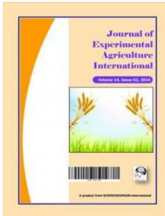

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Factors Influencing Tomato Farmers' Perception of Climate Variability: Evidence from the Offinso North District, Ghana

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Authors' contributions

This research work was carried out in collaboration between all authors. Author LG designed the study and analyzed the data. Authors FA and GE managed the methodology and the literature search of the study respectively. All authors read and approved the content of the final manuscript.

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ABSTRACT

This paper sought to analyse tomato farmers' perceptions of climate variability in the Offinso North District, Ghana. A cross-section of 378 tomato farmers were interviewed to examine what they perceive climate variability to be and the factors that influence their perception of climatic variation (changes in temperature, changes in rainfall pattern and changes in the intensity of solar radiation) using binary logistic regression model. The study found that respondents had observed temperature rise (90.2%); decrease in rainfall (87.3%); prolonged drought (88.1%); increase in solar radiation (74.6%) and an unpredictable rainfall pattern (73.5%). The perceptions of the farmers were consistent with the meteorological time series data in the area of temperature rise, but while farmers perceived a reduction in rainfall, the meteorological data rather showed an increasing rainfall variability trend. The binary logistic regression results indicate that sex

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(P = 0.05), age (P = 0.05), formal education (P = 0.05), access to extension service (P = 0.05) and access to climate information (P = 0.05) are factors that significantly influence farmers perception of climate variability. The study concludes that sex, age, formal education, access to extension service and access to climate information are major determinants that influence farmers' perception of climate variability. Policies tailored at enhancing the adaptive capacity of farmers through access to formal and non-formal education should be provided to enable tomato farmers to produce more tomatoes to increase food production in the study area and Ghana in general.

Keywords: Climate variability; perception; binary logistic regression; tomato production; Offinso North District, Ghana.

1. INTRODUCTION

The phenomenon of global climatic changes has been scientifically described as "unprecedented" and "unequivocal" since the mid-21st century [1]. Anthropogenic driving forces are widely argued as the main cause of climate variability across the globe. Sub-Saharan Africa is contested as the most vulnerable region to be affected by global changing climate as a result of its reliance on rain-fed agriculture which is highly sensitive to weather and climate variables such as temperature, precipitation and extreme events coupled with the low adaptive capacity [2]. In view of the emissions of greenhouse gases (e.g. carbon dioxide, methane, water vapour and ozone) in the atmosphere, crops and forage plants are expected to be subjected to increasing temperatures and changing precipitation patterns with the cumulative effects of reducing plant growth and yield [3]. The Intergovernmental Panel on Climate Change 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 alter the hydrological cycle in countries [4].

Tomato (*Lycopersicon esculentum*) is one of the several vegetables produced in Ghana, and contributes immensely to the socio-economic development of the country. Tomato is widely produced in the Northern, Upper East and Southern Volta Regions of Ghana as well as notable districts like the Offinso North and Wenchi Districts of the Ashanti and Brong Ahafo Regions respectively [5]. There are vast arable lands for the cultivation of tomato in Ghana. Most farmers in the Offinso North District cultivate tomato as one of the crops they grow. Apart from the provision of livelihood assets to some farmers in the country, tomato also provides important sources of vitamins to the body. These minerals help the body to fight against diseases. Even though domestic tomato production seems to have increased in the country, it still does not meet the high demand of the population and this has culminated in the importation of tomatoes from other countries, especially Burkina Faso [6].

According to Asante et al. [7] the reduction of the availability tomato fruit can be attributed to several production constraints which include biotic and abiotic factors. While the abiotic factors look at erratic rainfall, high temperature, and poor soils, among others, the biotic constraints include diseases such as the tomato yellow leaf curl virus, bacterial wilt, bacterial spot, early blight, and tomato mosaic viruses [7]. Sinnadurai [8] also postulates that climate variability especially high temperature has the potential to delay flowering and reduce the number and size of the flowers of tomatoes causing a reduction in production. This assertion by Sinnadurai is further supported by Kalibbala [9] who posits that excessive rainfall and high relative humidity can be harmful to the tomato crop due to proliferation of leaf diseases during humid conditions.

This brings to the fore the need to probe to understand and appreciate how local people involved in cultivation of tomatoes experience and perceive climate variability. Their perception will help them to devise effective adaptation strategies in response to the shocks of the observed variability. "Local perceptions" as used in this paper refers to the manner in which local people identify and interpret observations and concepts [10]. In developing countries farmers have been identified as people who perceive climate variability differently and employ a plethora of strategies in response to the effects of the variability [11,12,13]. Socio-demographic characteristics, environmental and institutional factors have been documented as factors that have far-reaching influence on the perceptions of farmers regarding the phenomenon and its associated effects on agricultural production in general [14,15,16,17]. These factors include: age, sex, marital status, income, educational levels of farmers (socio-demographic characteristics), access to credit, extension services (institutional factors) temperature and rainfall (environmental factors).

Even though Ghana and the Offinso North District in particular is vulnerable to climate variability due to its reliance on rain-fed agriculture, micro-level studies at the farm level regarding how smallholder farmers in Ghana perceive climate variability are very limited if not absent and hence, not fully understood. This paper analysed the factors that influence farmers' perceptions of climate variability in Ghana with evidence from tomato farmers in the Offinso North District using a modeling approach. Specifically, the study teases out how socio-demographic characteristics and institutional factors influence tomato farmers' perceptions of climate variability.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in the Offinso North District (OND) of the Ashanti Region of Ghana, which covers an area of 741 square kilometers and lies between longitudes $1^\circ 60^1$ W and $1^\circ 45^1$ E and latitudes $7^\circ 20^1$ N and $6^\circ 50^1$ S (Fig. 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 while the second period starts from September to October. The mean annual rainfall is between 1250 mm and 1800 mm. Relative humidity is generally high ranging between 75-80 percent in the rainy season and 70-72 percent in the dry season. A maximum temperature of 30℃ is experienced between March and April. The mean monthly temperature is about 27℃.

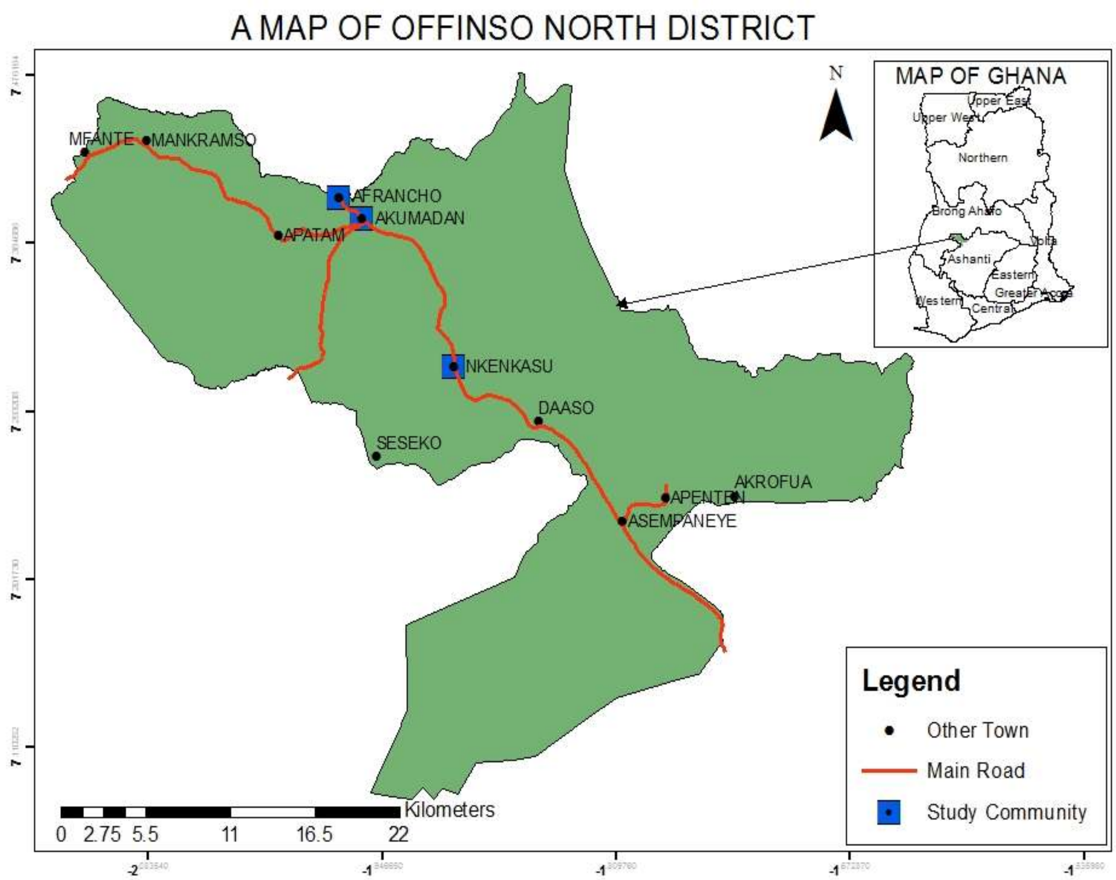

Fig. 1. Map of the study area indicating the selected communities

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. Four major forest reserves are found in the district. These are: the Afram Headwaters Forest Reserve (189.90 km^2); the Afrensu-Brohoma Forest Reserve (89.06 km^2); the Mankrang Forest Reserve (92.49 km^2) and the Opro River Forest Reserve (103.60 km^2). 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.

The structure of the district's economy is made up of agriculture (64.7%), service (14.8%), commerce (17.2%) and industry (3.3%). Agriculture is the main economic activity in the district from which majority of the people derives their livelihood. Over 80 percent of the active population in the district are farmers. Out of this figure, the youth constitute about 25 percent. Fishing is done on a limited scale whilst livestock production is basically on free range basis. Poultry farming is also on a limited scale. Most of the land in the district is put under food crop production each year. Large tracts of fertile lands also remain uncultivated. The major crops cultivated are maize, plantain, cassava, yam and vegetables especially tomato. Cocoa and cashew production in the district is low and these are the only exportable commodities. Therefore, there is the need to protect and sustain the livelihoods of farmers through structural and institutional arrangements and interventions. Again, effort should be put in place to strengthen the adaptive capacities of farmers to enable them cope with the changing climate.

2.2 Data Types, Sources and Sampling Techniques

The study which is a quantitative cross-sectional research was conducted on smallholder tomato farmers' in the Offinso North District. Basically, primary data were employed for the study. The quantitative method was deemed appropriate for the study because it provides a better appreciation of the issues under consideration and helps to clearly represent the issues by quantifying the variables. This approach is also relevant because of its objectivity and ability to generalize the findings. The primary data were obtained from a cross-section of tomato farmers from three selected communities through the administration of a structured questionnaire. The data collected include farmers' socio-demographic characteristics and their perceptions of climate variability and its effects on their operations. The data were analysed descriptively and inferentially using the IBM SPSS Statistics version 21. A sample size of 378 individual tomato farmers was taken out of a total population of 7063 registered tomato farmers from the District Directorate of the Ministry of Food and Agriculture (MoFA) using the systematic sampling technique. The mathematical model expressed by Yamane [18] as:

$$n = N / 1+ N (e^2) \quad (1)$$

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 proportionate sampling method expressed as SC = TS x NH/TI, where SC is the Sample size per community, TS is Total sample size, NI is Number of individuals per community and TI is Total number of individuals (Table 1). Additionally, some tomato farmers were sampled to gather qualitative responses through separate focus group discussions for male and female farmers in the study area. This is shown in Table 1 with their respective percentages of selection.

Table 1. Study communities and their respective total number of farmers and sample sizes

Study communities	No. of farmers (N)	Proportionate sample SC = TS x NH/TI
Akomadan	2966	42/100*378= 159
Afrancho	2754	39/100*378= 147
Nkenkaasu	1343	19/100*378= 72
Total	7063	378

Source: Authors fieldwork (2014)
**--: Multiplication sign*

2.3 Theoretical Framework

Perception discourses in climate variability issues have always been limited to whether farmers perceive climate variability or not. Household characteristics (e.g. age, sex, marital status, income and educational levels of farmers), farm characteristic (e.g. farm size, soil type and fertility), infrastructural factors (e.g. storage facilities and market) institutional factors (e.g. access to credit and extension services) and environmental factors (e.g. temperature and rainfall) have been well documental as factors that influence farmers perception of climate variability [14,15,16,17]. The logistic regression model was used to analyse the perception of climate variability using key indicators such as changes in temperature, changes in rainfall pattern and changes in the intensity of solar radiation from the perspective of tomato farmers. This model is preferred because of its ability to simply compute and estimate binary choices. According to Ndambiri et al. [19], the relationship between the response variable and the set of explanatory variables can be expressed as:

$$Y_i = \beta_0 + \beta_i X_i + e_i \tag{2}$$

Where Y_i represents the perception of farmers with $Y_i = 1$ indicating when a farmer perceives climate variability (changes in temperature, changes in rainfall pattern and changes in the intensity of solar radiation) and $Y_i = 0$ showing when a farmer does not perceive such climate variability indicators; β_0 denotes the y-intercept with β_i indicating the parameters to be estimated; X_i are the independent variables under consideration with e_i indicating the error term.This model in equation (2) is a linear regression model, however, because the regressand is binary in nature, it is referred to as the linear probability model (LPM). However, due to the weakness associated with LPMs which according to Feder et al. [20] fail to meet statistical assumptions necessary to validate conclusions based on set hypotheses, the logit or probit models are preferred [21]. According to Ndambiri et al. [19] the logistic cumulative probability function is expressed as:

$$P_i = F(Z_i) = \frac{1}{1+e^{-z_i}} \tag{3}$$

From equation (3) P_i is the probability that a farmer, ith, will be in the category in equation (2) where $Z_i = \beta_0 + \beta_i X_i + e_i$. ; β_0 denotes the intercept with β_i indicating the parameters to be estimated; X_i are the independent variables under consideration with *e* representing the base of natural logarithms. From equation (3), the Z can range from zero to infinity. The probabilities of perceiving the effects of climate variability are dummied with 1 being the perception of climate variability and 0 being otherwise. Multiplying both sides of equation (3) by $1 + e^{-z_i}$ results in equation (4) expressed as:

$$(1 + e^{-z_i})P_i = 1 \tag{4}$$

Rationalizing equation (4) results in:

$$e^{-z_i} = \frac{1}{P_i} = \frac{1-P_i}{P_i} \tag{5}$$

Since $e^{-z_i} = \frac{1}{e^{-z_i}}$ by definition,

This implies that,

$$e^{-z_i} = \frac{P_i}{1-P_i} \tag{6}$$

From equation (6) when logarithm of both sides is taken, the result will be:

$$Z_i = \log\left\{\frac{P_i}{1-P_i}\right\} \tag{7}$$

From equation (7)

$$\log\left\{\frac{P_i}{1-P_i}\right\} = \beta_0 + \beta_i X_i \ldots + \beta_{ni} X_{ni} + e_i \tag{8}$$

Equation (8) defines the logistic probability model based on the Z logit. From the above equations, the marginal effects of the explanatory variables according to Ndambiri et al. [19] can be expressed as:

$$\frac{\delta P_L}{\delta X_L} = \frac{\beta_L e^{-z_L}}{(1+e^{-z_i})^2} \tag{9}$$

2.4 Empirical Model

The study employed the binary logistic regression model for the analyses of tomato farmers' perception of climate variability. This particular model was employed because of its simplicity and ability to provide an opportunity for the researchers to analyse binary variables and the probabilities associated with farmers' perceptions. The response variables which are binary in nature (perception of climate variability [changes in temperature, changes in rainfall pattern and changes in the intensity of solar radiation] or non-perception of these variables) were regressed to see their effects on the explanatory variables of household characteristics (age, sex, marital status, farming experience and formal educational) and institutional factors (access to climate information and extension services). Therefore, Ndambiri et al. [19] express the logistic regression model as:

$$Z_i = (\beta X_i) + \varepsilon \quad (10)$$

Where Z_i represents the perception by an i[th] farmer who perceives climate variability effects; X_I denotes the vector of the set of explanatory variables of probability of perceiving climate variability effect by an i[th] farmer; β represents the vector of the parameter estimates that influence farmers perception of climate variability. The empirical model can therefore be defined and measured (Table 2).

To be able to appreciate farmers' perception and understanding of climate variability, a descriptive analysis was used to elicit responses from the selected farmers on how they perceive climate variability in the Offinso North District over the past decades. Specifically, farmers were asked to respond to questions as to whether they had noticed changes in temperature, rainfall and the intensity of solar radiation based on the following parameters: a general change in climate, increase in temperature, decrease in temperature, decrease in rainfall, unpredictability of the rains, increase in drought, increase in the incidence of flooding and increase in solar radiation (Table 3). The results are represented in Table 3.

Table 2. Explanation of variables

Explanatory variables	Definition	Measurement	Slope coefficient
X_1	Age	Years	β_1
X_2	Sex	Male=1 and 0= otherwise	β_2
X_3	Formal education status	Access=1 and 0= otherwise	β_3
X_4	Farming experience	Number of years in farming: >10 years= High experience <10 years=Low experience	β_4
X_5	Marital status	Married=1 and 0=otherwise	β_5
X_6	Access to extension services	Access=1 and 0=otherwise	β_6
X_7	Access to climate information	Access=1 and 0=otherwise	β_7

Table 3. Descriptive analysis of farmers perception of climate variability (n=378)

Farmers perception	Farmers perception by age (as a percentage of the respondents)					Farmers perception by education		Farmers perception by farming experience	
	Percent of respondents (%)	20-30 yr (%)	31-40 yr (%)	41-50 yr (%)	>50 (%)	Formal education (%)	No formal education (%)	Low (<10 yr) (%)	High (>10 yr) (%)
Changes in climate	100	12.2	30.3	50.4	7.1	55.6	44.4	3.2	96.8
Increase in temperature	90.2	10.9	30.0	42.7	6.6	50.1	40.1	2.9	87.3
Decrease in temperature	0	0	0	0	0	0	0	0	0
Decrease in rainfall	87.3	10.6	45.2	25.2	6.3	48.5	38.8	2.8	84.5
Increased flooding	57.9	7.1	30.2	16.5	4.1	32.2	25.7	1.8	56.1
Prolonged drought	88.1	10.7	20.1	51.0	6.3	48.9	39.2	2.8	85.3
Increased solar radiation	74.6	9.1	29.0	31.2	5.3	41.4	33.2	2.4	72.2
Unpredictable rainfall pattern	73.5	8.9	32.1	27.2	5.3	40.8	32.7	2.3	71.2

3. RESULTS AND DISCUSSION

Generally, all the respondents were of the view that the climate is changing. With respect to changes in temperature, 90.2 percent of the respondents perceived an increase in temperature with nobody perceiving a decrease in temperature. It was also established that 87.3 percent farmers perceived a decrease in rainfall with 73.5 percent perceiving an unpredictable rainfall pattern in the area. Also glaring was the fact that 88.1 percent of the farmers perceived an increase in the frequency of droughts while 57.9 percent perceived an increase in the frequency of flooding. Considering the intensity of solar radiation over the past decades, majority of the farmers forming 74.6 percent pointed out that the solar radiation had intensified over the years culminating in warmer conditions. The above analyses point to the fact that farmers in the area are aware of climate variability through their recent experiences of changes in some climatic systems.

To further establish some relationships among some of the variables, cross-tabulations were employed in the analysis. The result of the analysis between the age of respondents and their perception of climate variability indicated that, majority of the farmers who perceived a general change in climate over the years were farmers between the ages of 41 and 50 years (50.4%) as compared to those between the ages of 31 and 40 years (30.3%); those less than 31 years (12.2%) and those above 50 years (7.1%). Again, on farmers' perception of a rising temperature, 42.7 percent of them were found in the age group of 41 and 50 while 30 percent of them were found between the ages of 31 and 40 years. Also only 10.9 percent and 6.6 percent of those between the age groups below 31 and above 50 years respectively perceived increases in temperature. However, the study showed that no one across the various age groups perceived a decrease in temperature over the years. It was also observed that majority of the respondents (45.2%) between 31 and 40 years perceived a decrease in rainfall. This was followed by those aged between 41 and 50 years with a percentage of 25.2. Also, 10.6 percent of the respondents who perceived a decrease in rainfall were between the ages of 20 and 30 with 6.3 percent aged above 50 years. Regarding farmers' perception of unpredictability in the rainfall pattern, 32.1 percent of them were between the ages of 31 and 40 years. This was followed by those between the ages of 41 and 50 years (27.2%); those below the ages of 31 years (8.9%) and those above 50 years (5.3%). In the area of prolonged drought, 51.0 percent of the farmers between the ages of 41 and 50 years perceived they had observed several prolonged drought conditions. This was followed by those between the ages 31 and 40 years (20.1%). Also, only a few respondents below 31 years and above 50 years with the percentages of 10.7 and 6.3 respectively, perceived severe drought conditions in the study area.

Similarly, majority of the respondents (31.2%) who perceived increased solar radiation over the years were those aged between 41 and 50 years followed by those aged between 31 and 40 years (29.0%). Also, 9.1 percent and 5.3 percent of respondents who perceived an increase in solar radiation were those below 31 years and above 50 years respectively. Regarding farmers' perception of increased frequency of flooding, 30.2 percent of the respondents between the ages of 31 and 40 years perceived an increase in the incidence of flooding over the years. They were followed by those aged between 41 and 50 years (16.5%). However, 7.1 percent of the respondents who perceived an increase in flooding were those between the ages of 20 and 30 years while 4.1 percent of them were above 50 years. This means that majority of the middle-aged adults who are active in the cultivation of tomatoes in the District perceived changes have occurred in key climatic elements. These illustrate how informed they are in climate issues. The middle-aged adults' awareness of climatic changes will shape their adaptive capacities in response to the effects of the phenomenon on tomato production.

With respect to the educational status of the farmers, the study observed that, of all the respondents who perceived changes in the climate, 55.6 percent had formal education while 44.4 percent had no formal education. Also, majority of the farmers (50.1%) who perceived an increase in temperature were those who had formal education while 40.1 percent of them had no formal education. However, no respondent perceived a decrease in temperature. While majority of the farmers (48.5%) who perceived a decrease in rainfall had formal education, 38.8 percent of them had no formal education. The study again showed that, while 48.9 percent of the farmers who perceived an increase in protracted drought had formal education, 39.2 percent of them had no formal education. Regarding farmers' perception of unpredictable rainfall pattern, majority of them (40.8%) indicated they could not predict the rainfall pattern. These respondents had formal education. This was in contrast with 32.7 percent who had no formal education. Also, majority of the farmers (32.2%) who perceived increase in the frequency of flooding were those who had formal education. This was contrary to the 25.7 percent of the respondents who had no formal education. They formed 25.7 percent of the respondents. While 41.4 percent of the farmers who perceived an increase in solar radiation over the years had formal education, 33.2 percent of them had no formal education. The forgone analysis implies that some level of relationship exists between access to formal education and farmers' perception of climate variability in the study area.

Regarding farming experience, the study showed that, majority of respondents (96.8%) who perceived climatic variations had more than ten years of experience in farming and only 3.2 percent of them had less than ten years of farming experience. Also, regarding farmers who perceived an increase in temperature over the years, it was realised that 87.3 percent of them had more than ten years of farming experience as compared to only 2.9 percent with less than ten years of farming experience. Moreover, while majority of the farmers (85.3%) who perceived prolonged drought had more than ten years farming experience, only 2.8 percent of them had less than ten years of farming experience. The study also showed that 84.5 percent of the farmers who had more than ten years farming experience perceived a decrease in rainfall amount while 2.8 percent with less than ten years of farming experience perceived same. Regarding unpredictability of rainfall, the study showed that 71.2 percent of those who had more than ten years farming experience perceived unpredictability in the rainfall pattern as against 2.3 percent of those with less than ten years of farming experience. While the farmers who perceived an increase in the frequency of flooding had more than ten years of farming experience (56.1%), only 1.8 percent of them had less than ten years of farming experience.

With respect to the intensity of solar radiation, the study showed that 72.2 percent of farmers with more than ten years of farming experience and 2.4 percent of those with less than ten years of farming experience perceived that there has been an increase in solar intensity respectively. Farming experience therefore plays an important role in farmers' perception of climate variability. It can also inform their decision to employ sound adaptive strategies that would help them reduce the effects of adverse climatic conditions on crop production, especially tomato production in the study area.

3.1 Comparison between Meteorological Data and Farmers Perceptions

The inter-annual climatic variations between 1994 and 2013 show that, records of maximum temperature varied from year to year. It is evident from the inter-annual variability graph that there are anomalies in the maximum temperature as observed in the time series data with a greater number of the mean values being positive. These are indications that the district is becoming warmer (Fig. 2).

The temperature anomaly was calculated using the formular:

$$TA = MTY\text{-}TMT \quad (11)$$

where 'TA' is the temperature anomaly; 'MTY' is the mean temperature for a year and 'TMT' is the total mean temperature.

This supports the Inter-governmental Panel on Climate Change assertion of an increasing warming trend in the 21st century. Similarly, majority of the farmers during the interview also acknowledged the increasing trend in temperature over the years. The climatological data is therefore consistent with the perception of the farmers about an increasing temperature trend which has characterized the district over the past two decades. The reason for the rise or increase in maximum temperature in the district may be partly due to the extent of bad farming practices (e.g. slash and burn) coupled with deforestation that characterises farming activities in the area.

The inter-annual rainfall variation shows how rainfall totals vary from year to year (Fig. 3). It is evident from the trend anomalies that rainfall as observed in recent years recorded a relatively higher anomaly as compared to the earlier years which show positive mean values. This clearly gives an indication of an increase in rainfall in the district. The high amount of rainfall in the district as shown in the time series data may be due to the high temperature recordings which potentially increased evapotranspiration rates. It was also

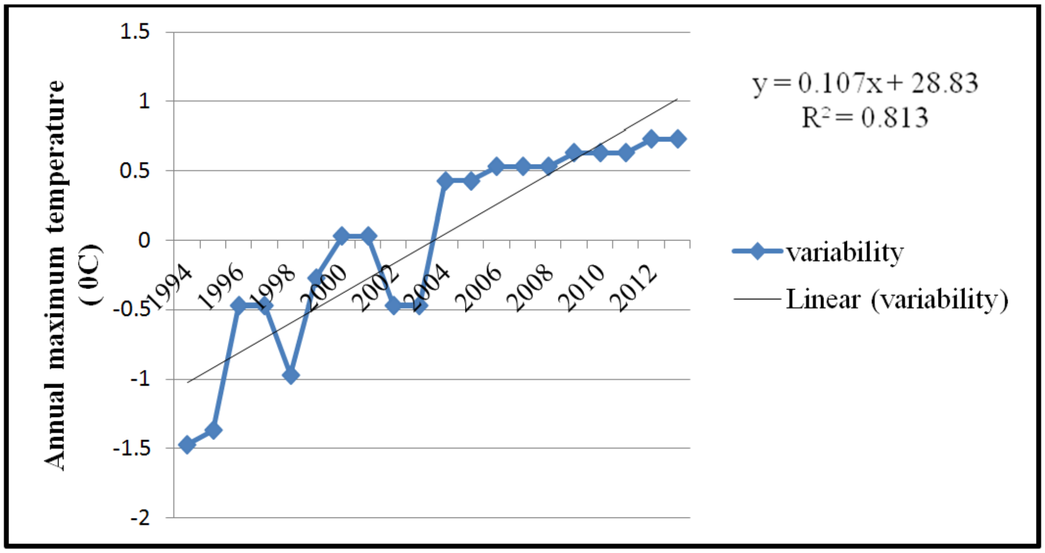

Fig. 2. Inter-annual maximum temperature anomaly (1994-2013)
Source: Field data (2014)

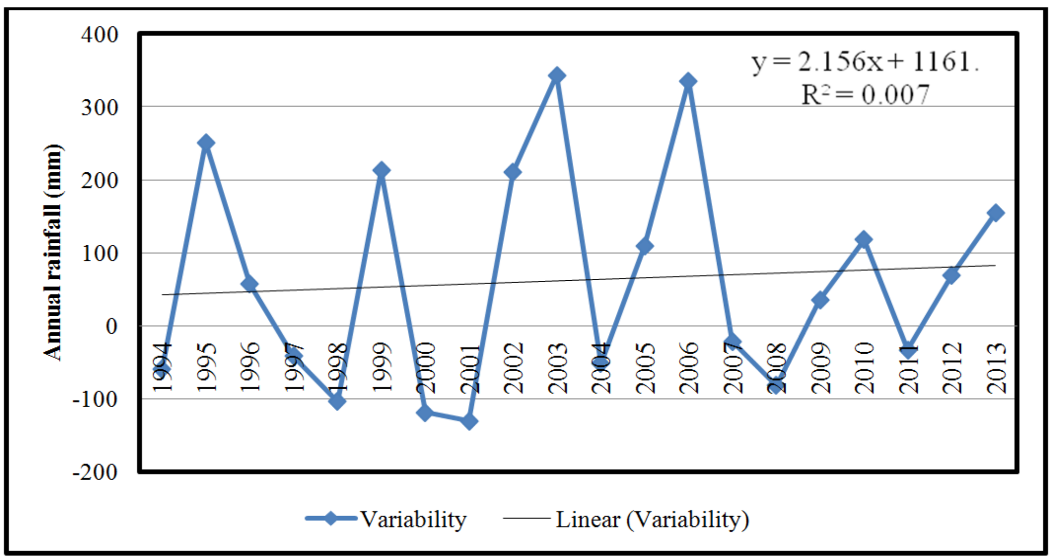

Fig. 3. Inter-annual rainfall anomaly (1994-2013)
Source: Author's fieldwork, 2014

observed that the rainfall peaked in June (for the major season) and October (for the minor season) due to the bimodal nature of the rainy season in the district. The peak of the major season was in June while that of the minor season was in October. However, there was uneven distribution of rainfall in the months with the pattern being unreliable over the years. This potentially could have affected most tomato farmers in the district who needed the rains after planting.

The rainfall anomaly was calculated using the formular:

$$RA = AR\text{-}TMAR \quad (12)$$

where 'RA' is the rainfall anomaly; 'AR' is the annual rainfall and 'TMAR' is the total mean annual rainfall.

The time series analysis of rainfall variability contradicts the observation of the farmers who perceived a reduction in rainfall over the past two decades in the district. However, the farmers during the focus group discussion perceived rainfall pattern to be generally unreliable in the district. The observed rising temperature and increased solar radiation facilitate increased evaporation of soil moisture than it was experienced in times past. This could possibly be the reason why most farmers perceived a decrease in rainfall amount.

3.2 Modeling Tomato Farmers' Perception of Climate Variability

The econometric model was used to analyse the perception of tomato farmers. The model involves a binary variable that indicates whether farmers perceive climate variability or otherwise.

Each of the outcome variables (changes in temperature, changes in rainfall pattern and changes in the intensity of the solar radiation) was regressed on the set of explanatory variables (age, sex, formal education, farming experience, marital status, access to extension services and access to climate information). The coefficient of the parameters show the nature and direction of the relationship between the variables and the probabilistic effect on the dependent variable when there is a unit change in the independent variable with all factors held constant (Table 4). The study reports on the variables that are statistically significant at 5 percent.

Generally, the results of the econometric analyses show that the sex of respondents, age, formal education, access to extension service and access to climate information are factors that significantly influence tomato farmers' perception of climate variability in the Offinso North District of Ghana.

With regard to the sex of farmers, the coefficient was found to be significant (*P* = 0.05) and positive for perceiving changes in the intensity of solar radiation but negative for perceiving changes in temperature and rainfall pattern. Therefore, the probability of a male farmer perceiving changes in the intensity of solar radiation is higher than that of a female farmer. This may be attributed to the fact that males have a higher probability of acquiring more information than females. Also, males have the energy to work under the scorching sun and are therefore able to experience some variations in the intensity of the solar radiation than their female counterparts. However, the probability of a female farmer perceiving changes in temperature and rainfall pattern is rather higher than that of the male farmer. Since females are normally good in records keeping, they are able to keep and provide accurate information regarding past rainfall dates and periods. This agrees with the study of Habtemariam et al. [22] who observed that gender is a significant determinant factor that influence farmers in Ethiopia.

Also, the coefficient of the age of farmers was found to be significant (*P* = 0.05) and positive for perceiving changes in temperature. This means that the older a farmer the higher the probability of perceiving changes in temperature. This corroborates the study of Debela et al. [23] who

Table 4. Logistic regression results of tomato farmers' perception of climate variability

Explanatory variables	**Changes in temperature**			**Changes in rainfall pattern**			**Changes in the intensity of solar radiation**		
	β	**S.E.**	**p-value**	**β**	**S.E.**	**p-value**	**β**	**S.E.**	**p-value**
Age	0.62**	0.32	0.05	-0.90**	0.29	0.00	-0.83**	0.24	0.00
Sex	-1.42**	0.44	0.00	-1.71**	0.34	0.00	0.91**	0.35	0.00
Formal education status	-1.71**	0.50	0.00	-0.05	0.36	0.90	1.62**	0.31	0.00
Farming experience	0.62	0.50	0.22	0.00	0.51	0.99	0.47	0.39	0.23
Marital status	0.87	0.58	0.13	-0.80*	0.46	0.08	0.16	0.45	0.72
Access to extension services	-2.07**	0.55	0.00	0.107	0.58	0.86	-0.42	0.47	0.37
Access to climate information	19.343	4358.6	0.99	1.04**	0.52	0.04	1.81**	0.50	0.00
Economic diagnostic									
Likelihood ratio test for zero slope	74.56, p> $Chi^2(8)$=0.05			46.39, p> $Chi^2(8)$=0.05			87.78, p> $Chi^2(8)$=0.05		
Total observation					378				

*NB. *** significant at 1% level; ** significant at 5% level; * significant at 10% level* found that elderly persons are more likely to perceive changes in climatic variables than their younger counterparts. However, the coefficient of the age of farmers was rather found to be negative for those who perceived changes in the rainfall pattern and changes in the intensity of solar radiation. This is inconsistent with the findings of Habtemariam et al. [22] who found significant positive relationship between the age of farmers and their perception of climatic variables.

Moreover, formal education of respondents was found to be significant (*P* = 0.05) and positive for perceiving changes in rainfall pattern and changes in the intensity of the solar radiation. This implies that the more formal education a person has the higher the probability of that person perceiving changes in rainfall pattern and intensity of the solar radiation. Farmers who are more educated have the tendency to interpret and apply information they receive to their daily lives. This makes them more aware of the local climatic variability which translates and informs their perception of climatic variations. This supports the findings of Ndambiri et al. [19] who found that, farmers with higher education have greater probability of perceiving climate variability. However, the coefficient of the education of farmers was rather found to be negative for those who perceived changes in temperature. This is inconsistent with the findings of Mustapha [24] who found a positive relationship between the educational levels of farmers and their perception of climate variability in Borno State, Nigeria.

Access to extension services by farmers was found to be significant (*P* = 0.05) and positive for perceiving changes in rainfall pattern. This means that the more extension services farmers receive the more is their likelihood to perceive changes in rainfall pattern. This is not a departure from the intended objective since extension services inform farmers about the periods that are best for farming activities due to the oscillations in climatic variables in this 21st century. This supports the study of Debela et al. [23] who observed farmers' perception of climate variability to be significantly influenced by the extension services farmers receive from agricultural extension officers in Borana, South Ethiopia. However, the coefficient of the access to extension services by farmers was found to be negative which contradicts the study of Deressa et al. [16] who found a positive relationship between access to extension service and farmers' perception of climate variability.

Access to climate information was found to be significant (*P* = 0.05) and positive for perceiving changes in rainfall pattern and intensity of the solar radiation. Therefore, the more farmers get access to climate information the greater the likelihood that they will perceive changes have occurred in the rainfall pattern and intensity of the solar radiation. This may be due to the fact that majority of the farmers in the area own radios sets which provide them with weather information on a daily basis. Provision of climate information is essential in equipping farmers with the relevant knowledge and skills in responding to the changing climate. This finding mirrors the study of Mamba [25] who found smallholder farmers access to climate information to significantly affect their perception levels of climate variability in Swaziland.

4. CONCLUSION

The study analysed tomato farmers' perception of climate variability and the factors that influence their perception using a modeling approach. The study found that majority of the tomato farmers are very much aware of the manifestations of climate variability in the Offinso North District of Ghana. The farmers perceived climate variability to be increase in temperature, decrease in rainfall, increase in the incidence of floods, increase in the severity of drought, increase in solar radiation and unpredictable rainfall pattern. Farmers' perception of increased temperature was consistent with the meteorological data. However, their perception of decreased rainfall was inconsistent with the time series data which showed a rather increasing variable rainfall trend. The descriptive analyses indicated that age, educational status and the number of years of farming experience have some relationship with the way tomato farmers perceive climate variability in the study area. While majority of the tomato farmers who perceived increased temperature, prolonged drought and increased solar radiation were between the ages of 41 and 50 years, those who perceived a decrease in rainfall, increased incidence of flooding and unpredictable rainfall pattern were between the ages of 31 and 40 years. The study therefore concludes that, majority of tomato farmers in the Offinso North District who perceived changes in climatic variations were middle-aged adults. Therefore, there is the need for policy interventions that are tailored to issues affecting middle-aged adults' capacity to adapt to enable them build resilience and respond appropriately to the changing climate in the study area.

The results of the study also observed that sex, age, formal education, access to extension services and access to climate information are major significant factors that influence tomato farmers' perception of climatic variables (changes in temperature, changes in rainfall pattern and changes in the intensity of solar radiation) in the Offinso North District, Ghana. These factors would provide the basis for policy formulation and implementation that seeks to sharpen the adaptive capacity of farmers in the study area and other areas with similar environmental characteristics. Such policies may include establishing irrigation projects in the area to supply farmers with water for their crops. This also has the potential to improve tomato production in the study area and the country at large. Again, policy should be geared towards developing more drought resistant tomato varieties that can withstand the vagaries of the weather and improve tomato production. Effort should also be made to provide early warning systems to update farmers on the weather dynamics to enable them plan well for their tomato cultivation. The consideration of these factors will go a long way to enhance the adaptive capacities of farmers which will culminate in improving tomato production in Ghana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IPCC. Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri RK, Meyer LA (Eds.)]. Geneva, Switzerland: IPCC; 2014.
2. Kotir JH. Climate change and variability in Sub-Saharan Africa: A review of current and future trends and impacts on agriculture and food security. Environment, Development and Sustainability. 2011; 13(3):587–605.
3. Walthall CL, Hatfield P, Backlund L, Lengnick E, Marshall M, Walsh M, et al. Climate change and agriculture in the United States: Effects and adaptation. Washington, DC. USDA Technical Bulletin; 2012.
4. IPCC. Managing the risks of extreme events and disasters to advance climate change adaptation, a special report of working groups I and II of the intergovernmental panel on climate change. Cambridge University Press, Cambridge; 2012.
5. Third World Network-TWN. The history of tomato farming in Ghana. Accra, Ghana Today. 2007;23-24.
6. Horna D, Smale M, Falck-Zepeda J. Assessing the potential economic impact of genetically modified crops in Ghana: Tomato, garden egg, cabbage and cassava. PBS Report 3-20; 2006.
7. Asante BO, Osei MK, Dankyi AA, Berchie JN, Mochiah MB, Lamptey JNL, Haleegoah J, Osei K, Bolfrey-Arku G. Producer characteristics and determinants of technical efficiency of tomato based production systems in Ghana. Journal of Development and Agricultural Economics. 2013;5(3):92-103.
8. Sinnadurai S. Vegetable cultivation. Asempa Publishers, Accra; 1992.
9. Kalibbala JM. The influence of organic manure on tomato growth in Rakai District Uganda. A Research Report Submitted to the Department of Zoology, in Partial Fulfillment of the Requirement for the Degree of Bachelor of Science, Makerere University; 2011.
10. Vignola R, Koellner T, Scholz RW, McDaniels TL. Decision-making by farmers regarding ecosystem services: Factors affecting soil conservation efforts in Costa Rica. Land Use Policy. 2010;27:1132-1142.
11. Arbuckle J, Morton LW, Hobbs J. Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk, environment and behavior; 2013.
    DOI: 10.1177/0013916513503832
    (Assessed 1 June, 2014)
12. Salau ES, Onuk EG, Ibrahim A. Knowledge, perception and adaptation strategies to climate change among farmers in Southern Agricultural zone of Nasarawa State Nigeria. Journal of Agricultural Extension. 2012;2:199-211.

13. Fosu-Mensah BY, Vlek PLG, Manschadi AM. Farmers perception and adaptation to climate change: A case study of Sekyedumase District in Ghana. Tropentag, Zurich; 2010.
14. Okonya JS, Syndikus K, Kroschel J. Farmers' perception of and coping strategies to climate change: Evidence from six Agro-ecological Zones of Uganda. Journal of Agricultural Science. 2013;5(8): 252-263.
15. Mudombi G. Factors affecting perceptions and responsiveness to climate variability induced hazards. A thesis submitted to the Department of Agricultural Economics and Extension, Faculty of Agriculture, University of Zimbabwe. 2011;8-14.
16. Deressa T, Hassan RM, Alemu T, Yesuf M, Ringler C. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798; 2008.
17. Maddison D. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10, Centre for Environmental Economics and Policy in Africa, University of Pretoria, Pretoria, South Africa; 2006.
18. Yamane T. Statistics: An introductory analysis. 2nd Ed., New York: Harper and Row. 1967;886.
19. Ndambiri HK, Ritho C, Mbogoh SG, Ng'ang'a SI, Muiruri EJ, Nyangweso PM, Kipsat MJ, Omboto PI, Ogada JO, Kefa C, Kubowon PC, Cherotwo FH. Analysis of farmers perception of the effects of climate change in Kenya: The case of Kyuso District. Journal of Environment and Earth Science. 2012;2(10):74-83.
20. Feder G, Just ER, Zilberman D. Adoption of agricultural innovations in developing countries. Economic Development and Cultural Change. 1985;33:255-298.
21. Gujarati DN. Basic econometrics. (4th Eds.). Tata McGraw-Hill Publishing Company Limited, New Delhi, India; 2004.
22. Habtemariam LT, Gandorfer M, Kassa GA. Factors influencing smallholder farmers' climate change perception: A study from farmers in Ethiopia. Environmental Management. 2016;58(2):343-358. DOI: 10.1007/s00267-016-0708-0
23. Debela N, Mohammed C, Bridle K, Corkrey R, McNeil D. Perception of climate change and its impact by smallholders in pastoral / agropastoral systems of Borana, South Ethiopia. Springerplus. 2015;4:236. DOI: 10.1186/s40064-015-1012-9
24. Mustapha SB, Sanda AH, Shehu H. Farmers' perception of climate change in central agricultural zone of Borno State, Nigeria. Journal of Environment and Earth Science. 2012;2:21–28.
25. Mamba SF. Factors influencing perception of climate variability and change among smallholder farmers in Swaziland. Indian Journal of Nutrition. 2016;3(2):138.

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