Climate change and food and nutrition security in the Bibiani-Anhwiaso Bekwai district in the Western Region of Ghana

Abigail A. Armah1*, Christina A. Nti2 and Gloria Ethel Otoo1

Abstract: Climate change has the potential to increase food insecurity and exacerbate malnutrition in small-scale farming households through its impacts on crop yield and income. Using a mixed-methods design, a cross-sectional study was carried out in the Bibiani-Anhwiaso Bekwai District in the Western Region of Ghana among 210 farming households with the objective of finding associations between climate change and food and nutrition security in small-scale farming households. Results from the quantitative study showed that 72% of the participants had perceived changes in weather patterns. Majority (94%) of the participants were food insecure and households that had perceived climate change were 11 times more likely to be food insecure than those that had not (p = 0.001). Results from the qualitative study showed that participants had observed less predictable weather patterns which had negative impacts on crop yield, food security and dietary diversity. The study recommended educating and encouraging farmers to adopt climate-smart agricultural practices and other modern technologies to enhance crop production and livelihood of small-scale farmers as well as food and nutrition security within the district.

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Ms Abigail Armah Ayorkor holds a BSc in Nutrition and Food Science and an MPhil in Nutrition from the Department of Nutrition and Food Science, University of Ghana. Her research interests include Food Security, Climate Change Issues and Maternal and Child Nutrition. The author’s work contributes to work on climate change impacts on food security and nutrition. This is part of a bigger study to assess the impacts of climate change on food security, dietary patterns and nutritional status of smallholder farming households in the Bibiani-Anhwiaso Bekwai District with emphasis on women and children below 5 years. Specifically, this work looks at knowledge of small-scale farmers on climate change, its impacts on dietary consumption patterns and food security among small-scale farming households.

PUBLIC INTEREST STATEMENT
Climate change poses enormous risk to agricultural production as well as food and nutrition security in small-scale farming households due to its impacts on crop yield. This study examined small-scale farming households’ experience on climate change impacts on agricultural production and household food security. Primary data for this study consisted of a questionnaire survey, focus group discussions and key informant interviews in four predominantly farming communities in the Bibiani-Anhwiaso Bekwai District. Study results revealed that small-scale farmers in the district experienced climate change evidenced mainly through erratic rainfall patterns and rising temperatures. This affected crop production and diversity of meals available for consumption in their households. About 72% of study participants perceived changes in weather patterns. Majority (94%) of the participants were food insecure and households that had perceived climate change were 11 times more likely to be food insecure than those that had not (p = 0.001).
1. Introduction

Issues concerning food and nutrition security have been a source of worry in many parts of the world, especially in developing countries for many years (Marx, 2015; Tlhompho, 2014). Though there is more than enough food supply globally to provide everyone with all the energy needed, an unacceptably large number of people around the world lack the food they need for an active and healthy life because food is unevenly distributed (FAO, 2006; Marx, 2015).

Recent data indicate that about 795 million people, majority of whom live in developing countries, are undernourished (Marx, 2015). Ironically, available data shows that about half of undernourished people happen to be small-scale farmers who even though grow food, do not have the resources to meet all of their dietary needs through either production or purchase (FAO, 2006). This was confirmed by studies in some rural communities in Northern Ghana which concluded that even though farming households usually cultivated mainly for consumption by their households, a greater percentage of them were food insecure (Adeniyi & Ojo, 2013; Kuwornu et al., 2013; Quaye, 2008). In Ghana, data from the three Northern Regions indicate that poorer households, households with smaller farms, Female-headed households and households with uneducated heads were among the most food insecure. Crop failure and seasonal difficulties in accessing enough food during lean seasons happen to be very common among these food insecure households (WFP, 2012).

According to Black et al. (2008), maternal and child undernutrition serves as the underlying cause of 3.5 million deaths each year and 35% of the disease burden in children younger than 5 years. Food insecurity serves as a major determinant of malnutrition and several studies have found positive associations between food insecurity and malnutrition (Matheson, Varady, Varady, & Killen, 2002; Saaka & Osman, 2013).

Climate change, on the other hand, refers to the regional or global-scale changes in historical climate patterns arising as a result of natural variability or human activities which results in intermittent but increasingly frequent extreme impacts (Akudugu, Dittoh, & Mahama, 2012; IPCC, 2007). The potential impacts of climate change on human lives and the world as a whole have made it a very topical issue (Akudugu et al., 2012). Agriculture is one of the most threatened sectors by climate change, particularly within the tropics (Edame et al., 2011). Changes in vegetation periods, precipitation and wind patterns, rising temperatures, soil erosion, alterations in water availability, increasing spread of and vulnerability to pests and plant diseases, invasive species and the loss of agro-biodiversity all make conditions more difficult for agricultural production (Gruber & Kepler, 2012).

Climate change poses enormous risk to food crop production globally due to its impacts on yields and has the potential to exacerbate the problem of food insecurity and malnutrition by negatively affecting household access to sufficient, safe and adequate food, care and feeding practices and environmental health and access to health services (FAO, 2015). According to Tirado, Crahay, Hunnes, Cohen, and Denton (2010), Africa is particularly vulnerable to the effects of climate change because of its low adaptive capacities and other multiple stresses which increase its vulnerability to the impacts of climate change. In Sub-Saharan Africa, climate change-related hunger is particularly a challenge as the livelihoods of a huge proportion of the populations depend on climate and environmental factors such as rain-fed agriculture which covers about 96% of all cultivated land (Tirado et al., 2010).

In Ghana, climate change and variability studies have reported reduced precipitation since the 1960s and rainfall patterns have been described as erratic. Temperature has been...
reported to have increased over the years and these have been shown to have negative impacts on crop yield and food security (Fosu-Mensah, Vlek, & MacCarthy, 2012; Owusu, Waylen, & Qiu, 2008; Williams, Larbi, Yeboah, & Frempong, 2018). Studies in Northern Ghana reported declines in crop yield and animal production as a result of changes in rainfall patterns. These negatively affected the ability of households to meet the dietary needs of their families (Rademacher-Schulz, Schraven, & Mahama, 2014; Akudugu et al., 2012; Williams, 2018). Very little is however known about changes in climate variables in Ghana’s middle belt which happens to be part of the rainforest where food is normally expected to be in abundance. This study, therefore, set out to investigate associations between climate change and food and nutrition security in small-scale farming households in the Bibiani-Anhwiaso Bekwai District in the Western Region of Ghana.

2. Methodology

2.1. Study area
Farming is the major occupation in the Bibiani-Anhwiaso Bekwai District. It serves as the means of livelihood for approximately 80% of the population (Ghana Statistical Service, 2014). The district experiences bimodal rainfall with averages between 1200 mm and 1300 mm annually. The annual mean temperature in the district is 26°C.

Figure 1. Map of the Bibiani-Anhwiaso Bekwai District indicating study communities.
2.2. Study design
Using a mixed-methods design, a cross-sectional study was carried out in the Bibiani-Anhwiaso Bekwai District to assess the impacts of climate change on food and nutrition security within the district. The study consisted of a quantitative survey which made use of pre-tested semi-structured questionnaires and a qualitative study which consisted of 4 focus group discussions (FGDs) and 11 key informant interviews (KIIs). The quantitative survey consisted of 210 households with children under 5 years old. Households involved in small-scale farming in four farming communities within the district, namely Basenkele, Lineso, Fahiakobor and Adukrom (Figure 1) were selected for the study and individual participants were randomly selected. The 210 households were distributed as follows: 52 participants each from Fahiakobor and Lineso and 53 participants each from Adukrom and Basenkele.

For the purpose of this study, secondary data of two climate variables (temperature and rainfall) were obtained for a period of 30 years (from 1985 to 2015) from the Ghana Meteorological Agency (GMet) Accra. This was analysed and used to establish the trend and variability in the climate for the district. Secondary data on crop yield were also obtained from the Ministry of Food and Agriculture (MoFA) for a period of 22 years (from 1992 to 2014) to assess crop yield within the study district.

2.3. Quantitative data collection
A pre-coded semi-structured questionnaire was developed in relation to the objectives of the study. It consisted of both open-ended and close-ended questions and was used to obtain information on background characteristics of respondents, perceived climate change and household food security. The FAO Household Food Insecurity Access Scale (HFIAS) questionnaire (Coates, Swindale & Bilinsky, 2007) was used to obtain data on household food security. To assess perceived climate change, data were collected on whether participants had observed changes in temperature and rainfall patterns, types of changes observed, effects of these changes on crop production and effects of changes in temperature and rainfall patterns on types and quantity of food consumed. Eight questions were asked in all concerning perceived climate change and the response to each question was scored 0 or 1 (Appendix) and results computed.

2.4. Data analysis
2.4.1. Quantitative analysis
Data entry, cleaning and analysis were done using SPSS version 16. Data cleaning was done to identify logically inconsistent data, data that were out of range and those with extreme values. Descriptive statistics such as mean and standard deviation for continuous variables and frequencies and percentages for categorical variables were computed. Binary logistic regression analysis was used to determine factors associated with household food security.

To assess climate change in the Bibiani-Anhwiaso Bekwai District, temperature and rainfall data for the district were obtained from the Ghana Meteorological Agency, Accra from 1985 to 2015. Microsoft Excel Version 2013 was used for the preliminary analysis of climate data to obtain yearly averages for the climate variables (temperature and rainfall) which were used to develop line graphs which gave a pictorial view of the trend of the climate variables. Data on crop yield was also obtained from the Ministry of Food and Agriculture (MoFA).

Descriptive tables were developed to generate the mean for the years. Annual mean for the 30-year period under study for each climate variable was determined and this aided in calculating the standard deviation for the climate variables (rainfall and temperature) using the following formula:
| Variable                        | Total sample | Perceived climate change | p-Value |
|-------------------------------|--------------|--------------------------|---------|
|                               | N = 210 (%)  | Yes (n = 151)            | No (n = 59) |  |
| Age (in years)*              | 30.3 ± 9.2   | 30.5 ± 9.5               | 29.2 ± 8.3 | 0.751 |
| Ethnicity                     |              |                          |          |      |
| Akan                          | 172 (81.9)   | 122 (70.9)               | 50 (29.1) | 0.504 |
| Others¹                       | 38 (18.1)    | 29 (76.3)                | 9 (23.7)  |      |
| Religion                      |              |                          |          |      |
| Christian                     | 189 (90.0)   | 136 (72.0)               | 53 (28.0) | 0.777 |
| Muslim                        | 19 (9.0)     | 14 (73.7)                | 5 (26.3)  |      |
| Others²                       | 2 (1.0)      | 1 (50)                   | 1 (50)    |      |
| Marital status                |              |                          |          |      |
| With partners³                | 173 (82.4)   | 130 (75.1)               | 43 (24.9) | 0.024 |
| Without partners⁴             | 37 (17.6)    | 21 (56.8)                | 16 (43.2) |      |
| Educational background        |              |                          |          |      |
| No formal education           | 37 (17.6)    | 28 (75.7)                | 9 (24.3)  | 0.319 |
| Basic education               | 158 (75.2)   | 110 (69.6)               | 48 (30.4) |      |
| Secondary education           | 15 (7.1)     | 13 (86.7)                | 2 (13.3)  |      |
| Community                     |              |                          |          |      |
| Basenkele                     | 53 (25.2)    | 46 (86.8)                | 7 (13.2)  | 0.01  |
| Lineso                        | 52 (24.8)    | 35 (67.3)                | 17 (32.7) |      |
| Fahiakobor                    | 52 (24.8)    | 39 (75.0)                | 13 (25.0) |      |
| Adukrom                       | 53 (25.2)    | 31 (58.5)                | 22 (41.5) |      |
| Primary occupation            |              |                          |          |      |
| Farmer                        | 161 (76.7)   | 126 (78.3)               | 35 (21.7) | 0.001 |
| Trader                        | 25 (11.9)    | 13 (52.0)                | 12 (48.0) |      |
| Others⁵                       | 24 (11.4)    | 12 (50.0)                | 12 (50.0) |      |
| Secondary occupation          |              |                          |          |      |
| Farmer                        | 47 (40.9)    | 25 (53.2)                | 22 (46.8) | <0.001|
| Trader                        | 52 (45.2)    | 46 (88.5)                | 6 (11.5)  |      |
| Others⁶                       | 16 (13.9)    | 16 (100.0)               | 0 (0.0)   |      |
| Average monthly income (GHC)  |              |                          |          |      |
| <100                          | 80 (38.1)    | 51 (63.7)                | 29 (36.3) | 0.118 |
| 100–199                       | 71 (33.8)    | 55 (77.5)                | 16 (22.5) |      |
| ≥2000                         | 59 (28.1)    | 45 (76.3)                | 14 (23.7) |      |

¹mean ± S.D; ¹Including: Ewe (1.4%); Ga-Adangme (4.8%); Northerners (11.9%); ²Including: Traditionalist (0.5%); No Religion (0.5%); ³Married (76.2%); Cohabiting (6.2%); ⁴Never married (10.9%); Widowed (2.9%); Separated (3.8%); ⁵Including: Baker (1.5%); Seamstress (3.4%); Nurse (0.5%); Teacher (0.5%); Not working (0.5%); ⁶Hairdresser (3.5%); Seamstress (6.1%); Cook (0.9%); Decorator (0.9%); Student (1.7%); ⁷n = 1
where SD = Standard deviation; “n” is number of years used in the calculation;

\[
\sum (x_i - \bar{x})^2
\]

is the sum of rainfall or temperature measure (X) for each year minus the mean value \(\bar{x}\) for the years all squared.

Using the mean (\(\bar{x}\)) and standard deviation calculated, the coefficient of variation (CV) was obtained for each of the climate variables (temperature and rainfall using the following formula):

\[
CV = \frac{SD}{\bar{x}} \times 100
\]

where CV is the Coefficient of variation; SD is standard deviation; \(\bar{x}\) is the mean of each of the climate variables (temperature and rainfall)

2.4.2. Qualitative data analysis
All focus group discussion and key informant interviews were digitally recorded, transcribed verbatim and translated to English. The transcripts were coded using NVivo 11 software. During coding, categories were developed, which evolved into themes and sub-themes. These themes were synthesized, summarized and used in report writing. Similarities and differences across the various groups were noted.

2.5. Ethical considerations
The study protocol was submitted for review and approval by the Ethics Committee for Basic and Applied Sciences (ECBAS), University of Ghana. Verbal consent was also sought from each participant before recruiting participants into the study.

3. Results and discussion

3.1. Background of study participants
The study participants had an average age of 30 years. Eighty-two per cent (82%) of the women involved in this study were married or cohabiting and only 7% had secondary education. Farming was the primary occupation of most participants (77%) and majority (72%) had an average monthly income below GH¢ 200 (Table 1).
3.2. Temperature variables

3.3. Climate change in the Bibiani-Anhwiaso Bekwai District

Figure 2 shows that about 92% of farmers interviewed had perceived an increase in temperature. Eighty-one per cent (81%) representing 157 out of 193 farmers (Table 2) who had observed some changes in temperature had perceived increase in temperature while 17% reported they had perceived a decrease in temperature. Historical annual data on temperature for the Bibiani-Anhwiaso Bekwai District from (1986–2015) showed an increasing temperature trend (Figure 3). The change in temperature from (1986–2015) was observed to be higher in minimum temperature than in maximum temperature (Figure 4).

Farmers’ response to change in precipitation varied slightly from response to temperature changes. About 54% perceived delayed rainfall while 44% perceived decreased precipitation (Figure 5). Verification with historical rainfall data for a period of 30 years (1986 to 2015) showed that rainfall was not evenly distributed across the years even though Figure 6 depicts a slightly increasing trend. Figure 7 explains the upward rainfall trend observed as an increase in rainfall intensity for particular months and not necessarily a uniform distribution throughout the years under review.

Participants in this study had varied opinions about the cause of climate change. Response from FGDs and KIIs identified deforestation as the main cause of climate change. Contrary to that only 35% of participants in the survey attributed climate change to deforestation. About 15% of survey participants who responded to the causes of climate change said climate change was a natural occurrence, another 15% attributed it to religious reasons (9.6% attributed it to God’s plan and 5.5% to the world coming to an end), 26% said they had no idea about the cause of climate change while 7% gave other reasons (Table 2).

A study by Kabo-Bah et al. (2016) and Fosu-Mensah et al. (2012) reported similar findings of increasing temperature and unevenly distributed rainfall patterns. Rainfall in Ghana according to Asante and Amoakwah-Mensah (2015) was mostly high in the 1960s but declined to low levels at the latter parts of 1970s and early 1980s. According to Prakash, Lall, and Luni (2011), temperature and precipitation are counted among the very important determinants of crop yields. Fosu-Mensah et al. (2012) in their study explained that rainfall distribution within cropping seasons were of major concern with regards to climate change impacts as these directly affect crop production. Rainfall pattern increases when temperature increases. Increasing temperature also rapidly depletes the land of its moisture, destroying crops as a result of salinization of agricultural lands and water scarcity (Tirado et al., 2012). Responses from FGDs and KIIs described the current...
rainfall pattern as erratic as these small-scale farmers could barely identify when to expect rainfall and prepare their lands and crops for planting.

### 3.4. Climate change and food and nutrition security

When asked how they were affected by changes in temperature and rainfall patterns, 55% said it caused food shortage in their households, 28% said it caused diseases and 13% said it reduced their income. These responses were confirmed by results from focus group discussions and key informant interviews (Figure 9). Further analysis (Table 4) revealed that participants who had perceived climate change were 11 times more likely to be food insecure compared to those who had not ($p = 0.001$). Other factors such as marital status, level of education, household size and income of household head were not statistically significant predictors of food insecurity.

Results from a study by Akudugu (2012) in the Northern Region of Ghana reiterated the negative impacts of climate change on livelihoods of small-scale farmers. This study explained that erratic rainfall resulting from climate change reduced crop yield, affecting food availability, thereby,

| Variable                                                                 | n(%)       |
|--------------------------------------------------------------------------|------------|
| Have you observed any changes in temperature over the past five years or more (n = 210) |            |
| Yes                                                                      | 193 (91.9) |
| No                                                                       | 17 (8.1)   |
| Have you observed any changes in rainfall over the past five years or more (n = 210) |            |
| Yes                                                                      | 193 (91.9) |
| No                                                                       | 17 (8.1)   |
| Causes of climate change (n = 146)                                       |            |
| Cutting down forest trees/deforestation                                 | 52 (35.6)  |
| Nature                                                                   | 22 (15.1)  |
| Part of God’s plan                                                       | 14 (9.6)   |
| Because the world is coming to an end                                    | 8 (5.5)    |
| Others¹                                                                  | 12 (8.2)   |
| Don’t know                                                               | 38 (26.0)  |
| Climate Change Effects on household (n = 144)                            |            |
| It causes food shortage and hunger                                       | 79 (54.9)  |
| It reduces our income and brings poverty because of reduced crop yield   | 18 (12.5)  |
| It causes diseases                                                       | 41 (28.5)  |
| Others²                                                                  | 6 (4.2)    |
| Some foods no longer consumed as a result of changes in climate variables (n = 210) |            |
| Yes                                                                      | 87 (41.4)  |
| No                                                                       | 123 (58.6) |
| Changes in quantities of foods available for consumption (n = 210)       |            |
| Yes                                                                      | 156 (74.3) |
| No                                                                       | 54 (25.7)  |

¹Including: Bush burning 3(2.05); Dumping refuse in the wrong places 2(1.37); Increasing population 1(0.68); Mining activities 1(0.68); Our sins 3(2.05); Not obeying taboos and the presence of churches 2(1.37) ²Including: Our crops don't grow well 4(2.78); It affects availability of water for farming and domestic use 2(1.39)
Figure 4. Change detection in maximum (a) and minimum (b) temperature (°C) in the Bibiani-Anhwiaso Bekwai District between the periods of 1986–1995 and 2006–2015.

Figure 5. Farmers’ perception of changes in precipitation in the Bibiani-Anhwiaso Bekwai District.

Figure 6. Trends of average annual rainfall (mm) in the Bibiani-Anhwiaso Bekwai District 1986–2015.

Figure 7. Change detection in rainfall patterns (mm) in the Bibiani-Anhwiaso Bekwai District between the periods of 1986–1995 and 2006–2015.
making very little or no surplus food available to be sold. This has negative implications on the income of small-scale farming households and makes resources which otherwise would have been invested get reallocated to ensure basic household dietary needs are met (Akudugu, 2012). On the other hand, non-farming households are posed with the challenge of purchasing food at a higher cost or starving since less or no food is available to be sold by farming households.
About 74% of participants in this study explained that availability of some crops had been negatively affected by changes in climate variables (Table 2). Studies by Iwuchukwu and Udoye (2014); Mugambwa (2014) and Williams et al. (2018) showed that climate variability negatively affected crop quality. Crop yield, fruit size and taste of fruits were also reported to have been affected by increasing temperature and variability in rainfall patterns (Williams et al., 2018).

### Table 3. Household food insecurity prevalence

| Variable                        | n (%)       |
|---------------------------------|-------------|
| HFIAS Score (mean ± S.D)        | 10.77 ± 5.2 |
| Food Insecurity Prevalence      |             |
| Food Secure                     | 13 (6.2)    |
| Mildly Food Insecure            | 21 (10.0)   |
| Moderately Food Insecure        | 78 (37.1)   |
| Severely Food Insecure          | 98 (46.7)   |

### Table 4. Predictors of food insecurity

| Variable                        | OR   | 95% CI       | p-value |
|---------------------------------|------|--------------|---------|
| Mother’s age:                   |      |              |         |
| <20 years                       | 0.21 | 0.03–1.45    | 0.113   |
| ≥20 years                       | 1    |              |         |
| Marital status:                 |      |              |         |
| Without partner                 | 4.9  | 0.53–44.28   | 0.16    |
| With partners                   | 1    |              |         |
| Household size:                 |      |              |         |
| ≥6                              | 0.47 | 0.12–1.88    | 0.287   |
| <6                              | 1    |              |         |
| Household head:                 |      |              |         |
| Mother                          | 0.235| 0.04–2.18    | 0.235   |
| Spouse or other household member| 1    |              |         |
| Household head’s level of education: |      |              |         |
| Below secondary education       | 1.81 | 0.41–7.96    | 0.431   |
| Secondary education and above   | 1    |              |         |
| Household head’s income:        |      |              |         |
| < Ghc200                        | 0.98 | 0.29–3.29    | 0.975   |
| ≥ Ghc200                        | 1    |              |         |
| No. of income generators        |      |              |         |
| ≤2                              | 1.04 | 0.23–4.64    | 0.963   |
| >2                              | 1    |              |         |
| Perception of climate change:   |      |              |         |
| Climate change perceived        | 10.91| 2.72–43.76   | 0.001   |
| Climate change not perceived    | 1    |              |         |
Figure 8 shows the relationship between climate variables and the yield of crops commonly grown in the Bibiani-Anhwiaso Bekwai District. Though statistically insignificant, there was a positive correlation between precipitation and the yield of rice, yam, cocoyam and cassava. Between the years 1998 and 1999 for instance, an increase in rainfall (from 1357.1 mm to 1685.7 mm) increased the yield of rice by 0.4 MT/ha, maize by 0.2 MT/ha and cocoyam by 1.63 MT/ha. The yield of these crops decreased as rainfall decreased in subsequent years. Studies by Tiamiyu, Eze, Yusuf, Maji, and Bakare (2015) and Bhandari (2014) indicated that rainfall was positively related to yield of cereals such as rice and maize.

Climate change through its impacts on crop yield and livelihoods further exacerbates the already existing challenge of food and nutrition insecurity in vulnerable households by making them resort to negative coping strategies such as reducing food intake and sale of productive assets which increase their vulnerability to climate change, hinders resilience and further makes them more vulnerable to food and nutrition insecurity (ACF, 2012).

4. Conclusion and policy implication
The results of this study make it obvious that the impacts of climate change on food and nutrition security are felt not only in the Northern parts of Ghana but also in the rain forest where it might be least expected. Climate change is a worrying situation which negatively affects food security and the livelihoods of small-scale farming households. Food insecurity prevalence was high among study participants (Table 3) and households that had perceived climate change were eleven (11) times more likely to be food insecure than households that had not perceived climate change.

To build resilience and reduce vulnerability to the impacts of climate change within this district, there is the need to integrate adaptation to climate change into an overall development agenda. It is important to educate and encourage farmers to adopt climate-smart agricultural practices and other modern technologies to enhance food and nutrition security within the district. Government and its development partners should also endeavour to invest in irrigation facilities as well as other modern agricultural technologies that would improve food production and food insecurity situation among small-scale farming households while also increasing resilience to climate change.

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Competing interests
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References
ACF. (2012). Who cares about the impact of climate change on hunger and malnutrition? Retrieved from http://www.cmamforum.org/Pool/Resources/Who-cares-about-impact-on-climate-change-on-hunger-and-malnutrition-ACF-2014.pdf
Adeniyi, O. R., & Ojo, O. A. (2013). Food security status of rural farming households in Iwo, Ayedire and Ayeaade local government areas of Osun State, South-Western Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 13(5), 8209–8223.
Akudugu, M. A, Dittoh, S, & Mahama, E. S. (2012). The implications of climate change on food security and...
rural livelihoods: experiences from northern Ghana. *Journal Of Environment and Earth Science*, 2(3), 21–29.

Akudugu, M. A., Dittoo, S., & Mahama, E. S. (2012). The implications of climate change on food security and rural livelihoods: Experiences from Northern Ghana. *Journal of Environment and Earth Science*, 2(3), 21–29.

Asante, F. A., & Amuokwa-Mensah, F. (2015). Climate change and variability in Ghana: stocktaking. *Climate, 3*(1), 78-99.

Bhandari, G. (2014). Effect of rainfall on the yield of major cereals in Darchula district of Nepal. *International Journal of Environment, 3*(1), 205–213. doi:10.3126/ijje.v3i1.9954

Black, R. E., Allen, L. H., Bhattu, Z. A., Caulfield, L. E., de Onis, M., Essati, M., ... Rivera, J. (2008). Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet, 371*, 243–260. doi:10.1016/S0140-6736(07)61690-0

Coates, J, Swindale, A. S., & Bilinsky, P. (2013). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide (v. 3). Food and nutrition technical assistance project. *Academy for Educational Development, 1689–1699. doi:10.1017/ CBO9781107415324.004*

Edame, G. E., Ekpenyong, A. B., Fonta, W. M., & Ejc, D. (2011). Climate Change, Food Security and Agricultural Productivity in Africa: Issues and policy directions. *International Journal of Humanities and Social Science, 2*(12),205–223. Retrieved on 15/ 03/ 2016from http://www.ijhssnet.com/journals/Vol_1_No_21_Special_Issue_December_2011/21.pdf

FAO. (2006). *FAO/FIVIMS framework: Linkages between the overall development context, the food economy, households and individual measures of wellbeing* (pp. 14–50). Retrieved from ftp://ftp.fao.org/docrep/fao/001/010a799e/a0799e02.pdf

FAO. (2015). Climate change impacts on food security and nutrition. Retrieved from http://www.fao.org/fsnforum/sites/default/files/resources/Webinar_Consclusions.pdf

Fosu-Mensah, B. Y., Vlek, P. L., & MacCarthy, D. S. (2012). Farmers’ perception and adaptation to climate change: A case study of Sekyedumase district in Ghana. *Environment Development and Sustainability, 15*(4), 495–505. doi:10.1007/s10668-012-9339-7

Ghana Statistical Service. (2014). *Ghana demographic and health survey 2013*. Accra: Author.

Gruber, P. C., & Kepler, J. (2012). Sustainable food and nutrition security under changing climatic conditions. Retrieved on 26/ 10/ 2015 from http://www.welthungerhilfe.de/en/about-us/media-centre/article/med iathek/sustainable-food-and-nutrition-security-under-changing-climatic-conditions.html

IPCC. (2007). AR4 SYR synthesis report summary for policymakers – 2 Causes of change. Retrieved from http://www.ipcc.ch/publications_and_data/ar4/syr/en/syms2.html

Iwuchukwu, J. C., & Udoye, C. E. (2014). Climate change information needs of pineapple farmers in Enugu state. *Nigerian Agricultural Journal, 18*(1), 73–83.

Kabo-Bah, A., Djii, C., Nkoe, K., Mulugetta, Y., Obeng-Ofori, D., & Akpati, K. (2016). Multiyear rainfall and temperature trends in the Volta river basin and their potential impact on hydropower generation in Ghana. *Climate, 4*(4), 49. doi:10.3390/clim4040049

Kuwornu, K. J., Suleyman, D. M., & PK, A. D. (2013). Analysis of food security status of farming households in the forest belt of the Central Region of Ghana. *Russian Journal of Agricultural and Socio-Economic Sciences, 13*(1), pp. 26-42.

Matheson, D. M., Varady, J., Varady, A., & Killen, J. D. (2002). Household food security and nutritional status of Hispanic children in the fifth grade. *The American Journal of Clinical Nutrition, 76*(1), 210–217. doi:10.1093/ajcn/76.1.210

Mugambwo, E. K. (2014). Effects of climatic variability on pineapple growing in Uganda: A case study of pineapple growers in Kangulumira sub-county, Kayunga District. *LAP Lambert Academic Publishing. ISBN: 978-8484-8828-5 OmniScriptum GmbH & Co. KG.

Owusu, K., Waylen, P., & Qiu, Y. (2008). Changing rainfall inputs in the Volta basin: Implications for water sharing in Ghana. *Geojournal, 71*(4), 201–210. doi:10.1007/s10708-008-9156-6

Prokash, J. N., Loll, M. K., & Luni, P. (2011). Effect of climate variables on yield of major food crops in Nepal. *Journal of Contemporary India Studies: Space and Society, 1*, 19–26.

Quaye, W. (2016). Food security situation in northern Ghana, coping strategies and related constraints. *Journal of Agricultural Research, 3*(5), 334–342.

Rademacher-Schulz, C., Schraven, B., & Mahama, E. S. (2016). Time matters: Shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity. *Climate and Development, 6*(1), 46–52. doi:10.1080/17565529.2013.830955

Saaka, M., & Osman, S. M. (2013). Does household food insecurity affect the nutritional status of preschool children aged 6–36 months? *International Journal of Population Research, 2013.*

Tiamoju, S. A., Eze, J. N., Yusuf, T. M., Maji, A. T., & Bakare, S. O. (2015). Rainfall variability and its effect on yield of rice in Nigeria. *International Letters of Natural Sciences, 49*, 63–68. doi:10.18052/www.sciencepress.com/ILNS.49

Tirado, M. C., Crayah, P., Hunnes, D., Cohen, M., & Denton, F. L. A. (2010). Climate change and nutrition in Africa with a focus on sub-Saharan Africa. Retrieved from *www.sunayafrica.co.za*

Tirado, M.C., Crayah, P., Hunnes, D., Cohen, M., & Denton, F. L. A. (2010). Climate change and nutrition in Africa with a focus on sub-Saharan Africa. *Public Health, 1*(1), 1–24.

Thomps, G. (2014). African indigenous food security strategies and climate change adaptation in South Africa. *Journal of Human Ecology, 48*(1), 83–96. doi:10.1080/09709274.2014.1190677

Williams, P. A., Lari, R. T., Yeboah, I., & Frempong, G. K. (2018). Smallholder farmers experiences of climate variability and change on pineapple production in Ghana: Examining adaptation strategies for improved production. *Journal of Agricultural Extension and Rural Development, 10*(2), 35–43. doi:10.5897/JAERD2017.0919

World Food Program. (2012). *Ghana Comprehensive Food Security & Vulnerability Analysis 2010: Focus on Northern Ghana, Ministry of Food and Agriculture Ghana Statistical Service*. Retrieved from http://documents.wfp.org/stellent/groups/public/documents/ ena/wfp257009.pdf
Table A1. Scoring of perceived climate change based on responses to perceived climate change-related questions

| Questions                                                                 | Responses                                             | Score |
|--------------------------------------------------------------------------|-------------------------------------------------------|-------|
| 1. Have you observed any changes in the rainfall patterns over the past 5 years or more? | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
| 2. What changes have you observed in rainfall patterns over time?         | * [Increasing rainfall, Delayed rainfall]             | 1     |
|                                                                          | * [No change, Reducing rainfall, Too early rainfall Don't know] | 0     |
| 3. Do the changes affect the food crops you grow in anyway?               | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
| 4. Have you observed any changes in temperature over the past 5 years or more? | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
| 5. What changes have you observed in temperature over time?               | * [Increasing temperature]                            | 1     |
|                                                                          | * [Reducing temperature, No change, Don't know]       | 0     |
| 6. Do the changes affect the food crops you grow in any way?              | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
| 7. Are there some foods that you no longer eat because of the changes in weather conditions over time? | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
| 8. Are there some foods that you no longer eat in the quantities you used to eat because of the changes in weather conditions over time? | * Yes                                                 | 1     |
|                                                                          | * No                                                  | 0     |
