

Factors influencing tomato farmers' perception of climate variability: evidence from the Offinso North District, Ghana

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 climate variability using a binary logistic regression model. The study found that respondents had observed temperature rise (90.2%); decrease in rainfall (87.3%); protracted drought (88.1%); increase in solar radiation (74.6%) and unpredictable rainfall pattern. The binary logistic regression results indicate that the sex ($P = .05$), farming experience ($P = .05$), formal education ($P = .05$) and severity of drought ($P = .05$) are factors that significantly influence farmers perception of climate variability. The study concludes that sex, farming experience, formal education and severity of drought are major significant factors 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

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), global climate is changing “unequivocally” and “unprecedentedly” since the mid-21st century [1]. Anthropogenic forces through Greenhouse Gas emission (GHG) is 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 these greenhouse gases, especially carbon dioxide 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 IPCC 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 their crops grown. 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 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 the leaf disease 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

59 perceive climate variability differently and employ a plethora of strategies in response to the effects of
 60 the variability [11, 12, 13]. Factors such as socio-demographic characteristics, environmental and
 61 institutional have been documented as factors that have far-reaching influence on the perceptions of
 62 farmers regarding the phenomenon and its associated effects on agricultural production in general
 63 [14, 15, 16, 17]. These factors include: age, sex, marital status, income, educational levels of
 64 farmers(socio-demographic characteristics), access to credit, extension services (institutional factors)
 65 temperature and rainfall (environmental factors).

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

73 **2. MATERIALS AND METHODS**

74 **2.1. Study Area**

75
 76 The study was conducted in the Offinso North District (OND) of the Ashanti Region of Ghana, which
 77 covers an area of 741square kilometers and lies between longitudes $1^{\circ} 60^1$ W and $1^{\circ} 45^1$ E and
 78 latitudes $7^{\circ} 20^1$ N and $6^{\circ} 50^1$ S (Figure 1). The Offinso North District lies in the semi-equatorial climatic
 79 zone and experiences a double maxima rainfall regime.

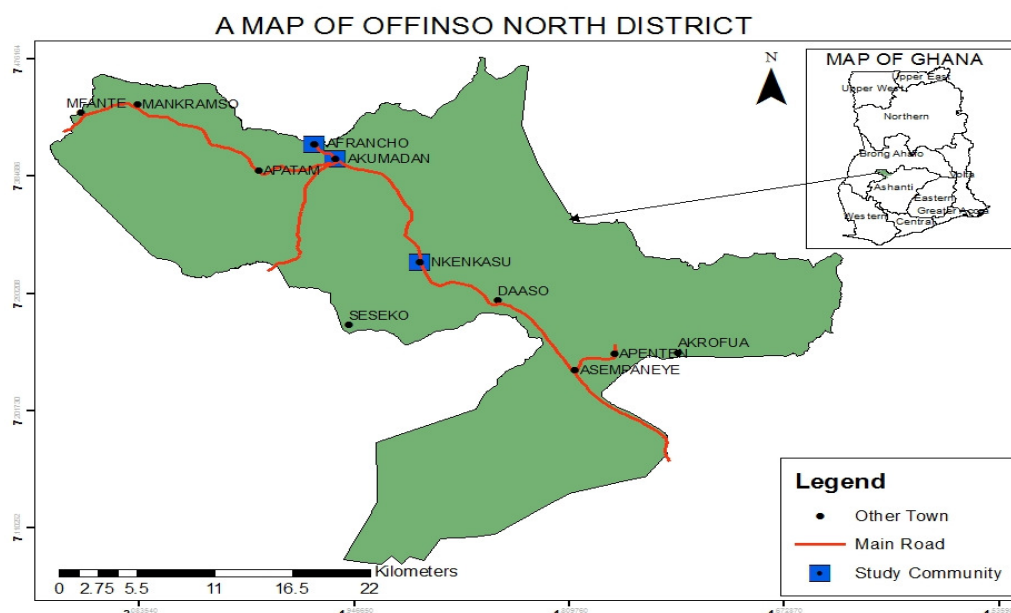


Figure. 1: Map of the study area indicating the selected communities

The first rainfall season begins from April to June, 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°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 (189.90km²); the Afrensu-Brohoma Forest Reserve (89.06km²); the Mankrang Forest Reserve (92.49km²) and the Opro River Forest Reserve (103.60km²). 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. 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 is a quantitative cross-sectional research which 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 as: $n = N / 1 + N (e^2)$ 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 (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.

129 **Table 1: Study communities and their respective total number of farmers and sample sizes**

Study Communities	No. of Farmers (N)	Percentage (%) [No./Total*100]	Proportionate Sample Percentage/100*Total Sample Size
Akomadan	2966	2966/7063*100 =42	42/100*378= 159
Afrancho	2754	2754/7063*100 =39	39/100*378= 147
Nkenkaasu	1343	1343/7063*100 =19	19/100*378= 72
Total:	7063	100	378

130 Source: MoFA, Offinso North District, 2014.

131 *--: multiplication sign

132 2.3 Theoretical Framework

133 Perception discourses in climate variability issues have always been limited to whether farmers
 134 perceive climate variability or not. Household characteristics (e.g. age, sex, marital status, income and
 135 educational levels of farmers), farm characteristic (e.g. farm size, soil type and fertility), infrastructural
 136 factors (e.g. storage facilities and market) institutional factors (e.g. access to credit and extension
 137 services) and environmental factors (e.g. temperature and rainfall) have been well documental as
 138 factors that influence farmers perception on climate variability effects [14, 15, 16, 17].The logistic
 139 regression model was used to analyse the perception of climate variability from tomato farmers'
 140 perspective. This model is preferred because of its ability to simply compute and estimate binary
 141 choices. According to Ndambiri et al. [18] the relationship between the response variable and the set
 142 of explanatory variables can be expressed as:

$$Y_i = \beta_0 + \beta_i X_i + e_i \quad (1)$$

143 Where Y_i represent the perception of farmers with $Y_i = 1$ indicating when a farmer perceives climate
 144 variability and $Y_i = 0$ showing when a farmer does not perceive climate variability; β_0 denotes the
 145 intercept with β_i indicating the parameters to be estimated; X_i are the independent variables under
 146 consideration with e_i indicating the error term.This model in equation (1) is a linear regression model,
 147 however, because the regressand is binary in nature, it is referred to as the linear probability model
 148 (LPM). However, due to the weakness associated with LPMs which according to Feder et al. [19] fail
 149 to meet statistical assumptions necessary to validate conclusions based on set hypotheses, the logit
 150 or probit models are preferred [20]. According to Ndambiri et al. [18] the logistic cumulative probability
 151 function is expressed as:

$$P_i = F(Z_i) = \frac{1}{1+e^{-Z_i}} \quad (2)$$

From equation (2) P_i is the probability that a farmer, i^{th} , will be in the category in equation (1) 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 (2), 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 (2) by $1 + e^{-Z_i}$ results in equation (3) expressed as:

$$(1 + e^{-Z_i})P_i = 1 \quad (3)$$

Rationalizing equation (3) results in:

$$e^{-Z_i} = \frac{1}{P_i} = \frac{1-P_i}{P_i} \quad (4)$$

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

This implies that, $e^{-Z_i} = \frac{P_i}{1-P_i}$ (5)

From equation (5) when logarithm of both sides is taken, the result will be:

$$Z_i = \log \left\{ \frac{P_i}{1-P_i} \right\} \quad (6)$$

From equation (6)

$$\log \left\{ \frac{P_i}{1-P_i} \right\} = \beta_0 + \beta_i X_i \dots + \beta_{ni} X_{ni} + e_i \quad (7)$$

Equation (7) defines the logistic probability model based on the Z logit. From the above equations, the marginal effects of the explanatory variables according to [18] can be expressed as:

$$\frac{\delta P_L}{\delta X_L} = \frac{\beta_L e^{-Z_L}}{(1 + e^{-Z_L})^2} \quad (8)$$

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 or non-perception of climate variability) were regressed to see their effects on the explanatory variables of household characteristics (age, sex, marital status, farming experience and formal educational status of farmers), institutional factors (access to climate information and extension services) and other characteristics such as farmers' experience of changes in rainfall pattern, changes in temperature and severity of drought. Therefore, [18] express the logistic regression model as:

$$Z_i = (\beta X_i) + \varepsilon \quad (9)$$

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).

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
X_8	Changes in rainfall pattern	Experience=1 and 0=otherwise	β_8
X_9	Changes in temperature	Experience=1 and 0=otherwise	β_9
X_{10}	Severity of drought	Experience=1 and 0=otherwise	β_{10}

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 flooding and increase in solar radiation (Table 3). The results are represented in table 3.

3. RESULTS AND DISCUSSION

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
Increase flooding	57.9	7.1	30.2	16.5	4.1	32.2	25.7	1.8	56.1
Protracted 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

Generally, all the respondents were of the view that the climate had become variable. With respect to the 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 decrease in rainfall with 73.5 percent perceiving 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 increased 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 warming conditions. The above analysis points 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, the study showed that, while 42.7percent of the farmers in the age group of 41 and 50 perceived a rising temperature, 30% of them were between the ages of 31 and 40 years. Also only 10.9percent and 6.6percent 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 shown that majority of the respondents (45.2%) between 31 and 40 years perceived decreases in rainfall. This was followed by those aged between 41 and 50 years with a percentage of 25.2 percent. Also, 10.6percentof the respondents who perceived decrease in rainfall were between the ages of 20 and 30 with 6.3percent aged above 50 years. Again, 32.1percent of the respondents between the ages of 31 and 40 years perceived unpredictability in rainfall pattern. This was followed by those between the ages of 41 and 50 years (27.2%) who perceived unpredictable rainfall pattern in the area. Also, respondents below the ages of 31 years (8.9%) perceived unpredictable rainfall pattern with those above 50 years (5.3%) who formed the minority perceived unpredictability in rainfall pattern. In the area of protracted drought, 51.0percent of the farmers between the ages of 41 and 50 years perceived they had observed severe drought conditions. This was followed by those between the ages 31 and 40 years (20.1%). Also, only few respondents below 31 years and above 50 years with

the percentages of 10.7percent and 6.3percent respectively, perceived severe drought condition 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, 9.1percent and 5.3percent of respondents who perceived increase in solar radiation were those below 31 years and above 50 years respectively. Regarding farmers' perception of increased frequency of flooding, 30.2percent of the respondents between the ages of 31 and 40 years indicated they had perceived increase in flooding over the years. They were followed by those aged between 41 and 50 years (16.5%). However, 7.1percent of the respondents who perceived an increase in flooding were those below 31 years while 4.1percent of them were above 50 years. This means that majority of the middle-aged adults who are active in the tomato business in the District perceived changes in key climatic elements which shows 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, majority of the respondents (55.6%) who perceived changes in climate had formal education while 44.4percent of the farmers who perceived climate variability and change had no formal education. Also, majority of the farmers (50.1%) who perceived increase in temperature were those who had formal education while 40.1percent of them had no formal education. However, no respondent perceived a decrease in temperature. While majority of the farmers (48.5%) who perceived decrease in rainfall had formal education, 38.8percent of them had no formal education. The study again showed that, while 48.9percent of the farmers who perceived an increase in protracted drought had formal education, 39.2percent 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 those who had no formal education. They formed 32.7percent. Also, majority of the farmers (32.2%) who perceived increase in frequency of flooding were those who had formal education. This was contrary to those who had no formal education. They formed 25.7percent of the respondents. While 41.4percent of the farmers who

perceived an increase in solar radiation over the years had formal education, 33.2percent of them had no formal education. The forgone analysis implies that some level of relationship exist between access to formal education and farmers perception of climate variability in the study area.

Regarding farmers farming experience, the study showed that, majority of respondents (96.8%) who perceived climatic variations are those with high experience (above 10 years), only 3.2percent of them are those who had low farming experience (below 10 years). Also, regarding farmers who perceived an increase in temperature over the years, it was realised that 87.3percent of them had several years of farming experience as compared to those with few years of farming experience. They formed only 2.9 percent of the respondents. Moreover, while majority of the farmers (85.3%) who perceived protracted drought had more than 10 years farming experience, only 2.8 percent of them had low farming experience. The study also showed that 84.5percent of the farmers who had more than 10 years in the farming perceived decrease in rainfall while 2.8 percent of them had few years of farming experience. Regarding unpredictability of rainfall, the study showed that 71.2 percent of those who perceived the rainfall pattern to be unpredictable had more than 10 years farming experience as against those with less than 10 years farming experience with a percentage of 2.3 percent. While the farmers who perceived increased frequency of flooding had high experience (56.1%), only 1.8 percent of them had low farming experience.

With respect to the intensity of solar radiation as perceived by the farmers, the study showed that majority of them had high farming experience (72.2%) while 2.4percent of the rest had low farming experience. Farming experience therefore plays an important role in farmers' perception of climate variability. The experience of farmers could also inform their decision to employ sound adaptive strategies that would go a long way to help them reduce the effects of adverse climatic conditions on crop production, especially tomato production in the study area.

3.1 Modeling tomato farmers perception of climate variability

The econometric model was used to analyse the perception of tomato farmers. The model involves a

Table 4: Results of Logistic Regression Model of Tomato Farmers Perception of Climate Variability.

Explanatory variables	Coefficients (beta)	Sig. values
Sex	0.65**	.02

Age	0.19	.20
Marital status	0.04	.78
Farming experience	0.28**	.05
Formal education	0.09**	.02
Changes in rainfall pattern	0.48	.16
Changes in temperature	0.11	.81
Severity of drought	-0.56**	.04
Access to climate information	0.23	.53
Access to extension services	-0.26	.43
Economic diagnostic		
<i>Likelihood ratio test for zero slope</i>	34.18, $p > \chi^2(15) = 0.05$	
<i>Total observation</i>	378	

NB. *** significant at 1% level; ** significant at 5% level; * significant at 10% level

binary variable that indicates whether farmers perceive climate variability or otherwise. The outcome variable was regressed on the set of explanatory variables. 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 the variables that are statistically significant at 1percent, 5percent and 10percent.

Generally, the results of the econometric analyses show that the sex of respondents, farming experience, formal education and severity of drought are factors that significantly influence tomato farmers' perception of climate variability in the Offinso North District.

With regard to the sex of farmers, the coefficient was found to be significant ($P = .05$) and positive for perceiving climate variability in the study area. Therefore, the probability of a male farmer perceiving climate variability 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. Males in the study area may be interested in listening to and watching of news where they get information than their female counterparts.

Also, the coefficient of the farming experience of farmers was found to be significant ($P = .05$) and positive for perceiving that there are variability in climate. This means that the more the experience of

respondents the higher the probability of perceiving the manifestation of climate variability. Hence farmers with more farming experience have higher likelihood of perceiving climate variability.

Moreover, formal education of respondents was found to be significant ($P = .05$) and positive for perceiving climate variability. This implies that the higher a person acquires formal education the more the probability of perceiving climate variability. This was consistent with the findings of Ndambiri et al. [18] who found that, farmers with higher education have greater probability of perceiving climate variability.

Finally, with regard to the severity of drought as a factor influencing farmers perception, the coefficient was found to be significant ($P = .05$) and negative for perceiving climate variability. Hence, the more the respondents experience the severity of drought, the less their perception of climate variability. This was found to be inconsistent with the expectation of the study, since farmers' experience of drought condition will influence their perception of climate variability.

4. CONCLUSION

The study sought to analyse 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 and Ghana to a larger extent. 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 unpredictability of rains. The descriptive analysis indicated that age, educational status and farming experience were found to 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, protracted drought and increased solar radiation were between the ages of 41 and 50 years, those who perceived decrease in rainfall, increased incidence of flooding and unpredictable rainfall pattern were aged between the ages of 31 and 40 years. The study therefore concluded that, majority of tomato farmers in the Offinso North District who have perceived changes in climatic variations are the middle-aged adults. Therefore, there is the need for policy interventions that are tailored to issues affecting middle-aged adult 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 concluded that sex, farming experience, formal education and severity of drought are major significant factors that influence tomato farmers' perception of climate variability in the Offinso North District. These factors would provide a basis for policy formulation and implementation that would seek 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 would go a long way to improve tomato production in the study area and the country at large, where more fresh tomatoes are imported into the country to supplement what is locally produced. Again, policy should be geared towards developing more heat resistant tomato varieties which can withstand the vagaries of the weather and improve tomato production. Effort should also be made to provide a forecast of the weather on a regular basis through the electronic media such as the radio stations in the district to update farmers on the weather dynamics to enable them plan well for their tomato activities. Farmers should be encouraged to get formal education so that it can positively inform their decision in employing sound adaptive measures in response to the climatic variation on tomato production. One way of achieving that is to encourage the farmers to take part in the non-formal education in the country that emphasises on literacy and numeracy skills of elderly people. This will help farmers to read and apply simple instructions relating to application of agrochemicals as well as becoming informed of the new technological ways of farming. It will also broaden their horizon and knowledge on the nexus between climate variability and tomato production and enhance their adaptive capacities regarding the effects of the climatic variations on agriculture.

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, Adkins S, Aillery M, Ainsworth EA, Ammann C, Anderson CJ, Bartomeus I, Baumgard LH, Booker F, Bradley B, Blumenthal DM, Bunce J, Burkey K, Dabney SM, Delgado JA, Dukes J, Funk A, Garrett K,

- 379 Glenn M, Grantz DA, Goodrich D, Hu S, Izaurralde RC, Jones RAC, Kim SH, Leaky ADB,
380 Lewers K, Mader TL, McClung A, Morgan J, Muth DJ, Nearing M, Oosterhuis DM, Ort D,
381 Parmesan C, Pettigrew WT, Polley W, Rader R, Rice C, Rivington M, Roskopf E, Salas WA,
382 Sollenberger LE, Srygley R, Stöckle C, Takle ES, Timlin D, White JW, Winfree R, Wright-
383 Morton L, Ziska LH . Climate change and agriculture in the United States: Effects and
384 adaptation. Washington, DC. USDA Technical Bulletin; 2012.
- 385 4. IPCC. Managing the risks of extreme events and disasters to advance climate change
386 adaptation, A Special Report of Working Groups I and II of the Intergovernmental Panel on
387 Climate Change. Cambridge University Press, Cambridge; 2012.
- 388 5. Third World Network-TWN. The history of tomato farming in Ghana. Accra, Ghana Today, pp.
389 23-24; 2007.
- 390 6. Horna D, Smale M, Falck-Zepeda J. Assessing the potential economic impact of genetically
391 modified crops in Ghana: tomato, garden egg, cabbage and cassava. PBS report 3-20; 2006.
- 392 7. Asante BO, Osei MK, Dankyi A A, Berchie JN, Mochiah MB, Lamprey JNL, Haleegoah J, Osei
393 K, Bolfrey-Arku G. Producer characteristics and determinants of technical efficiency of tomato
394 based production systems in Ghana. Journal of Development and Agricultural
395 Economics.2013;5(3):92-103
- 396 8. Sinnadurai S. Vegetable Cultivation. Asempa Publishers, Accra ;1992.
- 397 9. Kalibbala JM. The influence of organic manure on tomato growth in Rakai District Uganda. A
398 research report submitted to the Department of Zoology, In partial fulfillment of the
399 requirement for the degree of Bachelor of Science, Makerere University; 2011.
- 400 10. Vignola R, Koellner T, Scholz RW, McDaniels TL. Decision-making by farmers regarding
401 ecosystem services: factors affecting soil conservation efforts in Costa Rica. Land Use Policy.
402 2010;27:1132-1142.
- 403 11. Arbuckle J, Morton LW, Hobbs J. Understanding Farmer Perspectives on Climate Change
404 Adaptation and Mitigation: The Roles of Trust in Sources of Climate Information, Climate
405 Change beliefs, and Perceived Risk, Environment and Behaviour.
406 Doi:10.1177/0013916513503832, 2013; Assessed 1 June, 2014.

- 407 12. Salau ES, Onuk EG, Ibrahim A. Knowledge, Perception and Adaptation Strategies to Climate
408 Change among Farmers in Southern Agricultural Zone of Nasarawa State Nigeria. *Journal of*
409 *Agricultural Extension*.2012; 2:199-211.
- 410 13. Fosu-Mensah BY, Vlek PLG, Manschadi AM. Farmers Perception and Adaptation to Climate
411 Change: A Case Study of Sekyedumase District in Ghana, Tropentag, Zurich; 2010.
- 412 14. Okonya JS, Syndikus K, Kroschel J. Farmers' perception of and coping strategies to climate
413 change: Evidence from six Agro-ecological Zones of Uganda. *Journal of Agricultural Science*.
414 2013; 5(8):252-263.
- 415 15. Mudombi G. Factors affecting perceptions and responsiveness to climate variability induced
416 hazards. A thesis submitted to the Department of Agricultural Economics and Extension,
417 Faculty of Agriculture, University of Zimbabwe. 2011; 8-14.
- 418 16. Deressa T, Hassan RM, Alemu T, Yesuf M, Ringler C. Analyzing the determinants of farmers'
419 choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia.
420 IFPRI Discussion Paper 00798, September; 2008.
- 421 17. Maddison D. The Perception of and Adaptation to Climate Change in Africa. CEEPA
422 Discussion Paper No. 10, Centre for Environmental Economics and Policy in Africa,
423 University of Pretoria, Pretoria, South Africa; 2006.
- 424 18. Ndambiri HK, Ritho C, Mbogoh SG, Ng'ang'a SI, Muiruri EJ, Nyangweso PM, Kipsat MJ,
425 Omboto PI, Ogada JO, Kefa C, Kubowon PC, Cherotwo FH. Analysis of farmers perception
426 of the effects of climate change in Kenya: The case of Kyuso District. *Journal of Environment*
427 *and Earth Science*. 2012;2(10):74-83.
- 428 19. Feder G, Just ER, Zilberman D. Adoption of agricultural innovations in developing countries.
429 *Economic Development and Cultural Change*. 1985;33:255-298.
- 430 20. Gujarati DN, (4theds). *Basic Econometrics*. Tata McGraw-Hill Publishing Company Limited,
431 New Delhi, India; 2004.