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What are the drivers of cocoa farmers’ choice of climate change adaptation strategies in Ghana?

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Abstract: This study analyses cocoa farmers’ perception on climate change and adaptation strategies in the Brong-Ahafo Region of Ghana. Better understanding of these perceptions would help identify knowledge gaps of cocoa farmers on climate change, and would help equip them with the requisite knowledge and skills on climate change and improve cocoa yields. The study is based on a cross-sectional survey of 240 cocoa farmers selected from six cocoa growing communities. Logit model is used to estimate factors influencing climate change adaptation strategies among cocoa farmers in the study area. The results of the study reveal that cocoa farmers perceive long-term changes in climatic variables which indicate their awareness of climate change and the impact on cocoa production. The adaptation strategies used by cocoa farmers in the study area include planting of improved varieties of cocoa, increasing pesticide and fertilizer application, crop diversification, diversification to non-farm activities and planting of trees for shade. Gender, marital status, educational level, household size, engagement in other economic activities, farming experience, access to extension services, access to credit/loan, and cocoa income influence the cocoa farmers’ choice of adaptation strategies. The study suggests that the government of Ghana should
develop more effective climate change adaptation strategies as well as improve dissemination of information to farmers through extension agents in order to increase adoption of effective climate change adaptation strategies.

Subjects: Agriculture & Environmental Sciences; Environmental Sciences; Agriculture and Food; Agriculture; Environmental Studies; Environmental Management; Environment & Economics

Keywords: adaptation strategies; climate change; cocoa farmers; Ghana; logit model; perception

1. Introduction

Agriculture is the most important source of livelihood for millions of people in Africa. Majority (70%) of Africa’s population is involved in farming, and agricultural products cover about 40% of all exports (Intergovernmental Panel on Climate Change [IPCC], 2001). In addition, the percentage of Gross Domestic Product (GDP) in Africa which is generated by agriculture is about 70% (Mendelsohn, Dinar, & Daifelt, 2000). However, federal agencies and other institutions have expressed concerns about the potential effects of climate change on agricultural productivity due to the fundamental role agriculture plays in the welfare of humans (Fischer, Shah, & van Velthuizen, 2002; Lobell et al., 2008; Wolfe et al., 2005).

According to Chang (2002) the variations in climatic variables, for example, amount of rainfall, temperature, wind speed, relative humidity, and sunshine duration, plays a very crucial role in determining the yields of crops. Boko et al. (2007) and IPCC (2007), projected yield reduction due to climate change and variability in some poor countries to be as much as 50% by 2020. It is noted that Africa has already experienced worsening food production and this has been a challenge in meeting the United Nations Millennium Development Goals (MDGs) of reducing hunger by half by 2015 (IPCC, 2007).

In Ghana, agriculture is an important sector of the economy contributing about 21.3% of the country's total GDP and it is the main source of livelihood for about 60% of the labour force (Denkyirah et al., 2016; Institute of Statistical Social & Economic Research [ISSER], 2014). Cocoa is the main export crop and the third largest export commodity in Ghana, which accounts for over 80% of all foreign exchange earnings from the agricultural sector and it is the most important source of revenue for many smallholder farmers (Adu-Appiah, Seini, Mensah-Bonsu, & Dzomeku, 2013; Anang, 2011; Ayenor, Huis, Obeng-Ofori, Padi, & Röling, 2007; ISSER, 2014; Mensah, 2006). Currently, Ghana is second to Cote d’Ivoire in the world’s cocoa production and produces the best quality cocoa beans (Adu-Appiah et al., 2013; Gockowski, Afari-Sefa, Sarpong, Osei-Asare, & Dziwornu, 2011; Ntiamoah & Afrane, 2008; Okoffo, Denkyirah, Adu, & Fosu-Mensah, 2016).

However, climate change in the form of higher temperatures and reduced rainfall, is expected to adversely affect cocoa productivity and reduce the area suitable for cocoa cultivation in Ghana (Okoffo, Denkyirah, et al., 2016). Laux, Jäckel, Tingem, and Kunstmann (2010) and IPCC (2014) assert that the spatial and temporal variability of rainfall is the most important factor affecting crop productivity, and hence resulting in food insecurity. According to Anim-Kwapong and Frimppong (2004), climate change has the potential to alter the development of cocoa insect pests and diseases and modify the host’s resistance. For example, long periods of drought causes newly transplanted cocoa seedlings and some cocoa trees to wither while high relative humidity aggravate the incidence of black pod disease of cocoa. Flood, Ritchie, and Vos (2003), Bailey, Strem, Bae, de Mayolo, and Guitlan (2005) and Denkyirah et al. (2016) assert that cocoa yields are reduced by insect pests and diseases. Lass (2004), Lanaud et al. (2009) and International Cocoa Organisation (2015) reported that 30–40% of cocoa produced globally is lost to insect pests and diseases. Boyer (1970) also revealed that flowering is highly reduced in cocoa when mean monthly temperature drops below 23°C. This is likely to have major effects on the Ghanaian economy.
Due to the importance of cocoa to the Ghanaian economy, adaptation to climate change is therefore crucial. Adaptation is widely recognized as a vital component of any policy response to climate change. Adaptation involves managing risks posed by climate change, including variability. Effective adaptation needs to make vulnerable people resilient, and able to return to normal status quickly even after a major impact (Adger et al., 2007). The ability of farmers to perceive climate change is a prerequisite for their choice of adaptation. According to Maddison (2006), adaptation to climate change requires farmers’ perception of climate change, identifying useful adaptation strategies and implementing necessary adaptation responses.

Many smallholder cocoa farmers in the Brong Ahafo Region of Ghana depend on cocoa for their livelihood, yet there is little knowledge of adaptive measures in the light of climate change in the cocoa producing communities in the region and in Ghana. Most studies done on climate change, its effect and adaptation strategies in Ghana have targeted food crop farmers (Al-Hassan, Kuwornu, Etwire, & Osei-Owusu, 2013; Armah, Al-Hassan, Kuwornu, & Osei-Owusu, 2013; De-Graft & Onumah, 2011; Fosu-Mensah, Vlek, & MacCarthy, 2012; Mabe, Sienso, & Donkoh, 2014). However, the impact of climate change on cocoa cannot be overlooked. It is therefore important to access cocoa farmers’ perception of risks/effects from climate change and their current adaptation strategies related to climate change. This would help identify knowledge gap of cocoa farmers on climate change and help equip them with the requisite knowledge and skills on climate change and improve yields of cocoa. This study focused on cocoa farmers’ perspectives on and adaptation strategies in relation to climate change and investigated the socioeconomic factors influencing cocoa farmers’ ability to adapt to climate change and their choice of adaptation strategies.

2. Methodology

2.1. Study area
The study was carried out in the Berekum Municipality which lies in the North-western corner of the Brong-Ahafo Region of Ghana. The municipality lies between latitude 7°15′ South and 8°00′ North and longitude 2°25′ East and 2°50′ West and covers a total land area of about 863.3 km² (Denkyirah et al., 2016). The municipality lies within the wet semi-equatorial climate zone which occurs widely in the tropics and it experiences a maxima pattern of rainfall with a mean annual rainfall between 1,275 and 1,544 mm in May to June (Berekum Municipal Assembly [BMA], 2013). Basically, the municipality has the moist semi-deciduous forest type of vegetation which covers 80 percent of the entire stretch of the land (Denkyirah et al., 2016). The population of Berekum Municipality, according to the 2010 Population and Housing Census, is 129,628 representing 5.6% of the region’s total population. More than half (57.0%) of households in the municipality are engaged in agriculture, with most of these households (97.6%) involved in crop farming (Ghana Statistical Service [GSS], 2014).

2.2. Data collection and sampling technique
The study was conducted between March and July, 2015. The basic information for the analysis was obtained from primary data collected with the aid of a pre-tested semi-structured questionnaire. The structure of questions in the data collection instrument was a combination of close-ended, open-ended and partially close-ended questions. The survey questionnaire was used to collect data on socio-economic characteristics (e.g. gender, age, farm size, access to extension service, access to credit) and farmers’ perceptions on climate change, barriers to adaptation and adaptation strategies. The selection of the cocoa farmers followed a multi-stage sampling technique as used by Denkyirah et al. (2016), Okoffo, Mensah, and Fosu-Mensah (2016) and Okoffo, Denkyirah et al. (2016). In the first stage, the Brong Ahafo Region of Ghana was purposively selected due to the predominance of cocoa production in the region. In the second stage, the Berekum Municipality was randomly selected out of the several cocoa producing districts in the region. In the third stage, six cocoa growing communities, namely, Koraso, Kutre no. 1 and 2, Senase, Kato, Biadan and Ayimom were randomly selected from a list of cocoa producing communities in the district. In the final stage, 40 cocoa farmers were randomly sampled from each community making a total of 240 cocoa farmers.
for the study. All participants agreed to participate in the research study by signing informed consent forms.

2.3. Theoretical framework
For a farmer to make a decision on whether or not to adapt to a particular technology or innovation, he does not only consider how to maximize profit from that innovation but on how to attain the highest level of utility otherwise referred to as utility maximization (McConnell, Brue, & Flynn, 2009; Okoffo, Denkyirah, et al., 2016; Sadoulet, Janvry, & Benjamin, 1996). It is observed that farmers have a level of utility they want to meet and therefore make choices based on that. Any adaptation option could fall under the general framework of utility and profit maximization (Gbetibouo, 2009). The utility of a farmer is given as $U_j$, from choosing alternative $j$. A cocoa farmer will choose whether or not to adapt to climate change depending on the relative utility levels associated with the two choices. In this case, choice models are used to analyze a farmer’s decision to adapt or not to adapt to climate change.

The choice models are used based on the dependent variable which takes the form of 0 or 1 (i.e. dummy variable). Two models for this analysis are the logit and probit models. Logit and probit models can be derived from an underlying latent variable model:

$$y^* = \alpha + \sum_{i=1}^{k} \beta_i x_i$$

where $y^*$ denotes the unobserved, or latent variable; $x$ denotes the set of explanatory variables, $\alpha$ denotes the error term and $1\{y^* > 0\}$ defines the binary outcome. The main difference between the probit and logit models lies in the assumption of the distribution of the error term, $\varepsilon$. The error term is assumed to have the standard logistic distribution in the case of the logit, and the standard normal distribution in the case of the probit model (Bryan, Deressa, Gbetibouo, & Ringler, 2009).

The first strand of analysis which estimated the factors influencing cocoa farmers’ adaptation to climate change employed the logistic regression model. The STATA software version 13 was used for the estimation. The logistic model for "k" independent variables ($X_1, X_2, X_3, ..., X_k$) is given by

$$\text{LogitP}(x) = \alpha + \sum_{i=1}^{k} \beta_i x_i$$

where $\alpha$ denotes a constant and $\beta_i$ denotes the regression coefficient.

The logistic regression model could be specified for this study as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \varepsilon$$

where $Y$ denotes whether to adapt or not, $X_1$ denotes gender, $X_2$ denotes age of farmer, $X_3$ denotes marital status, $X_4$ denotes household size, $X_5$ denotes engagement in other economic activities, $X_6$ denotes education of the farmer, $X_7$ denotes years of farming experience, $X_8$ denotes farm size, $X_9$ denotes access to extension, $X_{10}$ denotes member of FBO, $X_{11}$ denotes access to credit/loan and $X_{12}$ denotes fraction of farm income from cocoa (Table 1).

2.4. Hypothesis of explanatory variables
Gender is expected to have a positive or negative effect on adaptation to climate change. Male farmers are more likely to have access to information about new technologies and undertake risky businesses than female farmers (Asfaw & Admassie, 2004). Furthermore, male farmers are well endowed with resource such as land than their female counterparts and would take initiatives to adapt to climate change. However, a study by Nhemachena and Hassan (2007) revealed that female farmers...
are more likely to take up climate change adaptation methods because they are responsible for much of the agricultural work in developing countries and therefore have greater experience and information on various management and farming practices.

Age of the farmer was measured in years and is expected to have a negative effect on adaptation to climate change. This is due to the fact that younger farmers are more likely to adopt new technologies than older farmers, since, older farmers stick to primitive ways of production and do not easily adopt newly introduced technologies. Again, younger farmers have much more energy and are more likely to invest in long term productivity (Adejumo, Ojoko, & Yusuf, 2014; Alavalapati, Luckert, & Gill, 1995; Baidu-Forson, 1999; Langyintuo & Mulugeta, 2005).

Danso-Abbeam, Setsoafia, and Ansah (2014) noted that farmers who are married consider the survival of their family in case of any uncertainty and are more likely to adopt any innovation. In this regard, the study hypothesized marital status to have a positive effect on adaptation to climate change. This means that married farmers are more likely to adapt to climate change.

Agricultural technologies are labour intensive and expensive to adopt. Therefore, it is expected that a farmer with large household size would have cheap labour to undertake agricultural activities which would lead to the adoption of innovations (Fatuase & Ajibefun, 2013; Mignouna, Manyong, Mutabazi, & Senkondo, 2011; Tiamiyu, Akintola, & Rahji, 2009; Zeleke & Aberra, 2014). This study hypothesized household size to have a positive effect on adaptation to climate change.

This study also hypothesized engagement in other economic activities to have a positive or negative effect on adaptation to climate change. It is assumed that farmers who are engaged in other economic activities feel secured and would therefore, not adopt any agricultural innovation directed towards mitigation of risk (De-Graft & Onumah, 2011; Oluwatusin, 2014). On the other hand, farmers engaging in other economic activities obtain income from other sources and would therefore be able to take up any agricultural activity that is deemed costly (Holden & Shiferaw, 2002).

Educational level is expected to have a positive effect on adaptation to climate change. This is due to the fact that educated farmers are more likely to obtain information, perceive and adapt to climate change (Maddison, 2006, 2007).

| Variable                                | Measurement                                                                 | A priori expectation |
|-----------------------------------------|----------------------------------------------------------------------------|----------------------|
| Gender                                  | 1 if male, 0 otherwise                                                     | +/-                  |
| Age                                     | Years                                                                      | -                    |
| Marital status                          | 1 if married, 0 otherwise                                                 | +                    |
| Household size                          | Number                                                                     | +                    |
| Engagement in other economic activities | 1 if engaged in other economic activities, 0 otherwise                    | +/-                  |
| Educational level                       | 1 = No formal education, 2 = primary, 3 = JHS, 4 = SHS, 5 = tertiary       | +                    |
| Farming experience                      | Years                                                                      | +                    |
| Farm size                               | Acres                                                                      | +                    |
| Access to extension services            | 1 = yes, 0 = otherwise                                                    | +                    |
| Member of FBO                           | 1 = member, 0 = otherwise                                                 | +                    |
| Access to credit/loan                   | 1 = yes, 0 = otherwise                                                    | +                    |
| Cocoa income                            | Ghana cedi                                                                | +                    |
This study hypothesized farming experience to have a positive effect on adaptation to climate change. Experienced farmers are expected to have information and knowledge about climate change and its impact on agriculture and are more likely to adapt to climate change (Maddison, 2006; Nhachena & Hassan, 2007).

Farm size was hypothesized to have a positive relationship with adaptation to climate change. Deressa, Hassan, Ringler, Alemu, and Yesuf (2009) assert that land positively influences adaptation to climate change. Bryan et al. (2009) and Maddison (2007) affirm that shortage of land is a barrier to climate change adaptation. This means that farmers who have large farm size are more likely to adapt to climate change.

Agricultural extension services/agents are sources of information to farmers and farmers rely on extension agents for information on farming activities (Fosu-Mensah et al., 2012). It is noted that farmers become aware of climatic conditions by having access to extension service (Tesso, Emana, & Ketema, 2012). It is therefore hypothesized that access to extension service would have a positive effect on adaptation to climate change.

Farmer Based Organizations (FBOs) serves as platforms where information is disseminated among farmers (Akudugu, Egyir, & Mensah-Bonsu, 2009). In this regard, FBOs educate farmers on climate change and the importance of adapting to climate change. Therefore, the study hypothesized membership of FBO to positively influence adaptation to climate change.

Credit/loan helps farmers to adopt new technologies, as access to cash allows farmers to purchase farm inputs (Akudugu, Guo, & Dadzie, 2012; Fosu-Mensah et al., 2012). Studies have revealed that adaptation to climate change mitigation strategies is positively influenced by access to credit/loan (Deressa et al., 2009; Gbetibouo, 2009).

It is noted that cocoa income has a positive impact on capacity of farmers and influence their adoption of new technologies (Asante, Boakye, Egyir, & Jatoe, 2012; Taneja, Pal, Joshi, Aggarwal, & Tyagi, 2014; Zakaria, Abuja, Adam, Nabila, & Mohammed, 2014). This study therefore hypothesized cocoa income to positively influence farmers’ adaptation to climate change.

2.5. Analyses of cocoa farmers’ choice of adaptation strategies
The second strand of analysis which estimated cocoa farmers’ choice of climate change adaptation strategies also employed the logit regression model. This model has been used by Mabe et al. (2014) to analyse factors that affect the choice of climate change adaptation strategies of farmers in Northern Ghana and Okoffo, Mensah, et al. (2016) to analyse factors influencing operational habits exhibited by cocoa farmers during and after pesticides application. The outstanding advantage of this model is that it allows one to analyse decisions and determine the associated probabilities for the choice of a particular adaptation strategy. It also allows for each adaptation strategy to be analysed separately and independently, unlike the use of multinomial logit model. This is to eliminate the effects of the choice of one adaptation strategy on the other. Five adaptation strategies (i.e. planting improved varieties, increasing pesticide and fertilizer application, planting trees for shade, crop diversification and diversification to non-farm activities) which are employed by the cocoa farmers were analysed for this study. The STATA software version 13 was used for the estimation.

3. Results and discussion

3.1. Socio-economic characteristics of the farmers
As shown in Table 2, majority of the cocoa farmers (80.4%) were males while the remaining 19.6% were females. The domination by male respondents among the farmers could be the result of males having greater access to farm land than females. It could also be due to the fact that cocoa farming is more labour-intensive. Therefore, women are not able to meet the needed effort to cultivate the crop.
The proportion of cocoa farmers who were aged between 20–29 years was 2.1%, 30–39 years was 8.3%, 40–49 years was 32.5%, 50–59 years was 31.3 and 60 years and above was 25.8%. The mean age of cocoa farmers was 53 years. This means that farmers involved in cocoa production in the study area are experienced.

The majority (71.7%) of the cocoa farmers are married while 28.3% are single. This means that most farmers who engage in cocoa farming in the study area are married. This result is consistent with Bammeke (2003) who states that individuals who undertake agricultural activities are married.

The majority (67.5%) of the cocoa farmers had household size of 5–10 persons. Proportion of farmers who had household size below 5 persons was 23.3%, household size of 11–15 persons was 8.3% and household size above 15 persons was 0.83%. The mean household size was 7 persons per household. This is an indication of large family size in the study area. This also means that farmers have a source of cheap labour from their large household size.

### Table 2. Demographic characteristic of cocoa farmers

| Variable                               | Description | Percentage (%) |
|----------------------------------------|-------------|----------------|
| Gender                                 | Male        | 80.4           |
|                                        | Female      | 19.6           |
| Age                                    | 20–29       | 2.1            |
|                                        | 30–39       | 8.3            |
|                                        | 40–49       | 32.5           |
|                                        | 50–59       | 31.3           |
|                                        | Above 60    | 25.8           |
| Marital status                         | Single      | 28.3           |
|                                        | Married     | 71.7           |
| Household size                         | Below 5     | 23.3           |
|                                        | 5–10        | 67.5           |
|                                        | 11–15       | 8.3            |
|                                        | Above 15    | 0.83           |
| Educational level                      | No education| 18.8           |
|                                        | Primary/JHS | 34.6           |
|                                        | Middle/SHS  | 43.3           |
|                                        | Tertiary    | 3.3            |
| Years of farming experience in cocoa   | 5–10        | 5.8            |
|                                        | 11–15       | 15.7           |
|                                        | 16–20       | 17.8           |
|                                        | Above 20    | 60.7           |
| Extension visit                        | Yes         | 35.0           |
|                                        | No          | 65.0           |
| Access to credit                       | No          | 82.1           |
|                                        | Yes         | 17.9           |

Source: Field data (2015).
In terms of education, 18.8% of farmers in the study area had no formal education, 34.6% had education up to junior high school, majority (43.3%) had senior high school education and only 3.3% had tertiary education. This shows that literacy level in the study area is high, although, very few farmers had tertiary education. It is noted that educated farmers tend to be more efficient in production and readily accept new innovation when compared to uneducated ones that rely on their experience (Enete & Igbokwe, 2009; Martey et al., 2013). This means that adaptation to climate change would not be a major challenge in relation to education.

Very few (5.8%) cocoa farmers had farming experience less than 10 years while the majority (60.7%) of the farmers had farming experience above 20 years with a mean of 28 years of experience. This result is in line with the findings of Danso-Abbeam et al. (2014). This means that majority of the farmers are experienced in cocoa farming in the study area and this is important in climate change adaptation.

A large percentage of the farmers (65.0%) had never had any extension contact. This shows that cocoa farmers lack access to extension service and therefore, majority of these farmers might not be adequately informed about improved adaptation methods to climate change, although they might be aware of long-term changes in climatic variables.

Majority (82.1%) of farmer’s lack access to credit/loan in the study area. This means that access to credit/loan by rural farm households is out of reach (Ansoglenang, 2006; GSS, 2008; Marchetta, 2011). This can hinder adoption of new technologies and also climate change adaptation.

3.2. Awareness of climate change
Cocoa farmers’ awareness of climate change is presented in Figure 1. Out of the 240 respondents, 146 (60.8%) indicated they have heard of climate change or have an idea of what climate change is, while 39.2% indicated they had never heard of climate change. This result indicates that cocoa farmers in the study area are gradually becoming aware of climate change. This would help farmers adapt to climate change mitigation measures and help create awareness among fellow farmers. The result indicates that cocoa farmers are well aware of climate change. Mertz, Mbow, Reenberg, and Diouf (2009), Gbetibouo (2009) and Fosu-Mensah et al. (2012) reported similar results on farmers’ awareness of climate change.

Figure 1. Climate change awareness among cocoa farmers in the Berekum Municipality in Ghana.

Source: Field data (2015).
3.3. Source of information on climate change

The majority of the farmers who were aware of climate change indicated the sources from which they heard of it (Table 3). The various sources as indicated by the cocoa farmers were own experience/observations (81.5%), fellow farmers (71.9%), farmer cooperatives (FBOs) (69.9%), family/friends (57.5%), media (radio and television) (41.7%) and extension officers (24.0%). The result indicates that cocoa farmers’ access to information on climate change and innovations through extension contact is a major challenge in the study area and that farmers rely on their own experiences in adopting innovations. A study by Tessema, Aweke, and Endris (2013) revealed that extension service was the least source of information on climate change to farmers.

| Source of information on climate change | Percentage |
|---------------------------------------|------------|
| Own experience                        | 81.4       |
| Fellow farmers                        | 71.9       |
| Farmer cooperatives (FBOs)            | 69.9       |
| Family and friends                    | 57.5       |
| Media (radio and television)          | 41.7       |
| Extension officers                    | 24.0       |

Note: Multiple responses allowed.
Source: Field data (2015).

3.4. Farmers’ perception of changes in temperature and rainfall

Farmers’ perception on climate change is important for climate change adaptation. Respondents were asked about their perception on climate change (i.e. temperature and rainfall) over the last 20–30 years. Figures 2 and 3 present the different forms of climate change that had been noticed by cocoa farmers in the study area. Figure 2 revealed that majority (92.1%) of the cocoa farmers interviewed perceived a long-term change in temperature. Out of the 92.1% who perceived long-term change in temperature, 82.1% perceived an increase in temperature while 10% perceived a decrease in temperature. Furthermore, 5% of the respondents perceived no change in temperature at all while 2.9% could not determine either there had been a change or not. Majority (65%) of the farmers attributed the increase in temperature to deforestation (depletion of forest resources), 20.3% attributed it to bush burning, while 14.7% indicated increase in population as the cause of increase in temperature. From Figure 3, the perceived changes in rainfall by cocoa farmers revealed that there has been a decrease in rainfall over the last two to three decades (84.2% of farmers). Again, deforestation was attributed to be the cause of decrease in rainfall over the years. The results on perceived changes in temperature and rainfall by cocoa farmers are in line with the findings of Hassan and Nhachena (2008), Fosu-Mensah et al. (2012), Oyekale and Oladele (2012) and Oluwatusin (2014).

Figure 2. Cocoa farmers’ perception of changes in temperature (%) in the Berekum Municipality in Ghana.

Source: Field data (2015).
3.5. Farmers’ perceived effects of climate change on cocoa production

Table 4 presents the perceived effects of climate change on cocoa production identified by cocoa farmers in the study area. Majority (73.8%) of the respondents perceived that climate change increases the prevalence of insect pests and diseases infestation. According to Anim-Kwapong and Frimpong (2004) and Kimengsi and Tosam (2013), climate change results in the modification of stages and rates of development of cocoa pests and pathogens, their resistance to pesticides application, and changes in the physiology of host-pathogen/pests interaction. For example, the black pod disease of cocoa is closely related to weather and is most destructive in years when the short dry period from July to August is very wet while cocoa mirids (capsids) which are sucking insects are usually most active and destructive from September to March particularly when moisture deficit is severe and are favored by high light intensity (Anim-Kwapong & Frimpong, 2004). Other effects of climate change on cocoa production perceived by cocoa farmers in the study area are; reduction in cocoa yield (67.1% of farmers), inability to dry cocoa bean (48.5%) and delayed cocoa bean maturity (45.2%). According to Anim-Kwapong and Frimpong (2004), in bearing cocoa plants, the existence of short dry season during main crop pod filling can affect bean size and weight, and hence yield if it is sufficiently severe.

3.6. Barriers to climate change adaptation

Table 5 presents the barriers to climate change adaptation identified by the cocoa farmers in the study area. Majority (87.1%) of the cocoa farmers indicated that lack of information on climate change and adaptation strategies was the major barrier to climate change adaptation. This result is in line with the findings of Deressa et al. (2009) and Tessema et al. (2013). This means that cocoa farmers have limited information on climate change and adaptation strategies in the study area. Other barriers to climate change adaptation indicated by the cocoa farmers were lack of financial resources (67.1%), high cost of climate change adaptation (59.2%), high cost of inputs (20.0%) and inadequate labour (19.6%). Inadequate labour being the least among the barriers to climate change adaptation indicated by farmers could be due to the fact that, farmers get cheap labour from their large household size. This means a cocoa farmer does not have to spend extra cost on labour to adapt to climate change.
Table 5. Barriers to climate change adaptation

| Barriers                                               | Percentages |
|--------------------------------------------------------|-------------|
| Lack of information on climate change and adaptation   | 87.1        |
| strategies                                             |             |
| Lack of financial resources                           | 67.1        |
| High cost of climate change adaptation                 | 59.2        |
| High cost of inputs                                   | 20.0        |
| Inadequate labour                                      | 19.6        |

Note: Multiple responses allowed.
Source: Field data (2015).

3.7. Factors affecting adaptation to climate change

Table 6 presents the logistic regression result of the factors influencing adaptation to climate change. The significant variables were marital status of a farmer, years of farming experience, farm size and cocoa income. The model had a log likelihood value of $-143.820$ and a $\chi^2$ value of 43.72 at 1% significance level ($p < 0.01$).

Marital status of a farmer was statistically significant at 10% and negatively influenced a farmer’s adaptation to climate change. This shows that married farmers are less likely to adapt to climate change. This could be due to the fact that married farmers invest their resources in household activities than climate change adaptation activities. This result is consistent with the findings of Apata, Samuel, and Adeola (2008).

Table 6. Logistic regression results of the factors influencing adaptation to climate change

| Variable                                              | Coefficient | Std. error | p-value  | Marginal effect |
|-------------------------------------------------------|-------------|------------|----------|-----------------|
| Gender                                                | -0.538      | 0.401      | 0.179    | -0.134          |
| Age                                                   | 0.012       | 0.022      | 0.574    | 0.003           |
| Marital status                                        | -0.771      | 0.455      | 0.090*   | -0.190          |
| Household size                                        | -0.071      | 0.076      | 0.350    | -0.018          |
| Engagement in other economic activities               | -0.850      | 0.625      | 0.174    | -0.209          |
| Education                                             | 0.171       | 0.194      | 0.379    | 0.042           |
| Farming experience                                   | 0.039       | 0.016      | 0.015**  | 0.010           |
| Farm size                                             | 0.235       | 0.078      | 0.002*** | 0.058           |
| Access to extension                                   | -0.376      | 0.386      | 0.331    | -0.093          |
| Member of FBO                                         | -0.074      | 0.428      | 0.863    | -0.018          |
| Access to credit                                      | 0.569       | 0.443      | 0.199    | 0.141           |
| Cocoa income                                          | -4.622      | 1.775      | 0.009*** | -1.150          |
| Constant                                              | 41.436      | 15.958     | 0.009    | -               |
| Log likelihood                                        | -143.820    |            |          |                 |
| $\chi^2$                                              | 43.72       |            | 0.000    |                 |
| Pseudo $R^2$                                          | 0.132       |            |          |                 |

Source: Field data (2015).
*Significance level at 10%.
**Significance level at 5%.
***Significance level at 1%.
Farming experience had a positive influence on adaptation to climate change and was statistically significant at 5%. This indicates that as the farming experience of a farmer increase by one year, he/she is more likely to adapt to climate change. This follows the a-priori expectation which shows that years of farming experience positively influence climate change adaptation. The result is in line with the findings of Oluwatusin (2014).

Farm size was statistically significant at 1% and positively influenced a farmer’s adaptation to climate change. This indicates that as the farm size of a farmer increase by one acre, he/she is more likely to adapt to climate change. A farmer would adapt to climate change as his/her farm size increases because he perceives to be at a greater risk and would lose a large portion of farmland in case of a negative impact of climate change on his/her farm. This result is in line with the findings of Oluwatusin (2014). However, it contradicts the findings of De-Graft (2011) and Uddin, Bokelmann, and Entsminger (2014).

Cocoa income was statistically significant at 1% and negatively influenced climate change adaptation. This shows that as the cocoa income increase by one Ghana cedi, a cocoa farmer is less likely to adapt to climate change. The result indicates that a cocoa farmer may use his/her cocoa income for non-farm activities other than climate change adaptation, since he/she might perceive climate change to have minimal impact on his/her farming activities.

### 3.8. Adaptation strategies to climate change

Although majority of the cocoa farmers were aware of climate change, only 46.3% adopted some adaptation strategies. Among the adaptation strategies, crop diversification was identified as the major adaptation strategy in the study area (Table 7). The least adaptation strategy adopted by the farmers was planting improved varieties of cocoa with 26.1% of the farmers adopting this adaptation strategy. The government of Ghana through the Ghana Cocoa Board (COCOBOD) have put in place agricultural policies such as provision of improved varieties of cocoa (i.e. drought and disease resistant variety) to farmers, however, the study revealed that only few cocoa farmers in the study area used improved varieties of cocoa as an adaptation strategy.

| Adaptation strategies                  | Percentage |
|----------------------------------------|------------|
| Crop diversification                   | 64.0       |
| Diversification to non-farm activities | 53.2       |
| Increasing pesticide and fertilizer applications | 44.1 |
| Planting of trees for shade            | 36.0       |
| Planting improved cocoa varieties      | 26.1       |
| No adaptation                          | 53.8       |

Note: Multiple responses allowed.

Source: Field data (2015).
3.9. Source of information on adaptation strategies

Cocoa farmers' source of information on adaptation strategies is presented in Table 8. It was revealed by the study that cocoa farmers' main source of adaptation strategies is through fellow farmers (76.7% of cocoa farmers). The other sources of information and knowledge on adaptation strategies were farmer cooperatives (55.4%), family and friends (46.8%), media (radio and television) (40.8%) and extension service (31.7%).

| Source of information on adaptation strategies | Percentages |
|-----------------------------------------------|-------------|
| Fellow farmers                               | 76.6        |
| Farmer cooperatives                          | 55.4        |
| Family and friends                           | 46.8        |
| Media (radio and television)                 | 40.8        |
| Extension service                            | 31.7        |

Note: Multiple responses allowed.
Source: Field data (2015).

3.10. Factors affecting cocoa farmers' choice of adaptation strategies

Using the logit model, the factors that significantly affect the choice of a particular climate change adaptation strategy was estimated (Table 9). To eliminate the possibility of interactions among the adaptation decisions of farmers, five different logit regression models were ran for each adaptation strategy.

| Adaptation strategies (Marginal effects) | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|-----------------------------------------|---------|---------|---------|---------|---------|
| Placing improved cocoa varieties        | 0.042   | 0.347   | 0.086   | 0.238   | −0.022  |
| Gender                                  | (0.181) | (0.021)**| (0.399) | (0.148) | (0.887) |
| Age                                     | 0.001   | −0.005  | 0.006   | −0.011  | −0.009  |
| Marital status                          | −0.044  | −0.315  | −0.024  | −0.683  | −0.179  |
| Household size                          | −0.023  | −0.032  | −0.152  | −0.026  | −0.046  |
| Engagement in other economic activities | −0.814  | −0.274  | −0.440  | 0.064   | 0.029   |
| Educational level                       | −0.023  | 0.239   | 0.012   | 0.031   | 0.119   |
| Farming experience                      | −0.002  | 0.001   | 0.005   | 0.003   | 0.018   |
| Farm size                               | −0.000  | −0.035  | 0.005   | 0.041   | −0.030  |

(Continued)
3.10.1. Planting improved varieties of cocoa

The factors which influenced a farmer to adopt planting improved varieties as an adaptation strategy are household size, other economic activities, access to extension service and access to credit. Household size was statistically significant at 5% and had a negative relationship with planting improved varieties. This means that as the household size of a cocoa farmer increases, the likelihood of the cocoa farmer to plant improved varieties of cocoa as an adaptation strategy decreases. This could be due to the fact that although cocoa farmers get cheap labour as a result of large household size, they invest the resource needed to purchase improved varieties of cocoa for planting into their household activities rather.

Engagement in other economic activities was statistically significant at 5% and had a negative relationship with planting improved varieties of cocoa. This means that a cocoa farmer engages in other economic activities, the likelihood of the cocoa farmer to plant improved varieties as an adaptation strategy decreases. This could be explained by the fact that the farmer invests resource in other economic activities other than purchasing improved varieties for planting (De-Graft & Onumah, 2011).

Access to extension service was statistically significant at 5% and had a positive relationship with planting of improved varieties. This shows that as a farmer gains access to extension service, the likelihood of planting improved variety increases. This means that extension agents educate farmers on the need to plant improved varieties such as drought resistance seeds/seedlings in order to...
mitigate the impact of climate change. It could therefore be said that extension agents are reliable source of information to farmers (Anang, Sipiläinen, Bäckman, & Kola, 2015; Muhongayar, Hitayezub, Mbatiac, & Mukoya-Wangiad, 2013; Sanusi & Adedeji, 2010).

Access to credit positively influenced planting of improved cocoa varieties and was statistically significant at 5%. This shows that as a farmer gains access to credit, the likelihood of planting improved variety increases. This could be due to the fact that cocoa farmers are able to afford the cost of improved seedlings when they have access to credit. De-Graft and Addo (2011) assert that transfer of technology into agriculture depends on availability and accessibility of credit.

3.10.2. Increasing pesticides and fertilizer application
Gender positively influenced increase in pesticides and fertilizer application and was statistically significant at 5%. This means that male farmers increase the likelihood of adopting pesticides and fertilizer application as climate change strategy. This could be due to the fact that female farmers have higher health risk when in contact with pesticides and other chemicals (Engel et al., 2005; Goldner et al., 2010). In the northern part of Ghana, women are advised not to engage in application of chemicals. Therefore, male farmers take up the activities of chemical application.

Educational level was positive and statistically significant at 1%. This means that as the educational level of a farmer increases, the likelihood of the farmer to increase pesticide and fertilizer application increases. This means that educated farmers are reliably informed that pests and diseases proliferate as a result of increase in rainfall and increased wash-off by rainfall necessitates further application of pesticides (Ntow, Gijzen, Kelderman, & Drechsel, 2006). The result is in line with the findings of Denkyirah et al. (2016) which revealed that educational level of cocoa farmers positively influenced pesticide use.

Access to credit was also positive and statistically significant at 1%. This means that access to credit increased the likelihood of the farmer to increase pesticide and fertilizer application as a climate change adaptation strategy. This means that cocoa farmers are able to purchase more chemicals and apply on their farms as a result of having access to credit. This result is consistent with the findings of Kebede, Gunjal, and Coffin (1990), Adesina (1996) and Denkyirah et al. (2016).

Finally, cocoa income was statistically significant at 10% and positively influenced farmers to increase pesticide and fertilizer application. This means that as the income from sale of cocoa increase, the likelihood of the farmer to increase pesticide and fertilizer application increases. This could be due to the fact that the cocoa farmers are able to purchase more chemicals and apply on their farms as a result of increase in farm income.

3.10.3. Planting of trees for shade
Household size was statistically significant at 1% and had a negative relationship with planting of trees for shade. This means that household size of a cocoa farmer decreases the likelihood of the farmer adopting planting of trees for shade. It was expected that cocoa farmers get cheap labour from large household size and would therefore adopt planting of trees for shade, however, the result revealed otherwise.

Engagement in other economic activities was statistically significant at 5% and had a negative relationship with planting of trees for shade. This means that other economic activities of a cocoa farmer decreases the likelihood of the farmer adopting planting of trees for shade. This could be explained by the fact that cocoa farmers invest their resource in other economic activities which may bring them higher returns than agricultural activities. This is consistent with the findings of De-Graft and Onumah (2011).
Access to extension service was also statistically significant at 1% and negatively related to planting of trees as an adaptation strategy. It was expected that extension service would have a positive relationship with planting of trees for shade but the result showed otherwise. This could be due to the fact that although farmers get access to extension service, the extension agents do not educate farmers on the need to plant trees for shade. This result contradicts the findings of Deressa et al. (2009).

3.10.4. Crop diversification
Marital status was statistically significant at 1% and had a negative relationship with crop diversification. This means that married farmers are less likely to adopt crop diversification as an adaptation strategy. This could be due to the fact that married farmers invest their resource in household activities than climate change adaptation activities.

Access to extension service was also statistically significant at 1% and had a negative relationship with crop diversification. This could be due to the fact that although farmers get access to extension service, the extension agents do not educate farmers on the need to adopt crop diversification as an adaptation strategy. This result is in line with the findings of Mabe et al. (2014).

Access to credit was positive and statistically significant at 1%. This means that access to credit increase the likelihood of cocoa farmers adopting crop diversification as an adaptation strategy. This contradicts the findings of Mabe et al. (2014) and Alabi, Lawal, Coker, and Awoyinka (2014) which state that farmers invest credit in non-farm activities, which are likely to have higher returns than agricultural production.

3.10.5. Diversification to non-farm activities
The result revealed that farming experience and access to credit were both statistically significant at 5% and had a positive relationship with diversification to non-farm activities. The result on farming experience could be due to the fact that more experienced farmers try different alternatives which may yield higher returns, hence, diversifying their resource to non-farm activities. The result contradicts the findings of Obayelu, Adepoju, and Idowu (2014).

It is noted that farmers invest the credit they obtain in non-farm activities which are likely to yield higher returns than farming activities (Alabi et al., 2014), hence, adopting diversification to non-farm activities as an adaptation strategy.

4. Conclusions
Cocoa farmers perceived long-term changes in temperature and rainfall which indicates their awareness of climate change in the study area. However, only few of the farmers adopted some form of adaptation strategies. This was due to lack of information on climate change and adaptation strategy, lack of financial resources, high cost of climate change adaptation, high cost of inputs and inadequate labour. Cocoa farmers’ inability to effectively adapt to climate change aggravates insect pests and diseases infestation on cocoa farms, reduced cocoa yields, leading to the inability to dry cocoa bean and delayed cocoa bean maturity. In response to the impact of climate change on cocoa production, the adaption strategies used by cocoa farmers in the study area includes planting of improved cocoa varieties, increasing pesticide and fertilizer application, crop diversification, diversification to non-farm activities and planting of trees for shade. Farming experience and farm size positively influenced adaptation to climate change while marital status and cocoa income negatively influenced adaptation to climate change. The results on adaptation strategies indicate that household size, engagement in other economic activities, access to extension service and access to credit/loan influenced planting of improved cocoa varieties as an adaptation strategy. Decision to increase pesticide and fertilizer application is influenced by gender, educational level, access to credit and cocoa income. Planting of trees for shade as climate change adaptation strategy was influenced by household size, engagement in other economic activity and access to extension service. Crop diversification as an adaptation strategy is governed by marital status, access to extension
service and access to credit. Diversification to non-farm activities is found to be influenced by farming experience and access to credit. In summary, gender, marital status educational level, household size, engagement in other economic activities, farming experience, access to extension services, access to credit/loan, and cocoa income influenced cocoa farmers’ choice of adaptation strategies.

5. Recommendations
Since the study indicated that lack of information on climate change and adaptation strategies was the major barrier to climate change adaptation, it is essential to mobilize resources towards the expansion of extension agent and media coverage in order to disseminate information on climate change and adaptation strategies to farmers. Again, there is the need for governments and non-governmental organizations to improve dissemination of information to farmers through extension agents in order to increase adoption of improved varieties of cocoa as an adaptation strategy option. Government policies should as a matter of priority, ensure cocoa farmers have access to flexible and affordable credit in order to give them greater flexibility to modify their adaptation strategies in response to climate change. Lastly, there is the need for governments and non-governmental organizations to invest in climate resilient projects.

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