Climate variability, subsistence agriculture and household food security in rural Ghana

Peter Asare-Nuamah a, b, *
a University of Environment and Sustainable Development, Ghana
b Pan African University, Cameroon

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ABSTRACT
This study investigates smallholder farmers’ perceived impact of climate variability on subsistence agriculture. The study further explores household food security from access perspective and the factors that influence food accessibility in the rural Adansi North District of Ghana. The study randomly selected 378 smallholder farm households while 41 key informants were purposively selected. Questionnaire survey and semi-structured interview were employed to collect primary data. Descriptive and inferential analysis were computed for quantitative data while qualitative data was analyzed thematically. Results show that climate variability greatly affects subsistence agriculture, as a result of the reduction in agriculture yields, thereby leading to household food insecurity. It also emerged that the majority of households (58%) experienced food anxiety while 62% were unable to access their preferred quantity and quality food. Household food security is significantly influenced by gender, household size, years of farming experience, access to forest and adaptation. The implications of the study have been teased out alongside the recommendations.

1. Introduction

While there is no doubt that there have been remarkable changes in global climate, Africa and Asia experience extreme climate events (Blöndal et al., 2013). According to the Alliance for a Green Revolution in Africa (AGRA), Africa recorded the highest temperature in 2010 and 2013, with Violsdrif in South Africa and Navrongo in Ghana recording 47.3 °C and 43 °C, respectively (AGRA, 2014). Erratic rainfall has been reported in Africa, with marked variations across regions. For instance, studies have reported 20–40% reduction in rainfall in West Africa (Sissoko et al., 2011). The 2015/2016 El Nino Southern Oscillation (ENSO) contributed immensely to reduction in rainfall and the associated prolong drought in region (Hirons et al., 2018). In Ghana, the Ministry of Environment, Science, Technology and Innovation (MESTI) reports 1 °C rise in temperature, with remarkable reduction in rainfall between 1960 and 2000. Future projections reveal extreme rising temperature and rainfall trends in Africa, including Ghana (IPCC, 2014, 2018), with negative implications on food security (Connolly-Boutin and Smit, 2016).

Food security is defined as the availability of food to all people at all times and the physical and economic accessibility to sufficient, safe and nutritious food, to meet dietary and food presence for an active and healthy life (FAO, 2015). Food security, which comprises availability, accessibility, use and stability of food, is nondiscriminatory, without geographical boundary and ensures right to sufficient, safe, nutritious and preferred food (FAO, 2015). The Food and Agriculture Organization (FAO) warns that achieving food security requires equal and relevant attention to the components of food security. Nevertheless, food security initiatives, particularly in Africa, have focused extensively on increasing the production of food, which corroborates the assertion that food security is understood by many as the availability of food on the global market (FANTA, 2003). Similarly, food security studies have focused mainly on crop production (Thornton et al., 2009). However, Akudugu & Alhassan (2013) argue that the mere increase in food may not lead to food security, as vulnerable communities may not be able to access the food on the market, which drums home the critical need to enhance access to food, particularly at the grassroots. According to Scoones (2009), livelihood assets, entitlement and endowment increase access to food, particularly among the poor.

Although, changes in the global food system have resulted in changes in food security (Erickson, 2008), there is enough evidence that climate change affects food security (Connolly-Boutin and Smit, 2016). This corroborates the argument that food security cannot be achieved without...
addressing the menace of climate change (IPCC, 2018). For instance, studies in rural Africa and Asia denote that climate change leads to reduction in crop yields and marine foods (Dasgupta et al., 2017). Similarly, rising temperature and erratic rainfall also increase spread of pests and diseases, heat stress, and water and forage challenges in livestock as well as reduction in growth and reproduction (Thornton and Herrero, 2015). Studies across the globe have equally reported loss of livestock and reduction in milk and wool production, due to climate change (Dhar Chakrabarti, 2015). Again, climate change increases food prices (Hasegawa et al., 2016; Wossen et al., 2018), which affects the purchasing power and the ability of poor households to access sufficient, safe, nutritious and preferred food. Indeed, rural communities, especially in Africa and Asia, experience the brunt of changing climate.

Figure 1. Map of the Adansi North District projected from the Ashanti Region in Ghana. The triangles in the district map show the survey communities. Source: Author's modification from GSS (2014).
In Ghana, studies have examined the impact of climate change on food security, mainly from production perspective (Akudugu and Alhassan, 2013; Nkegbe et al., 2017; Wossen and Berger, 2015), with little to no attention on access to food, especially in rural households. This is problematic, as Stutley (2010) note that climate extremes, such as floods and droughts in Ghana, cause about 6.3% and 9.3% reduction in maize and rice production, respectively. It is troubling to note that about 5% (1.2 million) Ghanaians, majority of whom are smallholder farm households, face food insecurity, due to climate extremes, and 2 million more people are likely to experience food insecurity in Ghana (WFP, 2009). It is therefore imperative to understand rural food accessibility, due to the implication of climate variability on subsistence agriculture, which is the main food security and livelihood strategy of many rural households.

This study therefore investigates smallholder farmers’ perceived impact of climate variability on subsistence agriculture. The study further explores household food security from access perspective and the factors that influence food accessibility in the rural Adansi North District of Ghana. The study therefore makes significant contribution to literature, policy and practice pertaining to the eradication of hunger, and improving sustainable agriculture, nutrition and food security, as stated in goal 2 of the sustainable development goals (SDGs). Again, the study contributes immensely to SDG 13, which seeks to combat climate change and the associated impacts, especially in poor and vulnerable communities.

2. Materials and methods

2.1. The study area

The study was conducted in the rural Adansi North District in the Ashanti Region of Ghana (see Figure 1). Subsistence agriculture is the major source of employment for 77% of the labour force in the district (GSS, 2014). Consequently, climate variability and change pose serious risks and threats to farmers and households livelihood and food security in the district (Asare-Nuamah, 2020; Asare-Nuamah and Botchway, 2019a; Asare-Nuamah and Mandaaza, 2020). The district is located in the Semi-Equatorial climate and the semi-deciduous forest agro ecological zone of Ghana and hence experiences high temperature and rainfall, leading to intermittent drought and flash floods (Asare-Nuamah and Botchway, 2019b). Average rainfall and temperature is 1250–1750mm, and 27 °C, respectively (GSS, 2014). High poverty and dependency ratio, coupled with low income, growing population and poor access to essential resources (GSS, 2014), increase vulnerability in the district and expose smallholder farm households, in particular, to the adverse impact of climate change.

2.2. Study design, sample size and sampling techniques

The study adopted mixed methods design underpinned by pragmatism (Creswell, 2014; Creswell and Plano Clark, 2018). The adopted design allowed the collection of quantitative and qualitative data from the natural setting of participants. The choice of mixed methods design was based on the assumption that climate change and food security could not be solely studied either quantitatively or qualitatively and hence a blend of both approaches would enhance a deeper understanding of the subject matter and have over 20 years of farming experience, were selected for interviews. In the case of agriculture officers, the inclusion criteria were: five or more years of station in the district, direct contact with farmers, and knowledge of climate variability and food security in the district.

2.3. Instruments and data collection procedure

The study employed questionnaire survey and semi-structured interviews. The questionnaire survey allowed the collection of qualitative data on the perceived implications of climate variability on subsistence agriculture, and household food accessibility. Household food accessibility was assessed using household food insecurity access scale (HFIAS), developed by Coates et al. (2007). The study also used semi-structured interviews to collect in-depth information on climate variability and subsistence agriculture, in the words and natural setting of participants. Thus, the meanings smallholder farm households attached to climate variability and agriculture were paramount for a deeper understanding of the subject matter in the district. The instruments were validated through perusal by experts that enhanced both content and face validity, and pilot testing, which also aided in the revision of ambiguous questions (Creswell, 2014). This study forms part of a larger study that was approved by the institutional review committee of the Pan African University.

Primary data was collected from participants from April to September 2018. Prior to data collection, the Institutional Review Committee of the Pan African University ensured that data collection procedure and the instruments were not in violation of research ethics and hence approved the study. In the field, the study sought initial permission from gatekeepers and opinion leaders in the district and the participating communities. These included the District Director of the Ministry of Food and Agriculture, community Chiefs, Chief farmers and Committee chairpersons. Oral and written informed consent were also sought from participants. To avoid deception, detailed information on the objective of the study was also given. In addition, the study adhered to voluntary participation of participants. Furthermore, pseudonyms (for instance, HH for household head, DDO for District Development Officer and AEA for Agriculture Extension Officer) were used for anonymity and confidentiality purpose.

Face-to-face questionnaire administration and interviews were conducted in the homes of smallholder farm household heads while in the case of agriculture officers both telephone and face-to-face interviews were conducted at various locations such as farm, shop, home and workplace, based on their preference. Questionnaire administration and interviews lasted for an average of 20 min and 1 h, respectively. The interviews were conducted in the local language (Twi) and were tape recorded, with participants’ consent. Field notes were also taken to complement the interviews.

2.4. Data analysis

The study computed descriptive and inferential analysis for quantitative data while qualitative data was analyzed thematically. Quantitative primary data was entered and cleaned in Statistical Package for Social Sciences (SPSS) version 20 after which frequencies were computed to identify and fill missing data. Outliers, normality, homogeneity and multicollinearity assumptions were checked (Pallant, 2016). Reliability of the data was explored using Cronbach alpha computation and arrived at a coefficient of 0.82, which indicated internal consistency in the data (Pallant, 2016). Household food insecurity access scale score and food insecurity access-related conditions were computed, following Coates et al. (2007) computation procedure.

Basic descriptive statistics was computed for food security and the perceived impact of climate variability on agriculture. Standard and hierarchical multiple regression analyses were computed to understand the factors that influence smallholder farmers’ food security using HFIAS score as the dependent variable. The computed score ranged from 0 to 27, where high scores indicated high households food insecurity (see Coates et al., 2007). In the case of standard regression, the independent variables included gender, age, years of farming experience, education,
household size, farming system (mono or mixed farming), income, access to forest, farm landholding size, marital status, locality (rural or urban) and whether a farmer has adapted to climate change/variability or not. For hierarchical regression, the sources of household food (whether households derived their food from the farm, purchased from the market, received food support from friends and families and/or from government food programmes) were controlled to examine the influence of gender, age, years of farming experience, education, household size, farming system, income, access to forest, landholding size, marital status, locality and adaptation to climate change, on food security of respondents. These variables have theoretical backing from previous studies that used them to explore their influence on household food security (see Gebre, 2012; Mango et al., 2014; Mitiku et al., 2012).

Qualitative interviews were transcribed from Twi to English, and the transcripts were then shared with participants for validation. Thematic analysis was employed by following Braun and Clarke’s (2014) four stages of thematic analysis (coding, theme identification, theme organization and interpretation). The validated transcripts were perused consistently to identify emerging themes and draw patterns (Creswell, 2014). The expressions of household heads and district agriculture officers were grouped under identified themes and patterns, to have a deeper understanding of the meanings they attached to the subject matter. The classification of themes took cognizance of similarities, differences and frequency of expressions. The meanings attached to climate variability and subsistence agriculture from the perspective of participants are reported in verbatim quotes.

3. Findings and discussion

3.1. Perceived impact of climate variability on subsistence agriculture

Table 1 presents the farmers responses on the impact of climate variability on smallholder agriculture system. Indeed, 74.4% and 64.5% of the respondents, respectively reported of reduction in crop yields and loss of livestock, which are as a result of the change in climate observed in the district. Although the respondents were ambivalent with respect to climate change and water availability, particularly for agriculture activities, more than half of respondents (54%) indicated that climate variability has led to a decrease in water for agriculture purposes. As revealed by 71% of the respondents, there has equally been a decrease in soil fertility. About 45% of the respondents also indicated that climate variability has intensified soil aridity. In addition, pests’ invasion, spread of diseases, growth of weeds and soil erosion, have intensified in the district, due to the prevailing changes in climate.

The qualitative data provided an in-depth information and understanding of the impact of climate variability on smallholder agriculture. The findings revealed that climate variability affects agriculture activities, as the following themes emerged: flood, drought, soil infertility, soil erosion and soil aridity. Other themes included changes in farming season, growth of weeds, pest invasion, water availability, reduction in crop yields, loss of livestock, reduction in quality of meat and an increase in agriculture expenditure.

3.1.1. High temperature and agriculture

Both smallholder farm household heads and the district agriculture officers revealed that high temperature has great negative impact on food and cash crop production in the district. A household head echoed that “water bodies dry up so quickly, due to high temperature and soil aridity also increases, thereby making farming very difficult, particularly for farmers who use their physical energy to till, prepare and manage their farms” (HH26).

Another household head expressed that “high temperature makes farming activities difficult, as the land becomes dry and difficult to cultivate. Excessive temperature wither the leaves of crops which reduces productivity and yields of crops” (HH4). A District Agriculture Officer noted that “the increase in temperature has also increased dry spells in the district, thereby leading to an increase in soil aridity over the years” (DDO2). The participants concurred that crops such as maize, cocoa, and vegetables particularly pepper, tomato among others, wither due to the increase in temperature in the district. The continuous exposure of crops to excessive temperature makes them unproductive. The increase in the intensity and duration of temperature also affects the working hours of farmers. For instance, in a household, it was revealed that “due to high temperature, farmers have to go to their farms at dawn or early in the morning to enable them work for a longer time before 10 am when the sun sets with high intensity” (HH9).

An Extension Agent recounted an ordeal of high temperature on cocoa production in the district. According to the AEA1 “most of the cocoa farmers expected high yields from their cocoa farms in 2016 and 2017, particularly for the main cocoa season. This was because most of the cocoa plants flowered well and developed many buds. However, the continuous dry spells, due to the lack of rainfall coupled with intense high temperature in the district, destroyed a lot of cocoa beans and most of them turned black. This resulted in a drastic reduction in cocoa production”. The increase in evaporation due to the changes in climate also affects agriculture activities in the district. An Extension Agent asserted that “the rise in temperature increases the rate of evaporation and this results in reduced soil moisture, thereby leading to crop failure” (AEA11). The participants also raised concerns that the increase in temperature prolongs the dry season and intensifies the harmattan.

3.1.2. Erratic rainfall pattern

3.1.2.1. High intensity rainfall. The participants also stated that aside flood from excessive rainfall, the intensity of rainfall also damages crops. According to HH6 “we mostly have heavy rainfall particularly in June and we are not yet in June but we have received heavy rainfall. If this intense rainfall continues up to June, most crops will be destroyed, due to high humidity, which will affect crop yields”. Excessive rainfall in the district also affects soil fertility, which in turn affects crop productivity.

| Indicators                  | Decreasing A Lot (%) | Decreasing (%) | Neutral (%) | Increasing (%) | Increasing A Lot (%) |
|-----------------------------|----------------------|----------------|-------------|----------------|---------------------|
| Water availability          | 25.1                 | 28.6           | 2.4         | 39.7           | 4.2                 |
| Soil fertility              | 31.0                 | 39.7           | 2.6         | 25.1           | 1.6                 |
| Soil aridity                | 14.3                 | 24.9           | 16.4        | 35.2           | 9.3                 |
| Pests invasion              | 6.6                  | 18.8           | 13.2        | 46.8           | 14.6                |
| Spread of diseases          | 6.3                  | 18.0           | 13.2        | 48.7           | 13.8                |
| Growth of weeds             | 7.1                  | 18.8           | 13.2        | 47.1           | 13.8                |
| Soil erosion                | 9.0                  | 22.5           | 4.0         | 52.9           | 11.6                |
| Reduction in crop yields    | 6.3                  | 8.2            | 11.1        | 62.1           | 12.3                |
| Loss of livestock           | 12.6                 | 7.3            | 15.6        | 46.8           | 17.7                |
According to a Development Officer “high intensity rainfall has also resulted in an increase in erosion and run-off in the district and you can see splash and gully erosion in most of the communities. This washes away the top soil, which makes the soil infertile for crop production” (DDO4).

3.1.2.2. Late onset and early cessation of rainfall. The participants agreed that late onset and early cessation of rainfall also affects agriculture activities and productivity. According to a household head, “In 2016, I planted maize and soon after germination, the rains stopped and all the maize were destroyed. I wasted my time, energy and resources with corresponding poor yields from the farm” (HH25). Late onset and early retreat have significant impact on seasonal crops particularly maize and vegetables, such as tomatoes, pepper and garden eggs. In addition, the participants revealed that erratic rainfall intensifies its impacts on crops with the spread of pests and diseases, thereby leading to low productivity. Grasshoppers, weevils, stem borers and fall armyworm were some of the common crops pests reported by the participants. Crop diseases such as black pod and capsid have intensified in the district, as indicated by cocoa farmers. The participants have also experienced loss of crops and income due to changes in rainfall and temperature in the district. For instance, HH1 intimated that “so many acres of maize farms were destroyed in 2017, due to poor rainfall, rising temperature and fall armyworm invasion”. This was corroborated by the agriculture officers who reported that farmers are not getting good yields from crops and livestock, which reduces their income.

3.1.2.3. Growth of weeds. The participants further raised concerns on the increase in the growth of weeds, which affects agriculture in the district. An Extension Officer revealed that “farmers nowadays complain of growth of weeds, which has intensified the application of weedicides in the district” (AEA1). A household head also asserted that “growth of weeds has intensified. Therefore, if you want to get good harvest from maize and other crops, you need to regularly clear the farm or apply weedicides” (HH22). According to a participant “at first, we cleared our cocoa farms twice in a year but these days, we need to clear more than twice if we want to have healthy cocoa plants and increase yields” (HH2). The growth of weeds has increased agriculture expenditure among the participants. HH13 expressed that “…farmers use labourers or weedicides to control weeds, which makes farming expensive.”

3.1.3. Floods and agriculture

Some participants expressed that climate change causes flood through excessive rainfall in the district. According to a household head, “too much rains lead to floods and prevent people from doing their farming activities” (HH8). Another household head intimated that: “

People may think flood is not common in the district because our communities do not get flooded. However, floods are rampant in our farms. When you watch television, you mostly see reported floods in cities. We equally experience flood here. There are times especially during the raining season that our farms get flooded for weeks. Farmers cannot work on their farms, which affects livelihood and food security since the farms are the main sources of income. At times too, the flood does not occur in our farms but rivers or streams en route to the farms get flooded. During the raining season, most of the streams get flooded and overflow their banks. Flood sometimes washes away the wooden bridges on water bodies, making it very difficult to cross to our farms. It sometimes takes weeks for the water to recede before we can cross such flooded water bodies, particularly the bigger ones, to go and work on our farms (HH19).

3.1.4. Climate variability and livestock

Some participants expressed concerns on the impact of climate variability on livestock farming. The spread of pests and diseases and shortage in folder and water were the major concerns. Excessive rainfall has serious implication on health and quality of meat of livestock, due to rampant diseases. According to DDO3 “Newcastle disease is the most common disease among birds during the raining season and almost a whole village can lose their birds, particularly fowls and turkey, even though ducks and guinea fowls are resistant”. Ruminants such as goats, sheep and cows are heavily affected by heavy rainfall. DDO3 further hinted that “foot rot is rampant in ruminants during the raining season”. The participants agreed that pests such as worms (tapeworm, roundworms, liver flukes), houseflies and ticks, particularly the Amblyomma species, affect livestock in the district. Although pig farmers face less challenges during the raining season, DDO3 intimated that “earthworms become interleave host for some types of worms, which is common in pigs”. These conditions affect the stock of livestock of farmers with particular impact on the production and the quality of meat of livestock.

Conversely, a participant indicated that high temperature seems to be favourable to livestock rearing. According to DDO3, “…during the dry season, the spread of diseases and pests reduces, which favours healthy livestock.” However, livestock need water and that becomes a big problem during the dry season, as there is less availability of water for livestock. Moreover, since there is scarcity of feed or grass during the dry season, the animals are not able to put on weight compared to the raining season when there is enough grass to feed the animals.”

3.2. Household food security

The study employed household food insecurity access scale score as a proxy of food security and examined the conditions and categories of food insecurity among the respondents. It is indicative from Table 2 that the majority of the respondents were affirmative with most of the indicators of household food insecurity access scale related-conditions. More than half (58%) of the respondents have been anxious of food insecurity over the past 12 months, with 23.5% and 61.9% experiencing food anxiety sometimes, and often, respectively. This corroborated respondents’ inability to eat preferred food (62%), availability of limited variety of food (62%) and inability to even eat less preferred food (60%). The majority of respondents (60%) have over the past 12 months reduced the number and size of meals per day. About 45% of the respondents indicated that over the past 12 months they experienced periods with no food at all at home. This condition was prevalent among 34.7% and 40.4% of the respondents who sometimes and often, respectively, had no food at all at home. However, 23% of the respondents went to bed with empty stomach while 16% of the respondents indicated that there were periods their households had to go whole day and night without food.

3.2.1. Determinants of household food security

The study computed a standard regression to examine the factors the influence household food security (see Table 3). The choice of variables used in the model had considerable theoretical backing from previous studies, which emphasized that assets, endowment and entitlement affect access to food (Scoones, 2009; Turner et al., 2009). The independent variables in the model accounted for 21.1% variations in food security, which was also significant F (12, 365) = 2.61, p = 0.002. Food security was significantly predicted by access to forest (beta = 0.147, p = 0.004), years of farming experience (beta = 0.114, p = 0.037), household size
Table 2. Distribution of household food insecurity access-related conditions.

| Indicator                                      | Related conditions | Frequency of occurrence |
|------------------------------------------------|--------------------|-------------------------|
|                                                | Yes (%)            | No (%)                  | Rarely (%) | Sometimes (%) | Often (%) |
| Anxiety of food insecurity                     | 58.2               | 41.8                    | 14.6       | 23.5          | 61.9      |
| Inability to eat preferred food                | 61.6               | 38.4                    | 13.0       | 53.4          | 33.6      |
| Availability of limited food variety due to lack of resources | 62.4               | 37.6                    | 12.2       | 34.9          | 52.9      |
| Inability to even eat less preferred food      | 60.3               | 39.7                    | 18.0       | 52.1          | 29.9      |
| Availability of smaller amount of food         | 59.5               | 40.5                    | 12.2       | 57.4          | 29.4      |
| Reduced the number of meals per day            | 59.5               | 40.5                    | 11.9       | 33.3          | 54.8      |
| No food at all at home                         | 44.5               | 55.6                    | 24.9       | 34.7          | 40.4      |
| Going to bed with empty stomach                | 22.8               | 77.2                    | 60.1       | 21.3          | 18.6      |
| Whole day and night without food               | 16.1               | 83.9                    | 53.9       | 31.7          | 14.4      |

Table 3. Determinants of food security.

| Variable                                | Unstandardise coefficients (B) | Standard Error | Beta (β) | t-test value | Significance (p) value |
|-----------------------------------------|--------------------------------|----------------|----------|--------------|-----------------------|
| Gender                                  | -0.899                         | 0.880          | -0.059   | -1.022       | 0.039*                |
| Age                                     | -0.032                         | 0.031          | -0.055   | -1.016       | 0.311                 |
| Education                               | -0.611                         | 0.890          | -0.036   | -0.687       | 0.492                 |
| Years of farming experience             | 3.182                          | 1.517          | 0.114    | 2.097        | 0.037*                |
| Farming system                          | -2.758                         | 1.994          | -0.071   | -1.384       | 0.167                 |
| Marital status                          | 0.191                          | 0.949          | 0.012    | 0.201        | 0.841                 |
| Household size                          | -0.158                         | 0.085          | -0.096   | -1.863       | 0.043*                |
| Locality                                | 0.744                          | 0.984          | 0.039    | 0.756        | 0.450                 |
| Adaptation to climate change            | 1.504                          | 0.777          | 0.101    | 1.937        | 0.051*                |
| Income                                  | 0.823                          | 0.918          | 0.046    | 0.896        | 0.371                 |
| Access to forest                        | 2.155                          | 0.752          | 0.147    | 2.864        | 0.004*                |
| Landholding size                        | -2.715                         | 2.037          | -0.070   | -1.333       | 0.183                 |

*p is significant at 0.05.

Table 4. Predictors of food security.

| Model Variables                          | Unstandardize coefficients (B) | Standard Error | Beta (β) | t-test value | Significance (p) value |
|-----------------------------------------|--------------------------------|----------------|----------|--------------|-----------------------|
| 1                                       |                                |                |          |              |                       |
| Farm                                    | -3.602                         | 3.304          | -0.056   | -1.090       | 0.276                 |
| Purchased                               | 0.303                          | 1.016          | 0.015    | 0.300        | 0.765                 |
| Family and Friends                      | -3.333                         | 1.689          | -0.102   | -1.974       | 0.049*                |
| Government food programme               | 1.802                          | 3.339          | 0.013    | 0.245        | 0.806                 |
| 2                                       |                                |                |          |              |                       |
| Farm                                    | 2.666                          | 3.289          | -0.042   | -0.811       | 0.418                 |
| Purchased                               | -0.210                         | 1.012          | -0.011   | -0.208       | 0.836                 |
| Family and Friends                      | -3.850                         | 1.694          | -0.118   | -2.273       | 0.024*                |
| Government food programme               | -1.999                         | 3.246          | -0.013   | -0.264       | 0.792                 |
| Gender                                  | -0.956                         | 0.882          | -0.063   | -1.083       | 0.279                 |
| Age                                     | -0.036                         | 0.031          | -0.063   | -1.156       | 0.248                 |
| Education                               | -0.652                         | 0.896          | -0.039   | -0.728       | 0.467                 |
| Years of farming experience             | 3.508                          | 1.521          | 0.125    | 2.307        | 0.022*                |
| Farming system                          | -2.363                         | 2.012          | -0.061   | -1.175       | 0.241                 |
| Marital status                          | 0.208                          | 0.952          | 0.013    | 0.219        | 0.827                 |
| Household size                          | -0.172                         | 0.085          | -0.105   | -2.033       | 0.043*                |
| Locality                                | 0.947                          | 0.993          | 0.049    | 0.953        | 0.341                 |
| Adaptation to climate change            | 1.682                          | 0.784          | 0.113    | 2.143        | 0.033*                |
| Income                                  | 0.764                          | 0.917          | 0.043    | 0.833        | 0.401                 |
| Access to forest                        | 1.988                          | 0.762          | 0.153    | 2.610        | 0.009*                |
| Landholding size                        | -2.855                         | 2.033          | -0.074   | -1.407       | 0.161                 |

*p is significant at 0.05.
The study further computed a hierarchical regression to examine the factors that influence food security after controlling the sources of household food (farm, family and friends, purchase and government food programmes) as shown in Table 4. In model 1, sources of food accounted for 4.7% of the variations in food security, $F(3, 373) = 1.355, p = 0.005$. Only food from family and friends significantly predicted food security ($\beta = -0.102, p = 0.049$). In model 2, the combined effect of the variables explained 27.9% variations in food security, $F(16, 361) = 2.358, p = 0.002$. Food from family and friends again proved significant in determining food security ($\beta = -0.118, p = 0.024$). Other significant predictors of food security included years of farming experience ($\beta = 0.125, p = 0.022$), household size ($\beta = -0.105, p = 0.043$), adaptation to climate change ($\beta = -0.113, p = 0.033$) and access to forest ($\beta = 0.153, p = 0.009$). After controlling for sources of food, the variables in the model made addition contribution of 23.2% to the variations in food security.

4. Discussion

Climate variability and change constrains food security in developing countries, particularly in rural agrarian households (Searchinger et al., 2018). More importantly, achieving sustainable development and Agenda 2063 of the African Union, remains a hurdle, as climate change affects economic development globally and nationally (IPCC, 2014, 2018). Nevertheless, efforts to reduce the adverse impact of climate change on agriculture and food security, in particular, have focused on increasing food production. However, such a strategy may not be sustainable in itself, as the poor may not be able to access the food on the market, due to low purchasing power stemmed from low income and high poverty (Akudugu and Ahlassan, 2013).

The results from the study call into action the need to improve food accessibility while enhancing food production. Rural farming communities and smallholder farmers contribute significantly to food production in Ghana and other developing regions (FAO, 2012; MOFA, 2016). In Ghana, about 80% of food produced come from smallholder farmers (MOFA, 2016). Nevertheless, the results showed that majority of smallholder farmers have food security challenges. For instance, the majority of the respondents have food anxiety, which is typical of food insecure society. Coates et al. (2007) noted that food anxiety is prevalent in food insecure communities. Similarly, the majority of the respondents have limited ability to eat preferred and less preferred food, as well as limited access to diverse groups of food, due to the availability of small amount of food in households. The frequent occurrence of these conditions demonstrates food insecurity among the respondents.

Nevertheless, the majority of the respondents face less challenges with respect to no food at all at home, going to be with empty stomach and whole day and night without food. This may be partly due to the adoption of crop diversification in rural communities (Antwi-Agyei et al., 2014a). Through crop diversification, smallholder farmers plant different crops with different soil nutrient requirement and maturity periods, thereby enabling farmers to harvest multiple crops throughout the year. Hence, there is the possibility that such a strategy makes food available to smallholder farm households.

However, the prevailing climate variability expose smallholder households to food insecurity, due to the ripping effect of climate change on subsistence agriculture. Existing studies have reported that rising temperature, erratic rainfall, pests and diseases, decrease food production, thereby worsening food security, especially among the poor (IPCC, 2018). The study equally noted that climate variability affects food production and hence food security through droughts, floods, soil aridity, soil infertility, pests and soil erosion. As these conditions intensify, agriculture activities of smallholder famers are hampered, resulting in poor yields from agriculture. These finding are consistent with existing studies. For instance, Stutley (2010) and MOFA (2016) have reported decrease in maize and rice production, due to floods and droughts in Ghana. Dhar Chakrabarti (2015) and IPCC (2014) have also reported grave negative impact of soil aridity, soil infertility and pests on agriculture production.

Although climate change affects food security through reduction in food production, Turner et al. (2003) assert that food accessibility, which is an important component of food security, is influenced by assets, endowment and entitlement. The results showed that household access to food is significantly predicted by gender, years of farming experience, household size, adaptation and access to forest. Horrell and Krishnan (2007) noted that gender plays an important role in household food security. Male household heads have been reported to be influential in enhancing household food security, due to their access to essential resources. Although the Adansi North District is a matrilineal society, it is in practice patriarchal, as men have more access to important resources than women, and therefore make important decisions that affect households (GSS, 2014). Hence, male-headed households are more likely to be food secured than female-headed households. Nevertheless, according to the FAO (2012), about 43–50 percent of agriculture labour force in Africa are women, which portrays their critical role in food security. Similarly, the FAO (2012) stipulates that women have the potential to eradicate hunger among 100–150 million people, by increasing crops yields by 20–30%, should they have equal access to essential productive resources available to men.

Mango et al. (2014) argued that household size reveals the consumption level and the burden of the household to feed its members. For Gebre (2012) and Mitiku et al. (2012), there is the possibility that large households experience food insecurity, due to the larger size and the higher burden associated with feeding members of the household. Intuitively, households in the Adansi North District experience food insecurity due to larger household size prevailing in the district. The district has a household size of 4.4, which is higher than the regional average household size of 4.1 persons per household (GSS, 2010, 2014).

Adaptation enables households to reduce the negative impact of climate variability and change, and exploit opportunities (IPCC, 2018). On and off-farm and livelihood diversification strategies allow households to respond to climate change and increase yields, income and assets, essential for food security (Antwi-Agyei et al., 2014b; Roy et al., 2018). The results from the study revealed that adaptation significantly influences food security. The practical significance of this finding is that households that have adapted to climate change are more likely to be food secure than their counterparts. Nevertheless, some adaptation strategies are counterproductive (Antwi-Agyei et al., 2014a; Antwi-Agyei et al., 2018) whereas others are unsustainable and ineffective (Dankelman, 2010). Hence, ensuring effective and sustainable adaptation strategies is critical to achieving food security under climate change, particularly in poor communities, such as the Adansi North District.

Forest is an essential natural asset that enhances livelihood and food security of rural communities. Previous studies noted that forest serves as a source of income and food supplement for rural agrarian communities (Ofoegbu et al., 2017). The findings from the study showed that access to forest enhances food security of smallholder farm households. Rural communities derive processed and unprocessed forest products, such as charcoal and firewood as well as edible products, such as mushroom and game from the forest. This directly increases access to food and indirectly enhances food security through an increase in income from sales of forest products. Forest-based adaptation strategies have been reported to enable smallholder farmers to respond to climate change (Ofoegbu et al., 2015). Notwithstanding, according to Antwi-Agyei et al. (2018), unsustainable and poor forest practices of smallholder farmers increase greenhouse gases emission.

Years of farming experience also emerged as an important factor that influences food security. The more years of farming experience of household heads, the more likely they will adapt to climate change, due to their improved ecological knowledge derived from personal
experience and observation. Household heads with more years of farming experience have an in-depth knowledge of the changes in climate and are very likely to adopt ecological knowledge and practices to respond to climate change. Farming experience correlates with age, and hence Mitiku et al. (2012) noted that household heads with an in-depth farming experience are risk averse and are therefore in a better position to adapt to climate change by diversifying their production. Nevertheless, Gebre (2012) argued that as household heads increase in age, their productivity reduces, which affects their food security. In addition, sources of household food, particularly food from family and friends, also proved significant in determining food security of smallholder farm households. Families and friends have been reported to be essential social asset that enhance livelihood and food security in rural communities (Scoones, 2007, 2009).

5. Conclusion

This study adopted mixed methods design to investigate smallholder farmers’ perceived impact of climate variability on subsistence agriculture. The study further explored household food security from access perspective and the factors that influence food accessibility in the rural Adansi North District of Ghana. The study concludes that while rural agrarian communities contribute to food production, smallholder farm households experience food insecurity due to challenges in accessing preferred quantity and quality food. This may be partly due to the devastating effect of climate variability and change on smallholder agriculture, such as reduction crop yields and livestock, coupled with low income. Another factor may be poor access to essential resources that enhance smallholder farmers’ access to food. Household food security is significantly influenced by gender, farming experience, household size, access to forest and adaptation.

The study recommends the urgent need for policy makers and development practitioners to recognize access to food in poor households as an important development priority. As such, essential socioeconomic resources should be made available to the grassroots. This will increase the adaptive capacity of poor households and improve the purchasing power of rural communities, which are necessary to enhance access to preferred quantity and quality food. The capacity of rural communities should also be strengthened through climate change education, and state sponsored climate smart and technology-oriented adaptation strategies. Similarly, interventions and programmes that address gender gaps and gender differences in assets, endowments and entitlements, are highly recommended, especially in rural communities.

Declarations

Author contribution statement

Peter Asare-Nuamah: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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