Using a mixed-method approach to explore the spatiality of adaptation practices of tomato farmers to climate variability in the Offinso North District, Ghana

Lawrence Guodaar, Alphonsus Beni and Patrick Benebere

Abstract: There is a general scientific consensus that anthropogenic forces are the major cause of global climatic changes. The study explored the spatiality of adaptation strategies of farmers to climate variability in the Offinso North District of Ghana using the mixed method approach. Structured questionnaire and focus group discussion guide were the data collection instruments for a cross-section of 378 tomato farmers in selected study communities in the District. Farmers demonstrated their awareness of climatic changes through some characteristics such as temperature rise, unpredictable and reduction in rainfall, incidence of floods, intensity in solar radiation and prolong drought conditions. The study also showed that tomato farmers in the study communities employed both on-farm and off-farm adaptive strategies in response to the effects of climate variability on tomato production. Spatially, mixed cropping, crop diversification, application of agrochemicals, changes in farm location, changes in crop variety, irrigation, migration and diversification to non-farm activities were the adaptation practices of the farmers. Spatially, the on-farm adaptation strategies were uniformly practiced across the study communities unlike the off-farm adaptation practices that slightly varied across space. The regression

ABOUT THE AUTHOR
My areas of interest are climatology and biogeography with specific emphasis on human-environment interactions. I am particularly interested in employing a mixed methodological approach of research (quantitative and qualitative) in understanding the linkages between climate change and food security in a sustained manner in Ghana and Sub-Saharan Africa. Coming from a geography background, I try to unpack the spatiality of environmental phenomena and how they influence human actions in Ghana, especially rural communities. I am also interested in employing quantitative models with sound theoretical base that seeks to inform policy on how relevant actors of development respond to environmental stimuli.

PUBLIC INTEREST STATEMENT
Tomato is one of the vegetables which support the body with vitamins A, B and C. Tomato is produced in most parts of Ghana, especially the Offinso North District. However, due to the changes in temperature and rainfall pattern, there has been a significant reduction of tomato production in the district and Ghana at large culminating in the importation of tomato from neighbouring countries such as Burkina Faso. Our research explored the spatial variations of adaptation strategies that are employed by smallholder tomato farmers in the Offinso North District, Ghana. Focus group discussion and questionnaires were used as instruments for the data collection. A mixed method approach was used to provide the depth and breadth of the issues under investigation. Building the capacity of farmers in response to the changing climate is an important tool in improving food security in Ghana and other parts of Sub-Saharan Africa.
results showed that location has significant influence on some adaptation practices, especially changes in farm location \( (p < .005) \), changes in crop variety \( (p < .005) \), application of agrochemicals \( (p < .005) \) and irrigation practices \( (p \leq .005) \). An enabling environment should be created by the government to enable the youth get access to finance and other subsidized farming logistics (e.g. modern irrigation logistics) to boost their morale in the tomato business.

Subjects: Area Studies; Development Studies; Geography

Keywords: spatial; climate variability; tomato; Offinso North District; Ghana

1. Introduction

It is scientifically established that the global climate is changing as a result of the combined anthropogenic forces due to Greenhouse Gases (GHG) emissions (Intergovernmental Panel on Climate Change, [IPCC], 2014), especially carbon dioxide gas (United Nations Framework Convention on Climate Change [UNFCC], 2007). The annual amount of carbon dioxide emitted into the atmosphere through human activities is estimated between 13 and 15 billion tonnes (Tubiello, 2012). The human activities such as deforestation, burning of fossil fuels and bad farming practices absorb the ultraviolet radiation from the sun but prevent it from escaping through the atmosphere. The resultant effect is the warming of the atmosphere which affects the dynamics of climatic variables such as temperature and precipitation.

The dramatic changes in the climate adversely affect crops and forage plants with the cumulative effects on crop yield (Walthall et al., 2012). The IPCC’s projections and regional level studies suggest that a changing climate is likely to impact agricultural production, adversely affect human health through climate induced heat stresses and diseases as well as altering the hydrological cycle in countries such as East and Southeast Asia (Intergovernmental Panel on Climate Change, 2012). The implication is that, if the climate keeps changing without the development of cutting-edge technologies to respond to the situation, it may cause food insecurity and poverty especially, among food crop farmers in eastern and south-eastern parts of Asia.

According to Lee, Nadolnyak, and Hartarska (2012), the elasticity of annual climate variables indicates that warmer temperatures significantly decrease agricultural production including crops in Asia. It is estimated that when annual mean temperature increases by 1%, average agricultural production decreases by .346%. Also, the study of Waithaka, Nelson, Thomas, and Kyotalimye (2013) using crop modeling assessments of the potential effects of climate change have shown yield losses of maize in most parts of the Democratic Republic of Congo, Ethiopia, Tanzania, and northern Uganda. However, the study also shows an increase of sorghum yields in the western DRC, the highlands of Ethiopia, Kenya, Sudan, and Tanzania. Moreover, the study of Ayanlade, Odekunle, and Orimoogunje (2010) on the impact of climate variability on tuber crops in the Guinea Savanna part of Nigeria supports the extent to which climate variability affects crop production. According to their study, rainfall variability caused a reduction in yam yield during the periods of 1990/1991 in Nigeria.

Along similar lines, Lobell (2010) argue that, for each degree that a crop spends above 30°C, there is a reduction of yield by 1%. They further revealed that, the availability of water has an important effect on the sensitivity of crops with yields decreasing by 1.7% for each degree day spent over 30°C under drought conditions. Extreme climate conditions, such as dry spells, sustained drought, and heat waves have been projected to have large effects on crops and livestock production (Walthall et al., 2012). Again, it has also been revealed that high temperatures impact on vegetable crops like lettuce, carrot and cucumber to the extent that the high temperatures suppress bisexual flowers, decrease the number of flowers and inhibit flower differentiation and development, which result in low yield (Masahumi, Masayuki, Toru, & Yutaka, 2011).
Sub-Saharan Africa (SSA) has been professed as one of the regions that is vulnerable to the effect of global climate change as a result of its reliance on agriculture which is highly sensitive to weather and climate variables such as temperature, precipitation, light and extreme events and the low capacity for adaptation (Kotir, 2011). Even though there is a moderate increase in the length of crop growing period in some patches of the region (i.e. Eastern Africa), agricultural productivity could decline dramatically due to climate change in the decades ahead as temperatures increase and rainfall patterns change (Oxfam, 2011). For instance, the findings from a study conducted by Awotaye and Matthew (2010) on the impact of the changing climate on crop yield from 1991 to 2006 in South-Western Nigeria revealed that, temperature and rainfall have significant impact on crop yield. From their study, crop yield increased when there was enough rainfall and decreased when mean temperature increased. High temperatures increase evaporation and reduce the moisture content in the soil thereby affecting plant growth.

The situation is not different in Ghana as research continues to establish the impact of climate change on crops. The findings of researchers at the International Food Policy Research Institute (IFPRI) on the impact of climate change on yields of crops reveals an overall decrease in yields of all the crops (e.g. maize, groundnut, yam etc.) in the deciduous forest (Pinto, Demirag, Haruna, Koo, & Asamoah, 2012).

As a result of the impact of changing climate on agricultural production, the debate has now shifted from high level advocacy on “the need to act” to country and regional level responses on “how to adapt” (Bogamba, Bashoasha, Claessens, & Antle, 2012). It is in the light of this that farmers in various countries continue to develop strategies to cope with the stress and damage the changing climate can impose on the countries agricultural sector (Pinto et al., 2012). The application of coping strategies varies from location to location and farmer to farmer depending on the type of crop, the type of soil and the resources available to the farmer. Beside farmers’ efforts to adapt to the changing climate, governments through its institutions are also seeking ways of fashioning out policies to mitigate the impact to prevent food insecurity. The development and implementation of adaptation strategies will go a long way to help offset the unpredictable nature of the climate in order to sustain food production.

Tomato (Lycopersicon esculentum) is one of the major consumed vegetables that supply the body with vitamins A, B and C, iron and phosphorus on a daily basis by many households in the Offinso North district. Interestingly, most traditional staple foods consumed in the country lack some of these vital minerals. Again, epidemiological studies reinforce the fact that the consumption of tomatoes can go a long way to reduce the occurrence of human prostate cancer (Kotake-Nara et al., 2001). Moreover, tomato production is also an important source of income to most smallholder farmers in the Offinso North District which provides them the opportunity to take up some social responsibilities in the family. In view of the relevance of tomato to the socio-economic development of the country, Ghana, there is the urgent need for research to be conducted to see how best we can help sustain food production through the production of more tomatoes in the sub-region to meet the urgent need of the society.

The variability of the climate in recent times has led to a reduction in tomato yield with less than 10 tons per hectare in Ghana (Robinson & Kolavalli, 2010). Unfortunately, the Offinso North District happens to be one of the localities in the country that is vulnerable to climate variability and has suffered reduction in tomato yield over the years as a result of the changing climate. Since the reduction in tomato production is a threat to food security with the potential to contribute to the risk of famine, there is the need for a comprehensive research to explore the extent of the effect of the climate variability on tomato production. The effect of the low yield in tomato production partly attributed to the varying climate in the study area and the country at large may have necessitated the recent importation of fresh tomatoes from neighbouring countries especially Burkina Faso to supplement what is locally produced (Horna, Smale, & Faick-Zepeda, 2006).
Even though there seem to be much research regarding the impact of climate variability on agriculture in general (Awotoye & Matthew, 2010; Codjoe & Owusu, 2011; Malla, 2008), very little information is available in the area of climate variability adaptation and specific vegetable production, especially tomato in Ghana and the study area in particular, which is noted for its large scale production of tomatoes. The issues discussed thus far raise the question of whether adaptation practices of farmers at different spatial locations matter. Climate variability adaptation in rural farming is location specific and local-level analyses is therefore required to gain a better understanding of the fundamental processes underlying adaptation and for better targeting of adaptation policies by national and local governments (Tiwari, Rayamajhi, Pokharel, & Balla 2014). The study therefore explored the extent to which spatial variation influences the adaptation practices of tomato farmers in key selected locations in the Offinso North District of Ghana.

2. Materials and methods

2.1. Site characterisation
The study was conducted in the Offinso North District (OND) of the Ashanti Region of Ghana, which covers an area of 741 km² and lies between longitudes 10°60′ W and 10°45′ E and latitudes 7°20′ N and 6°50′ S (see Figure 1). The Offinso North District lies in the semi-equatorial climatic zone and experiences a double maxima rainfall regime.

The first rainfall season begins from April to June, the second period starts from September to October. The mean annual rainfall is between 1,250 and 1,800 mm. Relative humidity is generally high ranging between 75–80% in the rainy season and 70–72% in the dry season. A maximum temperature of 30°C is experienced between March and April. The mean monthly temperature is about 27°C.

The OND lies in the moist semi-deciduous forest zone which is bounded with thick vegetation cover. Nevertheless, there is the colossal emergence of guinea savannah and this is most prevalent in areas such as Afrancho, Akomadan, Nkenkaasu and Nsenoa. The four major forest reserves in the district are: the Afram Headwaters Forest Reserve (189.90 km²); the Afrensu-Brohoma Forest Reserve (89.06 km²); the Mankrang Forest Reserve (92.49 km²) and the Opro River Forest Reserve (103.60 km²).

Figure 1. Map of the study area.
Each forest reserve is composed of trees such as Odum, Mahogany, Ceiba, Cassia and Wawa. The presence of these forests in the district contributes immensely to the socio-economic development of the district, example timber.

2.2. Types, sources and methods of data collection

The study is a mixed method cross-sectional research which was conducted on smallholder tomato farmers’ in the Offinso North District. Basically, primary data were employed for the study. A mixed method is a procedure for collecting, analysing, and “mixing” both quantitative and qualitative research and methods in a single study to understand a research problem (Creswell, 2012). According to Creswell (2010), both quantitative and qualitative data together provides a better understanding of a research problem than either type by itself. Again, this particular approach is appropriate for this research because using either qualitative or quantitative method would not adequately address the research problem to help the author answer the research questions. The convergent parallel strategy of the mixed method approach was used. This strategy involves the collection of both quantitative and qualitative data concurrently with separate analyses of the two data sets (Creswell & Clark, 2010). The relevance of this strategy is that, both methods (quantitative and qualitative) complemented each other in arriving at the conclusion.

The primary data were obtained from a cross-section of tomato farmers from three selected communities through the administration of a structured questionnaire and focus group discussions. The data collected include farmers’ perceptions of climate variability and their adaptation strategies to climate variability. Farmers were interviewed using structured questionnaire which had both closed and open-ended questions. Most of the questions were on ‘Yes’ or ‘No’ basis, especially with regard to farmers’ adaptive strategies. The survey was conducted face-to-face with the respondents. Four interviewers (the lead investigator and 3 assistants) took part in the data collection exercise. The three assistants were University graduates who have experience in field research. The duration for the survey was one month (December to January). Prior to the exercise, the assisted interviewers and the lead investigator had a discussion on the nature of the questions and the ways to help elicit the right responses from the interviewees. The data were analysed descriptively using computer-based software, IBM SPSS Statistics version 21. Also, the multiple logistic regression with 95% confidence level was employed to predict how location influence farmers’ adaptation practices.

The focus group discussion responses (qualitative data) were manually processed and analysed using Dey’s (1993) three-tier thematic analysis of data transcription, categorisation and interconnecting supported by direct quotations. The unit of analysis was individual tomato farmers in the study area. A sample size of 378 individual tomato farmers was taken from a population of 7,063 tomato farmers from the District Directorate of the Ministry of Food and Agriculture (MoFA) using the systematic sampling technique. Available list of tomato farmers from the District Directorate of the Ministry of Food and Agriculture formed the sampling frame for the selection. The mathematical model expressed by Yamane (1967) as: \[ n = \frac{N}{1 + \frac{N}{e^2}} \] was used to determine the sample size: where \( n \) denotes the sample size; \( N \) denotes the sampling frame and \( e \) denotes the margin of error which was set at 5% with 95% confidence level. The equivalent sample size in the study communities were then determined using the principle of proportionality.

The systematic sampling method was employed to select farmers from each community. The use of this particular sampling method involved three steps. First, the sample interval (\( k \)) was determined by dividing the farming population of the various communities by their respective sample sizes. The second step involved a random sampling of respondents from the various communities. To begin the random process, the first number was picked between 1 and the \( k \)th number using the simple random sampling technique through the lottery method. Here, the first number to the \( k \)th number were written on pieces of papers and folded in a bowl. Afterwards, a blind-folded person was asked to pick the first number from the bowl which served as the basis for selecting the rest of the respondents using the sample interval. Finally, the \( k \)th term was selected successively from the list of tomato farmers until the total number of sample was obtained. This process was repeated in each
of the cases of the selected communities. The adoption of this particular sampling method was to give the respondents equal chances of selection and to also ensure a fair representation of the population in the communities.

Additionally, some tomato farmers were sampled to gather qualitative responses through separate focus group discussions for male and female farmers in the selected communities namely: Akomadan, Afrancho and Nkenkaasu. Two separate groups were organised for a focus group discussion. The first group comprised male farmers in the district while the second group comprised female farmers. The members from the three communities were brought together at Akumadan and their transport fares were paid to facilitate their movement. A total of 8 male tomato farmers were assembled for the Focus Group Discussion (FGD). These were farmers who had vast experience in the tomato business and were therefore in the better position to provide some relevant additional information. The farmers were selected from the various communities under consideration: Akomadan (4), Afrancho (2) and Nkenkaasu (2). Again, 8 female tomato farmers were also sampled for the second part of the FGD. The members of the discussion comprised of Akomadan (4), Afrancho (2) and Nkenkaasu (2). In all, 16 tomato farmers from the three communities were involved in the focus group discussion. In all the discussions, the lead investigator was the moderator.

The selection of these communities was based on the fact that, most of the tomato farmers are located in these areas, and hence produce most of the tomatoes in the district. This is shown in Table 1 with their respective percentages of selection.

### 3. Results and discussion

#### 3.1. Perceptions of farmers about climate variability

A descriptive analysis was used to elicit responses from the respondents on their perspectives of what climate variability mean. Generally, the results demonstrated their awareness of climate variability in the study area which consequently influenced their adaptive strategies (See Table 2).

Table 2 indicates that farmers in Southern Ghana are very much aware of the climate and have ideas regarding its changes, especially in the areas of temperature and rainfall variability and extreme climatic events. Also, the communities demonstrated a lucid memory of how the area has been characterized by

| Perceptions of climate variability                  | Increase | Decrease |
|----------------------------------------------------|----------|----------|
| High temperature                                   | 341 (90.2) | 37 (9.8) |
| Low and unpredictable rainfall                     | 48 (12.7)  | 330 (87.3) |
| Incidence of flooding                              | 219 (57.9) | 159 (42.1) |
| Protracted drought                                 | 333 (88.1) | 45 (11.9)  |
| High intensity of solar radiation                  | 281 (74.6) | 97 (25.4)  |
extreme climatic events culminating in the perturbation of their livelihood activities, especially farming. This is supported by studies in other parts of Africa, especially in Eastern Saloum of Senegal where majority of the respondents related the climatic changes to the intensity of heat and rainfall variability (Mertz, Mbow, & Reenberg, 2009). Majority of the respondents’ perceived increase in temperature (341 or 90.2%) in the study area with some reduction in rainfall (330 or 87.3%). It was also observed that respondents perceived the incidence of flooding (219 or 57.9%) in the area, especially during the rainy season. It was also evident that most of the respondents experienced prolonged drought (333 or 88.1%) with high intensity of solar radiation (281 or 74.6%). The implication is that, the perspectives of the farmers about the changes in the climate are very fundamental in influencing farmers’ preparedness to employ sound adaptive or coping mechanisms. These perspectives of the farmers in the focus group discussions were corroborated by the questionnaires as both male and female respondents unanimously attested to the changes in climate parameters. The discussants generally intimated that:

You don’t need any prophet to tell you that the climate is changing. We now experience severe and prolonged drought with hot seasons. The intensity of the solar radiation is now unbearable and this is coupled with the unpredictable nature of the rainfall pattern which hitherto was not the case. These conditions of the climate have serious effects on our agricultural productivity. (Focus Group Discussion, 2014)

3.2. Farmers’ adaptation practices to climate variability
While the effect of temperature on tomato product has spatial and temporal dependence, responding to future climate variability will depend on effective management and adaptive practices at the farm and off-farm levels (Tshiala & Olwoch, 2010). The study observed that tomato farmers employed myriads of on-farm adaptation measures as compared to the off-farm strategies. These adaptation strategies practiced by the tomato farmers demonstrate farmers’ preparedness in improving their social and economic livelihoods which are affected by the effects of climatic variations. Table 3 provides the results of the various on-farm and off-farm adaptation practices employed by tomato farmers in the Offinso North District, Ghana.

| Farmers adaptation strategies | Akomadan | Afrancho | Nkenkaasu | Total |
|-------------------------------|----------|----------|-----------|-------|
|                               | Yes (%)  | No (%)   | Yes (%)   | No (%) |
| Changes in farm location      | 60 (37.7) | 99 (62.3) | 38 (25.9) | 109 (74.1) | 20 (27.8) | 52 (72.2) | 118 (31.0) | 260 (69.0) |
| Changes in crop variety       | 30 (18.9) | 129 (81.1) | 33 (22.5) | 114 (77.6) | 16 (22.2) | 56 (77.8) | 79 (20.9) | 299 (79.1) |
| Crop diversification          | 123 (77.4) | 36 (22.6) | 96 (65.3) | 51 (34.7) | 52 (72.2) | 20 (27.8) | 271 (71.7) | 107 (28.3) |
| Application of agro-chemicals | 159 (100) | 0 (0) | 147 (100) | 0 (0) | 72 (100) | 0 (0) | 379 (100) | 0 (0) |
| Irrigation                    | 52 (32.7) | 107 (67.3) | 28 (19.0) | 119 (81) | 22 (30.6) | 50 (69.4) | 102 (27.0) | 276 (73.0) |
| Mixed cropping                | 139 (87.4) | 20 (12.6) | 113 (76.9) | 34 (23.1) | 49 (68.1) | 23 (31.9) | 301 (79.6) | 77 (20.4) |
| Diversification to non-farm activities | 87 (54.7) | 72 (45.3) | 40 (27.2) | 107 (72.8) | 22 (30.6) | 50 (69.4) | 149 (39.4) | 229 (60.6) |
| Migration                     | 50 (31.4) | 109 (68.6) | 44 (30.0) | 103 (70.1) | 39 (54.2) | 33 (45.8) | 133 (35.2) | 245 (64.8) |

Source: Field data (2014).
It is evident from Table 3 that tomato farmers in the study communities employ several on-farm and off-farm strategies in response to the shocks of climate variability. A change in farm location as an adaptive strategy was not a major practice in the area. Generally, out of the total of 378 valid cases, 118 (31.0%) changed their farming location while majority of the respondents, (260 or 69%) did not. This means that even though some of the farmers changed their location to other places for reasons such as the loss of the soil fertility, there were still majority of the respondents who did not change location. Again, other limiting factors such as farm distance, finance and the land tenure system in the study communities may have contributed to most farmers not changing their locations.

This was re-echoed during one of the FGD session when a farmer alluded that:

> It is not easy changing farm location because of the tenure of land. Apart from the family land which I have my share, securing another piece of land will mean buying one. But since I don't have money to buy one, it means I have to stick to what I have at the moment. (Focus Group Discussion, 2014)

The result did not show much variation in terms of the spatial distribution as majority of all the respondents in the communities under investigation indicated their failure in changing the farm location. At Akomadan, out of the total of 159 respondents, 99 of them (62.3%) did not change their farm location. Also at Afrancho, out of the total of 147 respondents, 109 (74.1%) did not change their farm location. The situation was not different at Nkenkaasu where 52 respondents (72.2%) out of the total respondents of 72, also did not change their farm location. The implication of changing the location of farms into new areas could mean clearing of more forest lands for cultivating tomatoes and this could contribute to global warming through removal of trees.

On changes in crop variety as an adaptive strategy, farmers particularly stuck to their preferred variety (Pectomech). While majority of the farmers, 299 (79.1%) answered ‘No’, indicating their resolve not to change the variety of tomato, only 79 (20.9%) of them responded ‘Yes’ indicating that they have changed the variety of tomatoes as an adaptive measure. Farmers who failed to change the variety of the tomato alluded that they did so as a result of the fact that most buyers normally preferred some particular varieties, especially Pectomech. Factors such as access to seeds, prices, potential yields, available markets and technology are some of the barriers that are likely to inhibit farmers’ resistance of changing crop variety (Robinson & Kolavalli, 2010). Spatially, there was not much difference in the respondents’ answers in the communities regarding their adaptation through changes in the tomato variety. Table 2 reveals that out of the total respondents of 159 in Akomadan, 129 (81.9%) had not changed the variety of tomato as an adaptive mechanism. Similarly, out of the total of 147 respondents in Afrancho, 114 (77.6%) maintained their tomato variety. The situation was not different from the responses of the respondents in Nkenkaasu where majority of the respondents (56 or 77.8%) also failed to change the variety of the tomato they produce. Their preference for the cultivation of Pectomech was due to the demand from the buyers. It was also observed that some of the farmers who changed their varieties preferred others like Power Rano. One of the reasons they provided was the resistance of the variety to tomato diseases (e.g. mosaic and leaf curl).

Crop diversification was also found to be an adaptive measure that was preferred by the farmers in the event of climate variability affecting tomatoes. Out of the total respondents (378), 271 (71.7%) employed crop diversification as an adaptive strategy with 107 (28.3%) failing to diversify. With an average farm size of about 2.5 acres, the farmers diversified into crops such as maize, yam, cassava and pepper on the same piece of land. The reason why majority of the farmers diversified to other crops was that it provided them the opportunity to absorb the shock of the climatic variation. This finding supports the view of Uddin, Bokelmann, and Entsminger (2014) who noted that farmers diversify crops to reduce the overall farm risk and expand opportunities for farm profit, which generally boost their average incomes. Similarly, the study of Tiwari et al. (2014) in Nepal stressed that crop diversification as an adaptive strategy adopted by rural farmers is location specific. To them, farmers at different locations diversified into different crop production to cope with the changing climate.
Geographically, the study results revealed that out of the total of 159 respondents at Akomadan, 123 of them (77.4%) diversified their tomato crop production. Again, out of the total of 72 respondents in Nkenkaasu, 52 (72.2%) diversified to other crops. It was also evident in Afrancho that 96 respondents (65.3%) out of the total of 147 also diversified to other agricultural crop production. This is an indication of the farmers’ preparedness of providing other livelihood opportunities to be able to absorb the shock of the climatic variation. However, this method may not be sustainable since the diversified crops also depend on rainfall which has been unreliable.

Application of agrochemicals was found to be a major adaptive measure that was common to all the farmers in the area. Generally, it was observed that all the farmers (378 or 100%), used agrochemicals. Spatially, all the respondents from the three settlements applied agro-chemicals (e.g. fertilizer, furadan etc.) as an adaptive strategy to improve the fertility of the soil and to eradicate tomato diseases. Most of the farmers applied NPK 15-15-15 because they believed that, it dissolves easily and helps the crops to grow faster. A major concern in the application of agro-chemicals to agricultural crops as an adaptive strategy is that, increasing interconnectedness and the formation of new kinds of connections between people and place could trigger unintended outcomes (maladaptation) to farmers (Rodriguez-Solorzano, 2014). Agrochemical applications upstream are likely to drain and affect water bodies downstream with myriads health implication to the population. This finding corroborates the study of Tshiala and Olwoch (2010) in the Limpopo Province of South Africa, who observed that the use of agro-chemicals especially fertilizer is a good adaptation strategy that improves tomato yield.

Irrigation as an adaptive strategy was also not popular among the farmers in the area. Out of the total of 378 respondents, majority of them (276 or 73.0%) did not practice irrigation with the minority (102 or 27.0%) employing irrigation as a strategy. Most of the farmers who did not practice irrigation explained that, irrigation involves a lot of cost, especially with respect to purchasing irrigation pipes and pumping machine. Most of the farmers also alluded that some of the nearby rivers dry up during the dry season which makes it tedious and unattractive for them to move to farther places for water. This was evident during the FGD when a discussant lamented that:

Irrigation is good but if your farm is around areas where the rivers and streams are drying up, how do you irrigate. Again, proper irrigation demands a pumping machine to facilitate the process but because of money we are not able to buy such machines to irrigate our crops and we leave them to the mercy of the rains. So when the rains also fail us then problem looms. (Focus Group Discussion, 2014)

Geographically, majority of the respondents in the communities failed to irrigate their tomato crops. However, it was observed that the number of respondents who failed to employ irrigation at Afrancho were comparatively more than those in Akomadan and Nkenkaasu. The reason was that some of the few streams around the farms were drying up making it difficult for the farmers to get enough water for irrigation. They were therefore worried about the extent of deforestation in the area especially around the water bodies which has culminated in the drying up of the streams. Irrigation as an adaptive mechanism is seen as relevant particularly in the dry season as opined by Tshiala and Olwoch (2010) who identified irrigation as one of the major adaptive strategies that could improve the yield of tomato in the era of climate variability.

Mixed cropping as an adaptive strategy was preferred by most of the farmers. Out of the total of 378 valid cases, majority of the respondents (301 or 79.6%) employed the mixed cropping strategy. It was observed that tomato farmers mix tomato with crops such as okro, pepper and maize. They explained that mixing such crops with the tomatoes was one of the major means by which they were able to absorb the risk of the climatic variation. The relevance of mixed cropping was re-echoed during the FGD when a discussant noted that:
In fact, almost every farmer mixes tomato with other crops such as okro, pepper and maize. The reason is to get something to fall on when the tomato fail us. At least the growing of these crops can help to reduce our cost. (Focus Group Discussion, 2014)

Spatially, the situation was not different from the general picture in the area of farmers’ adaptation strategy through mixed cropping. This was evident when a majority of 139 respondents (87.4%) out of the total of 159 in Akomadan employed mixed cropping. Also, majority of the respondents (113 or 76.9%) out of the total of 147 at Afrancho also employed mixed cropping. Similarly, out of the total of 72 respondents at Nkenkaasu (49 or 68.9%) employed mixed cropping as an adaptive mechanism. The common reason that permeated through the communities regarding their adoption of mixed cropping was that the strategy gave them the opportunity to rely on other crops as a means of improving their livelihood. Some of the crops farmers mixed with tomato crops include okro and maize.

It is evident from Table 3 that tomato farmers in the Offinso North District employed some off-farm adaptation strategies in their bid to responding to the shocks of climate variability. Diversification into non-farm activities as an adaptive measure by farmers was not popular and much preferred. This was evident when out of the total of 378 respondents, 149 (39.4%) diversified into non-farm activities such as trading, dress making, fashion designing and hair beautification, carving and rearing of farm animals. However, majority of the respondents (229 or 60.6%) did not diversify. The respondents explained that the tomato business is the main source of livelihood bequeathed to them by their forefathers. They further stated that, their experience and knowledge in the tomato business are factors that have also made them firmly glued to the tomato enterprise coupled with some financial difficulties. The implication is that if farmers continue in their old ways without diversifying into non-farm activities they are likely to experience much greater shocks in the event of failures in agriculture.

Spatially, it was glaring that even though majority of the respondents did not diversify to non-farm activities, the situation was not the same in all the study communities. Majority of the respondents in Afrancho, 107 (72.8%) and Nkenkaasu, 50 (69.4%) did not diversify to non-farm activities due to financial constraints, but a greater percent of the respondents, 87 (54.7%) at Akomadan rather diversified into a variety of non-farm activities such as carving, trading among others. The reason may be attributed to the greater loss of tomato farmers experienced during the major season of the year where most of them could not break even. Also, the presence of cooperative societies in Akomadan may influence their financial capacity to engage in other non-farm activities. The option of diversifying to other non-farm activities helped them to absorb more of the shocks of the climatic variations as compared to those at Afrancho and Nkenkaasu. This supports the study of Rodriguez-Solorzano (2014) who intimated that engagement in non-farm activities help farmers in overcoming the pressures of the climatic variations and hence allow them to distribute the climate risks over different economic activities. However, it is important to note that some of these off-farm activities such as carving may not necessarily be sustainable. Again, this particular livelihood option has the potential to contribute more to climate variability, since it depends on the cutting down of trees which plays a major role in anthropogenic climate variability.

Migration as an adaptive strategy was also not too popular among respondent. The study revealed that majority of the respondents (245 or 64.8%) did not migrate, as compared to 133 (35.2%) of them who rather migrated to other places to search for jobs. Those who migrated moved to urban centers to seek for other livelihood opportunities to better their livelihood outcomes. In terms of spatial distribution, there were some disparities regarding their adaptation through migration. Geographically, it was observed that majority of the respondents (54.2%) at Nkenkaasu migrated to other places as compared to respondents in Akomadan (31.4%) and Afrancho (30%). This finding tend to support the assertion by McLeman and Smit (2006) who opine that migration is a form of adaptation within a broader set of potential adaptive responses that individuals and households undertake to minimize their vulnerabilities to the pressures of environmental changes. More respondents at Nkenkaasu migrated to urban centers because most of them secured loans to finance
their tomato business and therefore needed to pay off their loans from the financiers. The overall implication is that the migrants end up compounding the social problems in the cities through pressures on social facilities and congestion.

3.3. Spatial determinant of farmers’ adaptation practices

The multinomial logistic regression showed that, location matters when it comes to farmers’ adaptation to climate variability. The adaptation practices were therefore found to be location specific to a larger extent (See Table 4).

In terms of the spatiality of adaptation practices of farmers, the study found that location significantly influenced strategies such as application of agrochemicals (\( p < .005 \)). From the study, there was a positive relationship between application of agrochemicals and location. This means that the more farmers vary their location, there is a higher likelihood of them employing agrochemicals as an adaptive measure. Again, location was also found to be significant in determining farmers’ decision in changing crop variety as an adaptive strategy (\( p < .005 \)). However, while farmers at Afrancho and Nkenkaasu had positive relationship with changing crop variety as an adaptive strategy, farmers at Akomadan rather had a negative relationship with their employment of changing crop variety as an adaptive measure (See Table 4). Therefore, there was less likelihood of farmers at Afrancho and Nkenkaasu changing crop variety but a more likelihood of the farmers at Akomadan changing the variety of the crop. Moreover, irrigation as an adaptive strategy had a significant positive relationship with the location of the communities (\( p < .005 \)). Also, the study found a significant relationship with farmers location (\( p < .005 \)). While farmers had a less likelihood of changing farm location, those at Afrancho and Nkenkaasu had a more likelihood of changing their farm location. In a similar study by Tiwari et al (2014), the adaptation practices of farmers such as crop diversification, farm diversification and income diversification were all found to be location specific.

4. Conclusion

Farmers in Ghana are much particularly concerned with climate variability and the role climate parameters play in the changing climate. The perspectives of the farmers regarding the oscillations in the climate parameters provided the impetus for initiating adaptive strategies as response mechanisms across space. While temperature, drought, solar radiation and flooding were principally regarding to assume an increasing trend, rainfall was perceived to be decreasing with the main reason being attributed to deforestation.

The study revealed a number of adaptation strategies employed by the farmers in the selected communities. These include; crop diversification, changes in farm location, changes in crop variety, mixed cropping, application of agro-chemicals, diversification to non-farm activities and migration. However, the study generally showed that majority of the farmers adopted mixed cropping, application of agrochemicals and crop diversification as on-farm adaptive mechanisms in response to the

| Variables                  | Akomadan  | Afrancho | Nkenkaasu |
|----------------------------|-----------|----------|-----------|
| Crop diversification      | 2.639 (.011) | -1.946 (.074) | -2.329 (.036) |
| Diversification to non-farm activities | 2.079 (.050) | -2.159 (.057) | -1.912 (.093) |
| Application of agro-chemicals | 3.611 (.000) | 2.462 (.002) | 2.512 (.001) |
| Mixed cropping            | 2.485 (.017) | -1.523 (.362) | -1.705 (.122) |
| Changing crop variety     | -16.054 (.000) | 16.434 (.000) | 16.988 (.001) |
| Irrigation                | 3.471 (.005) | 2.321 (.068) | 2.422 (.004) |
| Changing farm location    | -16.293 (.000) | 16.368 (.001) | 17.031 (.000) |

Note: Reference category: migration.
effects of climate variability on tomato crop production. Similarly, off-farm adaptation strategies such as migration and diversification to non-farm activities were employed by some of the farmers in the study communities. However, some of the farmers in the study area migrated to the urban centers for greener pastures with few of them diversifying to non-farm activities. The study also showed that location is a major factor that has the potential of influencing the adaptation strategies of farmers, especially application of agrochemicals, changing crop variety, irrigation practice and changes in farm location.

The study did not show much spatial variation in terms of the most practiced on-farm adaptive strategies (mixed cropping, changes in farm location, irrigation, changes in crop variety, crop diversification and application of agrochemicals) in the individual selected communities. Hence, efforts should be made to strengthen farmers’ adaptive capacities on how to effectively employ these on-farm adaptation measures so that they don’t become maladaptive. However, there were some spatial variations regarding the off-farm adaptation strategies employed by a cross-section of the farmers across the communities. Majority of the farmers at Nkenkaasu, especially the youth migrated to the urban centers to look for other source of livelihood opportunities after a failed tomato season as compared to those at Akomadan and Afrancho. This potentially have long term effects on the sustainability of tomato production in the community as majority of the youth leave. Also majority of the farmers at Akomadan diversified to non-farm activities to improve their livelihood opportunities as compared to those at Afrancho and Nkenkaasu. It is important that government and other private financial institutions empower the relatively old farmers who are normally left behind to enable them get the needed financial capacity to employ the services of labourers to help boost their farming business. Giving farmers loans at low interest rate will help them to increase their scale of production and also diversify to other non-farm activities to enable them absorb the shocks of the climatic variability. The agricultural extension officers should also strengthen their education on agronomic best practices to help farmers respond appropriately to the vagaries of the climate. There is also the need for the farmers to be provided with climate information through the various media in the area (e.g. radio station and information center) to enable them plan adequately for the planting season. Irrigation projects should be developed in these communities to ensure that farmers get access to water to irrigate their crops during the dry season. Agrochemicals and other farm inputs should be subsidized to enable farmers especially the youth get access to them to improve on tomato production. When these measures are put in place, it will empower and motivate the youth to produce more tomato to improve their economic status and reduce the level of poverty among households in the study area.

Supplementary material
Supplementary material for this article can be accessed here http://dx.doi.org/10.1080/23311886.2016.1273747.

Funding
The authors received no direct funding for this research.

Author details
Lawrence Guodaar
E-mail: lawrenceguodaar@yahoo.com
Alphonsus Beni
E-mail: benicssp@yahoo.com
Patrick Benebere
E-mail: nuoviel@gmail.com
1 Faculty of Social Sciences, Department of Geography and Rural Development, College of Humanities and Social Sciences, Kwame Nkrumah University of Science and Technology, PMB, University Post Office, Kumasi, Ghana.
2 Department of Philosophy and Social Sciences, Spiritan University College, Box 111, Ejisu-Ashanti, Kumasi, Ghana.

References
Ayanlade, A., Odekunle, T. O., & Orimoogunje, O. O. I. (2010). Effects of temporal changes in climate variables on crop production in tropical sub-humid South-western Nigeria. African Journal of Environmental Science and Technology, 4, 500–505.
Ayanlade, A., Odekunle, T. O., & Orimoogunje, O. O. I. (2010). Impacts of climate variability on tuber crops in Guinea Savanna part of Nigeria: A GIS approach. Journal of Geography and Geology, 2, 27–35.
Bagamba, F., Bashaasha, B., Claessens, L., & Antle, J. (2012). Assessing climate change impacts and adaptation strategies for smallholder agricultural systems in Uganda. African Crop Science Journal, 20, 303–316.
Codjoe, S. N. A., & Owusu, G. (2011). Climate change/variability and food systems: Evidence from the Afram Plains, Ghana. Regional Environmental Change, 11(4), 1–13.
Creswell, J. W. (2010). Research design: Qualitative, quantitative, and mixed methods approach (3rd ed.). Thousand Oaks, CA: Sage.
Creswell, J. W. (2012). Qualitative inquiry and research design: Choosing among five traditions (3rd ed.). Thousand Oaks, CA: Sage.
