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# Climate Variability: Cocoa Farmers Perception and Coping Strategies, Suaman District of Ghana as the Focal Point

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## Abstract

The study employed a treatment effect model in estimating factors that influence perception and coping strategies to climate variability. A simple random technique in selecting six (6) communities and respondents (cocoa farmers) from these communities was used since the study area is homogeneously a cocoa growing arena. A total of one hundred and twenty (120) respondents were interviewed with twenty (20) cocoa farmers randomly selected from each community for the study. From the result, 48.33% of respondents perceived climate variability correctly (thus rainfall is decreasing while temperature is increasing) whiles 51.67% perceived otherwise. The factors that significantly influenced farmer's perception were FBO membership, household size, residence, educational level of household members and farm management training. The assessment of farmers' perception on temperature and rainfall pattern and to unravel farmers' perception on climate variability are fallouts of the objectives of the study. The significant adjustment techniques embraced by the agriculturists were pesticides application, planting enhanced assortments, blended planting and changing planting dates. Agriculturists' observation was found to positively affect their adjustment. The study concluded that farmers in the study area are involved in specialization of the adaptation strategies to mitigate the adverse impacts of climate variability.

**Keywords:** Treatment effect model; Climate variability; Perception; Coping strategies; Ghana

## Introduction

Agriculture is both a victim and a culprit to climate change. Africa is the most vulnerable continent to climate change due to our dependence on rain-fed agriculture, poor infrastructure, high levels of poverty, and high levels of human and physical capital. Africa is the hardest hit to climate change despite its little contribution to greenhouse emission due to its dependence on rain-fed agriculture [1]. Climate variability is a disincentive to agricultural investment prompting the risk-averse farmer to take precautionary strategies that buffer against climatic extremes [2,3].

In Ghana, ten areas have been predicted to be affected by climate change. These areas are; water resources, agriculture and food security, biodiversity, human health, coastal zones, land management, national revenue, hydropower, production, tourism, women and the poor [4]. Low rainfall levels contribute to the downward trend in food production in Africa hence climate variability is a threat to achieving food sufficiency in developing countries and the whole world at large.

The Agricultural sector has been described as the bedrock of the Ghanaian economy in the post-independence history. The overall economic growth and development of a country depends upon the health of the agricultural sector [5]. The cocoa sub-sector dominates Ghana's agricultural exports and to a larger extent contributes significantly to the country's GDP. The share of cocoa to small household annual income is between 70-100%. It is estimated that cocoa production is responsible for the livelihoods of over 800,000 smallholder families (350,000 farm owners).

In 2013, the cocoa sub-sectorial growth rate was 3.7% despite a 5.0% percent target from a 6.9% decline growth in 2012 [6]. Rates of development of cocoa pests and pathogens are altered by climate variations. Oluwatusin [7], in his work indicated that every stage of cocoa beans production depends on favourable environmental variations with rainfall greatly influencing variations in yield hence there is the need to assess the level of cocoa farmer's perception on climate variability. Since perception is a precondition for adaptation, there is the need to also to determine the factors that influence cocoa farmers' perception on climate variability and further estimate the factors that affects cocoa farmers' coping strategies.

According to Obeng [8], rainfall has the most tremendous impact on agriculture among all climatic elements. Reduction in rainfall was as high as 300 mm (20%) in the forest regions of the country from 1951 to 2000 [9]. Western region recorded a 30 year average percentage reduction of 12.3 in rainfall as at 2010 [10]. Mean annual rainfall in the Sahel region dropped by 30% and an estimated 500,000 people died across the Sahel and as many as one million people left Burkina Faso for neighboring countries between 1997 and 2007 [1]. Peasant farmers have the lowest capacity to adapt to changes in climatic conditions [11].

The adverse effects of climate change on peasant farming have compelled African farmers to develop adaptive strategies to mitigate these effects. Reducing vulnerability means incorporating traditional indigenous knowledge in sustainable adaptive measures which can be policies, technology transfer and increasing adaptive capacities of the smallholder farmers who produce about 70% of the food supply on the continent. Climate variability in humid West Africa (south of 8°N) is

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less studied [9]. One way for farmers to overcome rainfall variability is to adapt coping strategies to minimize loses. However, like other farmers, cocoa farmers in the Suaman district have varying perception on climate variability and this has an implication on their adaptation of coping strategies. To develop a community-based coping strategy, there is the need to conceptualize the various perceptions among farmers hence the need for this research.

Generally, farmer's perceptions 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 behavior. 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 years.

Climate variability causes changes in climate. Climate variability is the year-to-year alterations in specific climate variables normally over a 30 year period within a particular area. The fact that climate variation has persisted and lingers on underlines the essence to understand and acknowledge farmers' perception and adaptation to climate change. Also potential impacts of climate change on cocoa production in West Africa have become a global concern warranting the essence of this research.

Further, it's imperative to therefore note that, the development of a community based coping strategy, assessment of the impact of climate on cocoa production, unraveling farmers perception on climate variability, to assess the mitigation strategies adopted by cocoa farmers to overcome these challenges from a climate change perspective, the assessment of farmers perception on temperature and rainfall pattern as well as bequeathing recommended strategies in coping and adjusting with the change in climate are the objectives of this study.

## Materials and Methods

The examination was completed in the Suaman region (which until the point when 2012 was a piece of Aowin Suaman area) situated in the Western Region of Ghana. The locale covers a territory of 400.14 sq km and offers limits with Juaboso and Bodi areas toward the north, the Aowin region toward the south, Sefwi Akontombra region toward the east and Cote d'Ivoire toward the west. From 2010 national populace statistics, the locale has an aggregate populace of 20,529, speaking to 4.5% of the Western area's populace. The area is situated in the woods belt. It gets nine months of precipitation with tops in May and June. The yearly normal precipitation of the locale is between 1500 mm and 1800 mm while temperatures go in the vicinity of 28°C and 37°C. The most elevated temperatures are recorded amongst February and March while the least is in August. The area has a decent waste example which improves the richness of the dirt for the creation of both nourishment and money crops.

Since the study area is homogeneously a cocoa growing district hence the use of a simple random technique in selecting six (6) communities and respondents (cocoa farmers) from these communities. These communities are; Adiepena, Aduyaakrom, Asuopokua, Donkorkrom, Susanso Camp "A" and Suibo. A total of one hundred and twenty (120) respondents were interviewed with twenty (20) cocoa farmers randomly selected from each community for the study.

The questionnaire for the study is divided into six (6) sections. Section 1 dealt with the personal information or bio-data of respondents. Section 2 focused on labor use for farming activities whiles section 3 collects data on the views of respondents on their perceptions of some climatic factors such as rainfall, sunshine intensity, temperature and wind speed. Section 4 dealt with the changes in climatic factors and farmers adaptation/coping strategies, while section 5 took a gander at the contributions for generation and their comparing yield levels. Finally, section 6 focused on the effects of climate change on cocoa production specifically on certain parameters like pest and disease as well as reduction in yield and death of cocoa trees. The questions are both closed and open ended which gives respondents possible answers to select from as well as the freedom to express their views. Since Suaman region is a cultivating group, the vast majority of the respondents couldn't read nor compose so this constrained the specialists to give time with such people by running over the inquiries with them to their level of comprehension. The other part of the respondents who are expressive diminished the weight on analysts by noting the surveys themselves.

### Theoretical framework specification

**Treatment effect model:** Maddala [12] extended the sample selection perspective to the evaluation of treatment effectiveness. Heckman's model offers a theoretical framework for modeling sample selection but is also based on what was at the time a pioneering approach to correcting selection bias. The sample selection model is among the most important contributions to program evaluation; however, the treatment effect model focuses on offering practical solutions to various types of evaluation problems. Equally important, Heckman's model lays the groundwork for understanding the treatment effect model. The treatment effect model investigates a class of policies that have partial participation at a point in time so there is a treatment group and a comparison group.

Following the examples of Lolig et al. [13] using treatment effect model to simultaneously estimate the adoption and welfare models, the estimation of the adoption model enabled them to know factors that influence the choice of a coping strategy whiles the welfare model measured the effects of the choice of a coping strategy on household welfare as well as other determinants of welfare.

The treatment effect model differs from the sample selection model in two aspects:

I. a dummy variable indicating the treatment condition $W_i$ (i.e., $W_i$=1 if participant $i$ is in the treatment condition and $W_i$=0 otherwise) is directly entered into the regression equation, and

II. The outcome variable $Y_i$ of the regression equation is observed for both $W_i$=1 and $W_i$=0. Specifically, the treatment effect model is expressed in two equations:

Regression equation: $Y_i = \mathbf{X}_i\beta + W_i\delta + \varepsilon_i$ (1)

Selection equation: $W_i^* = \mathbf{Z}\gamma + U_i$ (2)

$W_i$=1 if $Wi$=0 and $Wi$=0 otherwise

Prob $\left(W_i = 0 \mid \mathbf{Z}_i\right) = 1 - \Phi\left(\mathbf{Z}_i\gamma\right)$, and

Prob $\left(W_i = 0 \mid \mathbf{Z}_i\right) = 1 - \Phi\left(\mathbf{Z}_i\gamma\right)$,

where $\varepsilon_j$ and $U_j$ are bivariate normal with mean zero and covariance matrix $\begin{bmatrix} \sigma_\varepsilon & \rho \\ \rho & 1 \end{bmatrix}$. Given incidental truncation (or sample selection) and that $W$ is an endogenous dummy variable, the evaluation task is to use the observed variables to estimate the regression coefficients β, while controlling for selection bias induced by non-ignorable treatment assignment. The model expressed in Equations 1 and 2 is a switching regression. By substituting $W_i$ in Equation 1 with Equation 2, we obtained two different equations of the outcome regression:

$$\text{when } W_i^* > 0, W_i = 1: Y_i = \mathbf{X}_i\beta + (\mathbf{Z}_i\gamma + U_i)\delta + \varepsilon \quad (3)$$

and

$$\text{when } W_i^* \leq 0, W_i = 0: Y_i = \mathbf{X}_i\beta + \varepsilon_i \quad (4)$$

**Empirical model:** The treatment effect model offers the opportunity to simultaneously estimate the factors that determine the perception of climate variability and the effects of perceiving climate variability on adaptation of coping strategies as well as other factors that influence adapting a coping strategy.

The empirical OLS model for analyzing farmers' awareness of climate change is specified as:

$$Y^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_8 + U_1 \quad (5)$$

Where: $Y^*$=Coping Strategies

$X_2$=Farm age, $X_2$=Farm size, $X_3$=Access to input credit, $X_4$=Farm management training, $X_5$=Highest educational level of any member of the household, $X_6$=Experience of farmer, $X_7$=Education of farmer, $X_8$=Climate Variability, $\beta_0$=constant and $U_1$=error term.

Hence the probit model:

$$Pi = c + (1-c)F(b_0 + b_1\delta_1 + b_2\delta_2 + b_3\delta_3 + b_4\delta_4 + b_5\delta_5 + b_6\delta_6 + b_7\delta_7 + \varepsilon) \quad (6)$$

$\delta_1$=FBO membership, $\delta_2$=Household size, $\delta_3$=Sex, $\delta_4$=Residence $\delta_5$=highest educational level of any member of the household, $\delta_6$=Farm Management Training within the last 2 years, $\delta_7$=Education of farmer and $b_o$=constant and $\varepsilon$=error term

**Operationalization of the model:** Perception on climate change will be measured according to the responses of farmers on certain climatic variables. These responses are binary for the probit model. First farmers who perceive rainfall as increasing are given 1 and 0 if otherwise (Yi=1 if rainfall=increasing and Yi=0 if otherwise). The same binary response is recorded for temperature. Thus farmers who perceive temperature as increasing are given 1 and 0 if otherwise (Yi=1 if temperature=increasing and Yi=0 if otherwise). Secondly, a cross tabulation on these two variables is made in accordance with climatic trends given by the GSS 2010. Farmers who observe rainfall and temperature trends as decreasing and increasing respectively are given 1 and 0 if otherwise. The dependent variable in the probit model becomes the binary outcome from the cross tabulation.

In the OLS treatment outcome equation model, $Y^*$ is the dependent variable, which in this case is the coping strategies. Based on the 11 different adaptation options adapted by farmers, farmers were given values between 0 and 1, by dividing the number of coping strategies they have adapted by 11. For instance a farmer that has adapted seven strategies will be given a value 0.64, computed as 7 divided by 11.

## Results and Discussion

On rainfall pattern, 53.33% of the respondents perceived it to be decreasing which accords the GSS [10] report that the Western Region of Ghana has recorded a 30 year average 12.3 percent decrease in rainfall. On temperature pattern, an over-whelming majority of farmers thus 85.83% perceive temperature values to be on the increase in the last decade in the study area (Figure 1).

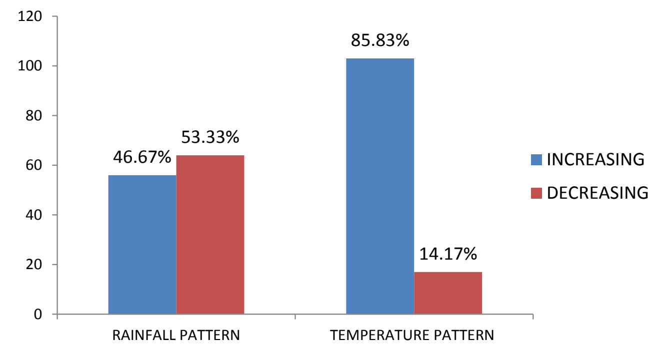


**Figure 1:** Farmer's perception on temperature and rainfall pattern.

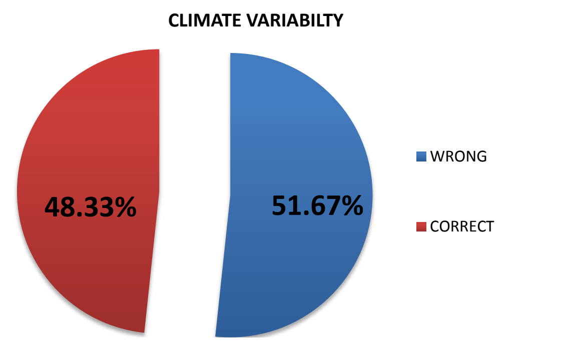


**Figure 2:** Farmer's perception on climate variability.

From the cross tabulation on the two climate variables (rainfall and temperature), fifty eight respondents representing 48.33% perceived both variables correctly (that rainfall is decreasing while temperature is increasing) whiles sixty two (62) representing 51.67% perceived otherwise according to GMS figures in GSS report [10] (Figure 2).

One would expect *apriori* that belonging to an FBO increases the probability of perceiving climate variability correctly; nonetheless it was significant at 5% with a negative relationship with climate variability. This means that a non-FBO member have a better level of perception to climate variability than an FBO member. This may be due to recent trend where FBO members are more focusing on market integration (good prices and bonuses), input accessibility and other social benefits they gain from joining these organizations. Thus, the orientation and focus of these bodies than been conscious of climate variability issues.

In contradiction to the findings of Tesso et al. [14], where household size was significant at 10% with a positive relationship with climate change perception, the results in this research show a negative relationship at a 1% significant level. This means that smaller households have a higher probability of perceiving climate variability in the right direction than those with larger households. This can be argued by the quality of information [15] available to households playing a key role in the perception of climate variability but not the quantity as argued by Tesso et al. [14] with respect to larger households. . Immigrants who are more engaged in cocoa production have higher possibilities of perceiving climate variability in the right direction than the natives. In most cases, the immigrant farmers have their relatives in other areas and are to source information from them. This could be the reason for the positive relationship between residence and climate variability at a 10% significant level.

| | The Probit Perception Model | | Adaptation Model | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Robust standard error** | **Coefficient** | **Standard error** |
| Sex | 0.1914048 | 0.3031786 | | |
| Farm age | | | 0.0017859*** | 0.0004619 |
| Farm size | | | 0.0017064*** | 0.0005391 |
| Household size | -0.1457997*** | 0.0443124 | | |
| Educational level of household member | 0.0877255** | 0.0350930 | 0.0055593 | 0.0035258 |
| Farm management training | 0.5654146* | 0.3395209 | 0.108298*** | 0.0325555 |
| Residence | 0.6432893* | 0.3836872 | | |
| Farmer's educational level | -0.0210416 | 0.0241041 | -0.0027436 | 0.0023905 |
| Access to input credit | | | -0.0329336 | 0.023174 |
| FBO membership | -0.57627** | 0.2837073 | | |
| Farmer's experience | | | -0.0013368 | 0.0016422 |
| Climate variability | | | -0.1333732** | 0.0601971 |
| Constant | -0.5753104 | 0.6311069 | 0.3641295 | 0.0469403 |
| | | | | |
| Rho | 0.5815836 | 0.2079534 | | |
| Sigma | 0.1361052 | 0.0140503 | | |
| Lambda | 0.0791566 | 0.0356412 | | |
| | | **Number of Observation=120** | | |
| Chi$^2$(1)=3.85 | | | | |
| | | **Wald chi square (8)=63.29** | | |
| Prob>chi$^2$=0.0496 | | | 0.0000 | |
| | | Log pseudo likelihood=7.9561854 | | |

***, ** and * indicates significance at 1%, 5% and 10% probability level, respectively

**Table 1:** Results of the treatment effect model.

Farm management training was found to be significant at 10% and positive. This indicates that a farmer who have received some level of farm management training within the last two years have an increase probability of perceiving climate variability. Like education, training improves the human capacity of the farmers while most of the trainings offered to the farmers are geared towards adoption of climate change strategies, especially, improved seed and farm management. In this case, farmers are able to appreciate possible changes in the production environment (Table 1).

The results on determinants of adapting coping strategies to climate variability implies that as the age of cocoa farms increases, farmers turn to adapt more coping strategies to mitigate the adverse impact of climate variability on production hence the positive sign on the coefficient of farm age at 1% significant level. Adaptation to coping strategy increase by 0.0017859 when there is a unit increase in the age of a farm.

Similarly, the positive sign on the coefficient farm size which is significant at 1% indicates that households with larger farm sizes adapt more coping strategies compared to households with smaller farm sizes. According to Tesso et al. [14] farm size is associated with greater wealth which can increase adaptation to change in climatic conditions. Gebrehiwot and van der Veen [16] also found a positive effect of farm size on adaptation. However, contrary to this study are the findings of Deressa et al. [15] who had a negative relationship between farm size and adaptation to climate change by farmers in the Nile basin of Ethiopia. In supporting their findings, they argued that adaptation is plot-specific, meaning that it is not the size of the farm, but the specific characteristics of the farm that dictates the need for a specific adaptation method to climate change.

There is a positive relationship between farm management training and adaptation to coping strategies which was significant at 1%. A unit increase in farm management training activities will lead to 0.108298 increases in adaptation to coping strategies. This result can be attributed to the quality and reliability of both the information given farmers and the training sections. From the perception model, it would be recalled that farmers who had training perceived climate variability in the right direction. These two results demonstrate the joint positive gains from training of farmers.

The treatment variable which was climate variability was expected to be positive with adaptation since research by Oluwatusin [7], Tesso et al. [14] and Deressa et al. [15] shows that farmers who perceive climate change adapt more. However, farmers who perceive climate variability in the study area adapt less of the coping strategies hence the negative sign on the treatment variable climate variability at 5% significant level. In a similar related finding, Oluwatusin [7] expected that farmers who received training on climate change will enhance adaptation to climate change but the reverse was true.

Farmers who perceive climate variability will see most of the coping strategies as not relevant hence adapting only the most effective ones that best suit them in mitigating the adverse effects of climate variability. This argument can be buttressed statistically with the average coping strategy of five (5) adapted by the farmers in the district as against a total of eleven (11) coping strategies made available during the field survey.

## Conclusion

From the research findings, farm households in Suaman have exhibited quite a high level of perception to climate variability. Farmers who perceived climate variability in the right direction adopted less adaptation strategies. Membership to FBO does not necessarily improve farmers' perception on climate variability unless there is a deliberate effort to re-orient them through training on climate variability.

The argument of our paper is that farmers have adopted specific strategies other than several strategies. This indicates that farmers in the study area are able to identify specific strategies suitable for their farms.

Individual farmers have constantly adjusted to climatic changes and some group adapting methodologies as of now exist, for instance changing sowing times or embracing new water-sparing systems. Conventional learning and adapting procedures must be kept up and fortified; generally versatile limit might be debilitated as nearby information of the earth is lost. Reinforcing these neighborhood systems and expanding upon them additionally makes it more probable that adjustment methodologies will be received, as it makes greater group proprietorship and inclusion all the while. Much of the time however this won't be sufficient to adjust to new conditions which are outside the scope of those already experienced and new methods will be required. Current advancement endeavors are progressively concentrating on group based environmental change adjustment, trying to improve neighborhood information, support and responsibility for systems.

## Implication

The findings of this study have provided a new insight and comprehension in as much as the study area is concerned. That's, cultivate family units in Suaman district have displayed a significant abnormal state of discernment to atmosphere inconstancy. Agriculturists who saw atmosphere changeability the correct way embraced less adjustment methodologies. Participation to FBO does not really enhance agriculturist's discernment on atmosphere inconstancy unless there is a consider push to re-arrange them through preparing on climate changeability.

Further, the discoveries of this investigation have given another understanding to the versatile adapting methodologies typifying the perception of the agriculturists of Suaman locale in regard of atmosphere changeability. This is because of the way that the people or gathering of individual ranchers of the examination region have a fluctuating or distinctive recognitions about climate changeability in this way considering their adapting techniques in various measurements.

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