, and erratic rainfalls can adversely impact on availability of food through variation in crop yields, as well as loss of productive land for agriculture purposes (WFP, 2012).

Conclusion

Awareness of climate change in the Bongo district was evident with majority of participants stating to have observed decreasing rainfall and increasing temperature over the past five years which has affected crop yields. This observed trend affected consumption patterns of participants due to food shortage, hence, most people reduced the quantity and quality of their food as coping strategy to make up for the reducing food stores. Almost all of the study participants were food insecure as a result of food unavailability. Decreasing rainfall at a rate of – 0.3 mm per annum was associated with decreasing crop yields and household food insecurity. Evidently, climate change has a negative impact on household food security in the Bongo district.

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