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## FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

# Cocoa farmer's perception on climate variability and its effects on adaptation strategies in the Suaman district of western region, Ghana

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**Abstract:** Climate Change has gained global attention due to its adverse impact on agriculture. Cocoa production in Ghana is also under threat following climate change. This study, therefore, examined farmers' perception on climate variability and its effect on adaptation strategies in the Suaman district of Western Region, Ghana. It involved 240 cocoa farmers. The study estimated Heckman's treatment effect model that corrected the presence of selectivity bias in the sample. From the result, 69.5% of the farmers perceived an increase in the average temperature while 22.5% perceived an increase in the average rainfall over the years. The factors that significantly influenced farmers' perceptions were farm size, farm management training, household size and farmer-based organization (FBO) membership. The major adaptation strategies adopted by the farmers were pesticides application, planting improved varieties, mixed planting and changing planting dates. Farmers' perception was found to have a positive impact on their adaptation. Other factors that significantly influenced adaptation were age of cocoa farm, household size and FBO membership. The study concluded that perceptions are essential in adapting to climate variability in the district. Training of farmers on cocoa production and other

### ABOUT THE AUTHORS

The authors are researchers and rural development experts with specialization in agricultural marketing and finance, farm technology adoption, agricultural value chains, farm-level efficiency and farm household welfare measurements. Over the years, the group has done a substantive fieldwork in terms of research and project implementation with both local and international donor organizations such as US. Agency for International Development (USAID), Netherland Development Organization (SNV), The Canadian International Development Agency (CIDA), Association of Church-Based NGOs (ACDEP) among others in the specific areas of project evaluations, baseline studies, farmer training, linking farmers to markets, and farm business developments.

Some of their research works that emanate from their field work have enriched teaching and learning over the years at the Department of Agricultural and Resource Economics, University for Development Studies, Tamale, Ghana where the authors teach courses at the undergraduate level.

### PUBLIC INTEREST STATEMENT

Crop production including cocoa is under threat due to the effects of climate variability and change. The study aims to contribute to the understanding of cocoa farmers' perception towards climate variability and how these perceptions intend affect their adaptation strategies towards the challenges of climate variability. Empirical findings show that majority of cocoa farmers perceived that there is indeed a year to year change in rainfall and temperature with their perception been influenced by agricultural related training received and membership of a farmer-based organization. The main adaptation strategies employed to mitigate climate variability include an application of pesticides, planting of improved seed varieties and changing of planting dates. These adaptations strategies were positively and significantly influenced by how they perceive a change in rainfall and temperature. Organization of workshops on climate variability or change, mitigation strategies and its effects on crop productivity is key to improving growth in Ghana's cocoa industry and is, therefore, highly recommended.

agricultural activities in relation to climate variability and its impact is highly recommended. Similarly, enhancing access to weather forecast information is important to enhance farmer's perceptions and also effectively implement adaptation strategies such as changing planting dates.

**Subjects: Environment & Economics; Environment & Resources; Environmental Issues; Resource Management-Environmental Studies**

**Keywords: adaptation; cocoa; climate variability; Heckman treatment effect model**

### 1. Introduction

Peoples all over the world who depend on nature for their well-being are exposed to climate variability or change and its effects. Agriculture in Africa been weather-dependent activity is most vulnerable to climate change and its effects. Rural dwellers in Sub-Saharan Africa heavily depend on the natural resource base for the provision of food and income for the survival of themselves and their family, and such resource availability is dependent on favorable climatic conditions (Solomon, Snyman, & Smit, 2007). In most parts of Sub-Saharan Africa where dry land farming is very common, over reliance on rain-fed agriculture increases farmers vulnerability to adverse effects of climate change (Mertz, Mbow, Reenberg, & Diouf, 2009; Thomas, Twyman, Osbahr, & Hewitson, 2007). Not only do resource-poor farm households have limited capacity to climate change adaptation, they are also particularly vulnerable (Antwi-Agyei, Fraser, Dougill, Stringer, & Simelton, 2012). There is no doubt that agriculture is a major contributor to climate change on one hand, and a key victim of climate change on the other hand and, of course, Ghana's agriculture is no exception.

Currently, the agricultural sector contributes 22% of Ghana's GDP (World Fact Book, 2014) and employs 42% of the economically active workforce (Ghana Statistical Services, 2012). The sector has been described as the bedrock of the country in the post-independence history. One major contributor to agriculture's share of Ghana's GDP is the cocoa sub-sector. Apart from all other crops combined, the cocoa subsector contributed 13.3% to agriculture's share of Gross Domestic Product (GDP) in 2012 (Ghana Statistical Services, 2012). The total land area under production in 2012 was 16,007,000 hectares with an average yield of 0.4 metric tons per hectare (Ministry of Food and Agriculture, 2013). Institute of Statistical, Social and Economic Research (ISSER) (2013) noted that Ghana has recorded an economic growth despite world recession as a result of an increased price for Ghana's major export commodities, cocoa, and gold. For instance, Ghana received US\$2.8 billion and US\$5.6 billion export revenues from cocoa and gold, respectively; accounting for 62% of export receipts in 2012 (Institute of Social, Statistical and Economic Research, 2013). Danso-Abbeam, Aidoo, Agyemang, and Ohene-Yankyera (2012) therefore described cocoa as a notable industrial tree crop that dominates agricultural exports. Locally, cocoa production provides an important source of employment and income for many households (Essegbey & Ofori-Gyamfi, 2012). Anim-Kwapong and Frimpong (2010) estimated that cocoa production accounts for the livelihoods of over 800,000 smallholder families (350,000 farm owners) in Ghana. The authors further noted that the share of cocoa to smallholder household annual income is between 70–100%. The implication is that some households depend entirely on cocoa production for all their income needs. Ghana's cocoa production is concentrated in the forest belts; Ashanti, Western, Eastern, Volta, Brong Ahafo and Central regions due to their favourable weather, especially, the high levels of rainfall as well as the bi-modal nature of the rains.

Unfortunately for Ghana, like many other parts of the world, climate change or variability may have a dwindling effect on agricultural activities, including cocoa production. The features of weather variability have over the years affected the production of cocoa. For instance, variation in the two key weather parameters, rainfall and temperature affect the sprouting and growth of the cocoa trees as well as the cocoa pods. The variation in rainfall pattern most times confuse farmers and alter the cocoa tree's production process. Farmers study the weather to apply inputs like fertilizer and pesticides to supplement soil nutrient and prevent insects and diseases while the normal

production process of cocoa trees are often altered by changes in the pattern of rainfall and temperature. Rural folks already have fair knowledge about climate variability as part of their traditional ecological knowledge, acquired and transferred through generations (Berkes, Colding, & Folke, 2000). However, the perception of indigenous farmers, their behaviour when it comes to the issue of climate change as well as their beliefs may have significant effect in the process of the challenges of climate change. As a result, it is very important to understand how farmers' response and react to such changes in climatic conditions to guide their climatic change adaptation strategies. Accounting for farmer's adaptation strategies is a necessary step to estimate climate variability or change adaptation responses. The main objective of this study is to answer the question of factors affecting cocoa farmer's choice of adaptation strategies and whether their perceptions have any significant effects on adaptation strategies.

## 2. Literature review

### 2.1. Climate variability and its impact on agriculture

Climate is the average weather conditions of a particular geographical area, measured over a longer period (National Aeronautics and Space Agency, 2008). Generally, climate refers to the patterns of variation in variables such as temperature, rainfall, humidity, wind, atmospheric pressure and precipitation. Climate change is a long-term continued changes, either increase or decrease, in the average weather condition. According to the Intergovernmental Panel on Climate Change (IPCC, 2012), climate change is the changes in the climate condition as a result of the changes in the mean and/or the variability of its properties and that which persists for an extended period, typically decades or longer. On the other hand, climate variability is the year-to-year fluctuations in the average weather condition. Climate variability describes how each year's climate deviates from a long-term average climate value. These changes must be measurable by statistical tests and may result from natural occurrences or human activities that affect the composition of the atmosphere. This means that climate variability describes short term changes while climate change describes long-term changes in a climate variable. For instance, rainfall variability is the differences in rainfall from place to place (spatial variability) or the differences in rainfall between years (inter-annual variability) (Obeng, 2014). Generally, temperatures have increased by about 1°C over the last 40 years of the twentieth century as rainfall reduced by about 20% while projections for Ghana indicates that the country is experiencing temperature increase in all agro-ecological zones by an average of 0.25°C from 2010 to 2020 (Environmental Protection Agency of Ghana, 2000).

Empirical evidence has suggested that changes in climate have led to a reduction in crop production in most parts of the world (Stige et al., 2006). Stige et al. (2006) indicated that poverty would rise in Africa since food production would be negatively affected. This points to the fact that the future of crop production is blurred as climate variability eludes the continent. Cocoa production relies on natural factors such as land, rainfall and sunshine (Codjoe, Ocansey, Boateng, & Ofori, 2013). The cocoa crop is highly responsive to these environmental and weather variations (Agbongiarhuoyi et al., 2013). For instance, climate change significantly alters cocoa pest and pathogens incidence hence affecting their interactions (Agbongiarhuoyi et al., 2013; Oyekale, 2009). Codjoe et al. (2013) concluded from their study that, climate change is the main factor affecting cocoa production.

### 2.2. Climate variability and change adaptation strategies in cocoa production

Climate changes are disincentive to agricultural investment, prompting the risk-averse farmer to take precautionary strategies that buffer against climatic extremes (Barrett et al., 2007; Hansen, Mason, Sun, & Tall, 2011). Jiri, Mafongoya, and Chivenge (2015) also reported that climate change and variability is one of the biggest global threats to agricultural production for the current and future generations. According to IPCC (2012), adaptation refers to the adjustments in natural or man-made systems in response to actual or expected climatic stimuli or their effects. Adaptation strategies may be specific to geographical area or vary from time to time; as a result, a climate change adaptation strategy could become inappropriate overtime (Food & Agriculture Organization, 2009). IPCC (2007) noted that most local communities have developed indigenous-based adaptation practices which

could be harnessed to improve the resilience of such communities. Adaptation strategies require that the individual adapting learns the potential risks of climate change, assess the implications of the strategy, provide conditions for a favourable adaptation process as well as mobilize resources for implementation (Codjoe et al., 2013). From Codjoe et al. (2013), cocoa farmers in Ghana adopted five main coping and adaptation strategies, namely, shade management strategy, soil fertility strategy, land preparation strategy, farm size strategy (diversification of crop) and lining and pegging strategy.

### 3. Materials and methods

#### 3.1. Study area

The study was carried out in the Suaman district (which until 2012 was part of Aowin Suaman district) located in the Western Region of Ghana. The district covers an area of 400.14 sq km and shares boundaries with Juaboso and Bodi districts to the north, the Aowin district to the south, Sefwi Akontombra district to the east and Cote d'Ivoire to the west. From 2010 national population census, the district has a total population of 20,529, representing 4.5% of the Western region's population. The district is located in the forest belt. It receives nine months of rainfall with peaks in May and June. The annual average rainfall of the region is between 1500 mm and 1800 mm while temperatures range between 28°C and 37°C. The highest temperatures are recorded between February and March while the lowest is in August. The district has a good drainage pattern which enhances the fertility of the soils for the production of both food and cash crops.

Economically, 72.3% of the entire district population are in economically active age (15 years plus) of which 95.7% are employed. The largest employer (94.1%) is the private informal sector. Cocoa production is the major economic activity of the people in the district with about 65–70% of the vegetation cover being cocoa plantations. This has affected land allocation for the production of food crops (Ghana Statistical Services, 2012).

#### 3.2. Sampling and data collection methods

Primarily, the information for the analysis was obtained from cross-sectional primary data through a well-structured questionnaire. The selection of cocoa farm households followed a multi-stage sampling procedure. In the first stage, Suaman district was randomly selected from the many cocoa-producing districts in the western region of Ghana. Western region was purposively selected due its dominance in Ghana's cocoa industry. Secondly, a simple random sampling was used to select 12 communities in the district where 20 cocoa farm households were selected from each community given a total sample size of 240.

#### 3.3. Analytical framework

In this study, we model the effects of climate variability or change perception on adaptation strategies adopted by cocoa farm households and correct the problem of selected bias that may arise in the data-set. Thus, selection bias may arise because farmers who perceived that there is a change in the climate over the past decade may be systematically different from their counterparts who may perceive no change in the climatic conditions over the same period. Like the Heckman model (1979), the treatment effect model is a two-stage model. The first stage is whether the cocoa farm household perceives that there is climate variability or not. This is a selection equation model which is a binary probit model. The second stage is a linear or average response model and it is called the substantive equation or the outcome model. This defines the number of adaptation strategies adopted by farmers. In the estimation process, the selection equation (perception) was first estimated and the predicted values of the dependent variable (in this case, perception) obtained and used to construct an additional variable, known as an Inverse Mills Ratio (IMR). The IMR is used as an additional variable in the outcome equation to correct sample selection so that the independent variables can be free from any bias. This enables us to measure the true effect of the selection variable on the outcome variable.

In this model, specification error is treated as a true omitted-variable problem and taken into consideration when estimating the parameters of outcome equation. This means the effect of selection bias is neither thrown away nor assumed to be random but is explicitly used and modeled in the outcome equation. Mathematically, the selection equation is assumed to be a probit distribution since this provides consistent, asymptotically efficient estimates for all parameters (Van de Ven & Van Praag, 1981). This is given as;

$$P_r(S_i = 1/Z_i, \beta) = \Phi(h(Z_i, \beta)) + \mu_i \tag{1}$$

where  $S_i$  the latent level of utility the farmer receives from his/her perception on climate variability (1 for perception, 0 otherwise)  $Z_i$  is a set of factors influencing  $S_i$ ,  $\beta$  is a set of parameters that would be estimated and  $\Phi$  is the standard normal cumulative distribution function.

In the second stage, the adaptation model is given as:

$$E(Y_i/S_i = 1) = f(X_i, \beta) + \gamma_1 \frac{\phi(Z_i, \delta)}{\Phi(Z_i, \delta)} \tag{2}$$

where  $E$  is the expectation from adopting a number of climate variability strategies,  $\phi$  is the normal probability density function,  $Y_i$  is the number of strategies adopted by the  $i$ th farmer and  $X_i$  are exogenous variables.  $\gamma$  is parameter estimate of IMR ( $\lambda$ ) estimated from the first stage as:

$$\frac{\phi(Z_i, \delta)}{\Phi(Z_i, \delta)} = \lambda \tag{3}$$

The IMR describes the ratio of the ordinate of a standard normal to the tail area of the distribution and provides OLS selection corrected estimates (Greene, 2003). If the IMR is statistically significant, then sample selection bias exist. However, if IMR is not statistically significant, the model has no problem with sample selection bias (Heckman, 1979; 1980). Adding  $\lambda$  to Equation 2, we have:

$$Y_i^* = X_i\beta + \gamma_i\lambda + \mu_{i2} \tag{4}$$

It would be observed that Equation (2) can only be estimated for farmers who had adopted a number of strategies in an attempt to mitigate climate variability. The addition of  $\lambda$  as an explanatory variable in the substantive equation (second stage) corrects for self-selection in the model. Supposed this is not added but ignored, then the result from the substantive equation would be biased as suggested by Heckman (1979). Nonetheless, estimating Equation 3 does not address the objective of estimating the effect of perception of climate variability on adaptation. Therefore, the formulation process of  $\lambda$  would have to be made such that it allows for the self-inclusion of perception in the substantive equation. This is given as:

$$\lambda^* = \frac{\phi(-Z_i\delta)}{1 - \Phi(Z_i\delta)} \tag{5}$$

This is obtained by an extrapolation process of Equation 1 with the substantive equation defined as:

$$Y_i = X_i\beta + S_i\omega + \mu_{i3} \tag{6}$$

Integration  $\lambda^*$  into equation 6 gives:

$$Y_i = X_i\beta + S_i\omega + \gamma_i\lambda^* + \mu_{i3} \tag{7}$$

**Table 1. Explanatory variables used in the Heckman’s model**

Variable	Measurements and units	Expected effects
Sex	Male = 1, female = 0	+/-
Farm age	Age of cocoa farm (in years)	+/-
Education	Years of school attendance (in years)	+
Household size	Number of persons in a household	+
Access to credit	d = 1 with credit access, 0 = otherwise	+
Farm experience	Number of years in cocoa farming	+
Farmer-based organization	FBO = 1 if member, 0 if otherwise	+
Farm size	Farm size (acres) allocated to cocoa farming	+
Climate change seminar	1 if attended, 0 if otherwise	+

### 3.3.1. Empirical model

Empirically, the study estimated the following equations in the first stage:

$$A_i = \beta_0 + \sum_{i=1}^6 \beta_i X_i + \mu_i \tag{8}$$

where  $X_1 \dots X_6$  denotes sex of the household head, household size, educational attainment, farm size, whether the farmer had attended training/seminar on cocoa farm or climate change and a membership of farmer-based organization (FBO) respectively.  $A_i$  represents perception while  $\mu_i$  represents error term.

The outcome equation in the second-stage is expressed as;

$$Y_i = \beta_0 + \sum_{i=1}^6 \beta_i X_i + A_i + \mu_i \tag{9}$$

where  $X_1 \dots X_6$  represents age of the farmer, whether the farmer had access to credit in the last 24 months, educational attainment, household size, experience and membership of any FBO respectively.  $A$  represents the perception variable.  $Y_i$  is the adaptation strategies and  $\mu_i$  denotes the error term. It should be noted that  $\gamma_i \lambda^*$  did not appeared in the empirical model since this is automatically generated during estimation. Description of variables used in the Heckman model, their measurement and the apriori expectations are presented in Table 1.

## 4. Results and discussions

### 4.1. Perceptions of farmers on climate variability

Generally, farmer’s perception are partly based on past observations with key interest on the recent climatic events to form their perceptions of climatic conditions and to make their decisions about adaptive behaviour (Maddison, 2006). However, it is possible that farmers’ opinions are influenced by others through communal interactions. This, notwithstanding, the farmers decide on the choice of trends in the climate variables. In this study, two main variables, temperature, and rainfall, were used as indicators for measuring climate variability. The study defined climate variability as perceived changes (year to year variations) in the average temperature and rainfall in recent times (less than 10 years). Farmers were asked about their perception on the year to year variations in temperature and rainfall for the past 10 years and the results are presented in Table 2.

**Table 2. Farmers perception of variations in temperature and rainfall**

Variable	Frequency	%
<i>(a) Temperature</i>		
Increase in temperature	167	69.58
Decrease in temperature	42	17.50
No change	31	12.92
<i>(b) Rainfall</i>		
Increase in rainfall	54	22.5
Decrease in rainfall	125	52.08
No change	61	25.42
Number of respondents	240	

The results indicated that majority (69.5%) of the farmers perceived an increase in the average temperature while 22.5% perceive an increase in the average rainfall. Additionally, 17.5% and 52.08% perceived a decrease in temperature and rainfall, respectively (Table 2). However, 12.92% and 25.42% of the respondents claimed they observed no change in average temperature and rainfall respectively. On rainfall, in particular, the farmers reported that the main change was the later onset of the rains leading to a short rainfall season. In a similar study, Jiri et al. (2015) found that as high as 85.7% and 87% of smallholder farmers’ perceived precipitation as decreasing and average temperature as increasing, respectively.

#### 4.2. Adoption of adaptation strategies

Adaptation is essential in mitigating the potential impacts of climate variability on the smallholder farmers. Jiri et al. (2015) argued that the vulnerability of smallholder farmers would continually increase without adaptation. From the survey, 11 adaptation and coping strategies were identified and presented to farmers in this study to indicate which ones they adopt. The result is shown in Table 3.

Generally, improved seed variety has been one of the important adaptation strategies to climate change and measures to increase food production. This has been affirmed by 91.7% of the cocoa farmers in the Suaman district. In most cases, these improved seed varieties are high yielding and drought resistant varieties. This confirmed Tesso, Eman, and Ketema (2012) findings that, farmers adopt crop varieties that are inherently resilient to moisture stress and increasing temperature. Studies such as Agbongiarhuoyi et al. (2013) noted that climate change significantly alters cocoa

**Table 3. Cocoa farmer’s adaptation strategies**

Strategies	Yes		No	
	Frequency	%	Frequency	%
Improved variety seeds and seedlings	220	91.7	20	8.3
Fertilizer application	80	33.3	160	66.7
Pesticides application	230	95.8	10	4.2
Land and water management practices	86	35.8	154	64.2
Plant shade trees	98	40.8	142	59.2
Mixed cropping	200	83.3	40	16.7
Livestock rearing	72	30.0	168	70.0
Off-farm income	74	30.8	166	69.2
Changing planting date	192	80.0	48	20.0

pest and pathogens incidence. Therefore, it is not surprising that 95.8% of the cocoa farmers adopt the use of pesticides as a measure to mitigate climate change impacts. The farmers admitted that without the use of pesticides, poor harvesting and high rate of post-harvest losses could be recorded. In their study also, Jiri et al. (2015) found that 77.3% of their respondents adopt agrochemicals such as pesticides in response to climate change impacts.

Generally, cocoa is noted as a mixed crop or an intercrop at the early stage (usually from 1 to 4 years). Farmers in most cases plant banana, plantain and/or cocoyam together with the cocoa. This is due to the fact that, this does not affect the yield of the cocoa but rather improve on the moisture content of the soils and also provide shade to the young cocoa trees. From the result, as high as 83.3% of the farmers practice a mixed cocoa cropping system other than mono-cropping. As a result of the changes in the pattern of rainfall, most farmers have changed their planting dates on their farms. Farmers who want to replace old cocoa trees with new seedlings have observed the changes and have also changed their planting dates in accordance. This is to ensure that the seedlings are well established before dry season begins.

#### 4.3. Factors influencing farmers' perceptions on climate variability

It was evident in the previous section that, farmers' perception on climate variability is essential for farm management. Therefore, it is important that the factors influencing farmers' perception are understood. Studies such as Bryman (2008) and Slegers (2008) suggested that farmers' perceptions on climate variability influence their adaptation since it influences their agricultural planning and management decisions. Neil Adger, Arnell, and Tompkins (2005), also revealed that adaptation to climate change and variability requires that farmers must first realize changes in the climate before they can identify and implement potential useful adaptations strategies. From the results in Table 4, farm size, farm management training, household size and FBO membership have a significant influence on farmers' perception. The significance of the Wald chi square indicates that the model estimated are appropriate and adequate. Farm size had a positive influence on farmers' perception. This means that farmers with larger farm sizes are more likely to perceive climate variability than their counterparts with smaller farm sizes. For sustainability of agriculture under climate variability and change, it is important that farmers, in general, are able to correctly perceive climate variability. In their study, Hadgu, Tesfaye, Mamo, and Kassa (2013) and Tesso et al. (2012) found no significant effect of farm size on farmers' perception, although the former study also found a positive sign on perception. Farm management training was found to have a positive effect on farmers' perception.

**Table 4. Factors influencing farmers' perceptions on climate variability**

Variables	Marginal effect	Std. error	p-value
Sex	-0.241	0.234	0.304
Household size	-0.092**	0.043	0.034
Education	-0.304	0.246	0.216
Farm size	0.013**	0.005	0.014
Farm management training	0.583*	0.311	0.061
FBO	-0.558*	0.334	0.095
Constant	0.726	0.395	0.066
Wald chi sq.		33.56***	

\*Significance at 5%.

\*\*Significance at 10%.

This indicates that farm management training received by farmers increase their perception levels in temperature and rainfall variations. Like education, training improves the farmer’s human capacity as well as their knowledge level. In this case, farmers are able to appreciate possible changes in the climate and production environment. Similarly, Tesso et al. (2012) found that access to climate change conferences has a positive influence on farmer’s perception of climate change. Deressa, Hassan, and Ringler (2011) suggested that access to climate change information improves the farmer’s perception on the subject matter.

From the result also, household size was found to have a negative influence on farmer’s perception. Thus, farmers with small household size are more likely to perceive climate variability than those with large household size. One would have expected that information flow or knowledge transfer on climate variability would increase with larger households. Perhaps, the quality of information available to the smaller households is higher than those with larger households. Ndambiri, Ritho, and Mbogoh (2013) also found that smaller households have a higher probability of predicting climate variability than larger households. Contrarily, FBO membership had a negative relationship with climate variability. This means that a non-FBO member has a better level of perception to climate variability than an FBO member. This may be due to the recent trend where FBOs are focusing on market integration (good prices and bonuses), contract arrangements, input accessibility and other social benefits they gain from joining these organizations. Thus, the orientation and focus of these bodies are negatively skewed towards environmental and climate variability issues. This is somehow consistent with a study by Bryan et al. (2013) who reported a negative relationship between farmer-farmer exchange of information and perception on temperature and rainfall variability.

#### 4.4. Determinants of farmer’s adaptation strategies

In this section of the study, we proceeded to the discussion of the second stage result of the treatment effect model. The dependent variable in this model is the number of adaptation strategies adopted by the farm households. From the result in Table 5, factors that influenced farmers adaptation strategies include the age of farm household head, household size, FBO membership and perception on climate variability; all having a positive effect. The significant of Lambda ( $\lambda$ ) in the model suggests that the estimation of the treatment effect model is appropriate and the variables are unconstrained from any bias.

The result indicated that perception on climate variability has a positive effect on the adoption of adaptation strategies among the cocoa farmers. Thus, farmers who perceived climate variability have adopted more strategies than those who did not. Thus, the farmers adopt more adaptation strategies as a strong measure to mitigate any failure on any one strategy or to enhance a combined effect of several adaptation strategies. This is consistent with previous studies indicating that farmers’ perception is essential in adaptation. For instance, Neil Adger et al. (2005) indicated that adaptation requires that the farmer has first identified a change. Tesso et al. (2012) found and argued that

**Table 5. Determinants of adaptation strategies**

Variables	Coefficient	Std. error	p-value
Farm age	0.020***	0.007	0.003
Credit	-0.287	0.266	0.281
Education	0.098	0.341	0.773
Household size	0.184***	0.057	0.001
Experience	-0.006	0.016	0.676
Farmer-based organization	1.201***	0.381	0.002
Perception	2.267**	0.938	0.016
Constant	1.427	0.911	0.117
Lambda	-1.390**	0.557	

\*\*Significance at 5%.

\*\*\*Significance at 1%.

perception is an important step to adapt to climate change. Using a multinomial model, Jiri et al. (2015) found that perceptions of climate change have a positive effect on adaptation strategies. Similar arguments were raised by Oluwatusin (2014), Nhemachena and Hassan (2007) and Maddison (2006). These studies have indicated that perception is essential for farmers' decision-making in climate change or variability adaptation (Table 5).

The age of cocoa farm was found to have a positive effect on adaptation strategies. Thus, farmers with older farms had adopted many adaptation strategies than those with relatively new farms. This could be as a result of a compounding effect of climate variability on such farms that required farmers to adopt more strategies to curb its effect. Similarly, household size had a positive effect on adaptation. The adoption of more adaptation strategies requires more labour, especially, human labour. In the cocoa growing communities such as Suaman district of Ghana, household labour is essential in cocoa farming. Therefore, it is true that more household members would provide labour assistance to their household cocoa farmers. In addition, FBO membership provides a local platform for farmers to share ideas, especially, on the various adaptation strategies. Farmers are also able to influence one another in groups. Therefore, FBO members might have provided this technical assistance to each other, leading to their adoption of more strategies.

## 5. Conclusion and recommendations

This study has econometrically estimated the effect of farmers' perception on the adaptation of climate variability strategies. The major adaptation strategies adopted by the farmers were pesticides application, planting improved varieties, mixed planting and changing planting dates. In line with other studies, this present study concluded that perceptions are essential in adaptation to climate variability in the Suaman district of Ghana. Training on agriculture activities, for that matter, cocoa production was identified as an important variable that has both positive influences on farmers' perception on climate variability and adaptation. Therefore, training of farmers on cocoa production and other agricultural activities is very important. As a result, extension services as well as other stakeholders, including agricultural related Non-Governmental Organizations (NGOs) should step up efforts in providing training and technical information to the farmers. Measures such as making weather forecast information to the farmers are also important to enhance their perceptions and also effectively implement adaptation strategies such as changing planting dates. Although farmers who belonged to an FBO had a lower probability of predicting climate variability, they are able to adopt more strategies. Therefore, the study recommends that FBO membership should be promoted while members are encouraged to use their platforms to discuss climate and environmental factors in addition to their usual discussions and assistance.

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### Competing Interests

The authors declare no competing interest.

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