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# ANALYSIS OF SMALLHOLDER MAIZE FARMERS' PERCEPTIONS ON CLIMATE CHANGE VARIABILITY AND ADOPTION OF ADAPTIVE AGRARIAN STRATEGIES IN THE GOMOA CENTRAL DISTRICT, GHANA

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## ABSTRACT

This research investigated the perception of maize farmers on climate change variability and adoption of agrarian strategies. The multi-stage sampling technique was used to select 400 respondents. Data were analyzed using means, standard deviation, percentage, frequency, multiple linear regression and multinomial logistic regression. All the maize farmers were aware of climate change variability, particularly with temperature. The factors that influenced the perceptions of the maize farmers on climate change variability were gender, membership in famer-based organizations, educational level and access to climate information. Farmers perceived that bush burning was the highest driver of climate change in the district. The effect of climate change on farmers' household basic needs was perceived to be increased cost of food while its effect on the environment was found to be reduction in crop yield. The three most adaptive agrarian strategies were planting of cover crops, rain harvesting and mixed farming. The choice of adaptation strategy was influenced by farmers' educational level, access to climate information, age, farm size, gender and years of experience. There is the need to create more awareness on the use of agrarian strategies to reduce the impact of climate change variability on agriculture.

**Keywords:** Agrarian Strategies, Bush Burning, Climate Change, Smallholder Maize Farmers.

## I. INTRODUCTION

Agriculture in Ghana engages about 57% of its economically active population and contributes about 34% to GDP (MoFA, 2014). About 90% of farms cultivate less than two hectares in size, although there are some large farms and plantations of variety of crops. Less than 1% of its land is under irrigation and the vast majority of its farmers rely entirely on

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rainfall (MoFA, 2014; World Bank, 2010). Ghana's agriculture sector is faced with climate variability and change issues (IPCC 2014; Niang *et al.,* 2014).

The changes in climate are obvious in African countries such as Ghana. These changes include season dynamics, increased frequency of droughts, increased temperatures, and altered patterns of precipitation and intensity. The activities of mankind in the form of crude farming practices and the persistent increase in population in Ghana have also contributed to desertification as mankind converts forest and farmlands into residential areas (Ntiamoah and Afrane, 2008).

One of the most cultivated and consumed staple crops in Ghana which is affected by the climate condition is maize. Maize provides 50% of the basic calories of most households. It also serves as a check against food insecurity and economic improvement in most communities in Ghana. The effect of climate change variables in dwindling production of maize could be a potential threat to food security (Winter - Nelson and Aggrey - Fynn, 2008; MiDA, 2010). Its production during the growing period to harvesting is dependent on rainfall and other weather conditions. However, the output of the maize farm is considered below the farmer's expectation, which is mainly attributed to the effects of climate change and related environmental phenomenon. Maize cropping in Ghana is highly dependent on sustained rainfall, especially during its critical development stages. The high demand for maize by the growing population and business such as poultry, fish farming and the brewery industry makes the production of maize very profitable for its farmers (Winter - Nelson and Aggrey - Fynn, 2008). Notwithstanding the high demand for maize, its production is dominated by rural smallholder farmers in Ghana (MiDA, 2010) and it is usually cultivated either as a single crop or with other crops, such as plantain, yam and cassava (MoFA, 2013).

Climate change is a threat to food security and livelihoods of the rural poor. Due to high levels of poverty, low levels of human and physical capital, and poor infrastructure, it has been reported that Africa will be the hardest hit because many smallholder farmers largely or totally rely on rain-fed agriculture and have fewer alternatives. Climate change variability is expected to have significant negative impacts on crop growth and development processes although the extent of this effect is known to be dependent on the nutrient status of the soil (Abera *et al.*, 2018).

The reliance of maize production on rainfall patterns and increasing temperatures makes it highly vulnerable to climate variability and change, and contributes to decreasing yield (Ragasa *et al.,* 2014; Morton, 2007). These negative effects of climate change cannot be underestimated as this has challenged production of cereals (e.g., maize) in Ghana (Maddison, 2007; Ntiamoah and Afrane, 2008).

For smallholder maize farmers, this variability can be explained by the cultural theory and the 'social amplification of risk theory'. The cultural theory which stems from studies in sociology and anthropology places more value on how groups interpret risks collectively. Smallholder maize farmers in Ghana and most African countries value the extension of their social networks. This culture system can influence their risk perceptions. Their perceptions of risk are highly mediated by the social context; hence, it is the socially shared worldview which determines risk (Leiserowitz, 2007; Schliep *et al.,* 2008). Leiserowitz (2007) found that cultural worldviews were indeed a significant predictor of risk perceptions in the context of climate change. Different cultures respond to threats differently and social structures can lead to diverging attitudes or a cultural bias towards a risk. This, in turn, plays a large role in constructing individual perceptions of risk (Schliep *et al.,* 2008). Schliep *et al.,* (2008) again found the organizational culture to be an important factor in risk perceptions on climate change. A second theory relating to risk perception is the 'social amplification of risk theory'. The principle behind this theory is that risk events interact with cultural, psychological and social factors to either increase or decrease perceptions of risk (Kasperson *et al.,* 1988). As Kasperson *et al.,* (1988) described, amplification occurs through two stages. The first is that information about the risk is communicated, while the second process occurs in the form of a response mechanism by society. This theory is mainly applied to threats in the environment or for human health and examines how communication of risk travels between channels and persons. Key aspects to consider include how to communicate the risk, how groups interpret the information, how the news media covers the story and how other interpersonal networks transfer information.

Considerably, a number of research have been done on the adaptation strategies on crop production in Ghana but not many is focused on adaptation strategies on maize production in specific locations in Ghana (Gutu, 2014; Fosu-Mensah *et al.*, 2012; Adjei-Nsiah and Kermah, 2012). Ahenkan *et al.,* (2021), Kpotor *et al.*, (2012) and Apata (2011) gave attention to the broad effects of climate change on agriculture as a whole as well as various adaptation measures employed by farmers to cope. Also, a study by Manyeruke *et al.,* (2013) considered climate change and its effects on agriculture as a whole. Some studies in African countries such as Ghana, Botswana, Ethiopia, and Malawi have shown that farmers perceive and are aware of changes in climatic conditions such as rainfall and temperature (Maddison, 2007; Mertz, 2009; Simelton *et al.,* 2011). Studies in Ghana showed that these perceived changes in climatic conditions affect maize yield (Kemausuor *et al.,* 2012; Klutse *et al.,* 2013). The impact of climate change on cereal production are evidenced and buttressed by the above studies raising food security concerns for Ghana. This study investigates the perception of maize farmers on climate change variability and their choice of adaptive agrarian strategies in the Gomoa Central District, Ghana. Specifically, the study investigates farmers' perception on climate change variability, analyses the factors that influence farmers' perception of climate change variability, examines the perceived effects of climate change on maize production, assesses the adaptive agrarian strategies used by smallholder maize farmers to improve the cultivation of maize, and analyses the factors that influence the choice of adaptive agrarian strategies by small holder maize farmers.

## II. MATERIALS AND METHODS

The research design that was used for this study was the descriptive design. It was used to obtain information to systematically describe climate change variability and adoption of adaptive agrarian strategies in the study and to help answer the research problem. The population for this study was all maize farmers in the Gomoa Central District, Central Region, Ghana. The total population of maize farmers in the district is over 2,000. Out of the total population, 400 maize farmers were selected using Yamane (1973) sample size formula:

$$n = \frac{N}{1 + N(a)^2}$$

Where, N is the population of maize farmers (N= 2000) and $(a)^2$ is 5% margin of error

The multi-stage sampling technique was used to select the respondents. First of all, the purposive sampling was used to select the Gomoa Central District. This was due to the fact that there are numerous maize farmers in the district relative to other Districts in the Central Region. Secondly, the simple random sampling method of probability techniques was employed to select the communities, thus, Afransie, Aworoopataa, Anitiefi, Akisimasu, Dadsonkwaa, Kobina Ogyam Mmofra Nfa Adwen, Tanoso. Thirdly, the simple random sampling technique was employed to select individual smallholder maize farmers. Fifty (50) smallholder maize farmers each were selected from each of the communities. Structured questionnaire was used as the main instrument for collecting data for the study and was administered in the local dialect and English language to obtain quality data. A week-long training was provided to the data collectors so that the right data could be collected. The researcher checked each filled-up questionnaire to ensure that no information was missing; any error detected was corrected immediately at the field, sometimes by revisiting the household, before it was entered into the computer. The procedure for collecting the data was face to face interaction with the respondents.

The SPSS (Statistical Package for Social Sciences, version 20) computer software was used to analyse the data. The summary statistics were reported as means with standard deviations (SD) for continuous variables, or as percentages with 95% confidence intervals (CI) for categorical variables. In developing the framework for the calculation of the perception index, the study adopted the measurement used by Wongnaa and Boachie (2018). The Likert scale was used to analyse farmers' perception on climate change variability, drivers and effects. The mean score X of a perception statement on the Likert scale is computed as:

$$X = \sum \frac{fijXij}{n}$$

where X is the ranked value of a perception statement i on the 3-point Likert scale and f is the total number of respondents assigning value x to a perception statement i on the 3-point scale. The 3-point Likert scale takes a ranked value of 1 if respondent j agreed to a perception statement i, 2 if neither agreed or disagreed and 3 if respondent agreed. The parameter n is equal to the total number of respondents. The overall perception index (PI), which reflects the general agreement of all respondents on all the perception statements on the Likert scale, is computed as:

$$PI = \frac{\sum \frac{fijXij}{n}}{\text{number of perception statements}}$$

The multiple linear regression was used to determine the factors that influence farmers' perception of climate change variability. The choice of the multiple linear regression was because the dependent variable was continuous, thus, overall perception index on rainfall, flooding, temperature, wind, atmosphere, harmattan while the independent variables were a mixture of dummy and continuous variables, thus, age, gender, marital status, education, membership in Farmer Based Organization (FBO), farm size, years of experience and access to climate change information. The choice of independent variables was based on literature from the following sources (Fosu-Mensah *et al.*, 2012; Adjei-Nsiah and Kermah, 2012; Leiserowitz, 2007; Schliep *et al.,* 2008; Kasperson *et al.,* 1988).

$$Yi = \beta o + \beta iXi + \beta pXxip + \varepsilon$$

Where, *i*=*n* observations; Yi=dependent variable (overall perception-continuous); Xi=explanatory variables; X1=age of respondent, measured in years (+); X2= gender, measured as a dummy (1 for male and 0 for otherwise) (+/-); X3= marital status, measured as a dummy (1 for married and 0 for otherwise) (+/-); X4=education, measured in years of school (+); X5= membership in FBO, measured as a dummy (1 for members and 0 for otherwise) (+); X6=farm size, measured in acres (+/-); X7= years of experience, measured in years of farming (+); X8= access to climate information, measured as a dummy (1 for access and 0 for otherwise) (+); βo =y-intercept (constant term); βp =slope coefficients for each explanatory variable; $\varepsilon$=the model's error term (also known as the residuals)

The Multinomial logistic regression model (MNL) was used to predict categorical placement or analyse the factors influencing smallholder farmers' choice of the three agrarian adaptation strategies with the highest means. The adaptive agrarian strategies were identified as mutually exclusive to predict a nominal dependent variable given one or more independent variables. The MNL model for choice of adaptation strategies specifies the relationship between the probability of choosing an adaptation option and the set of explanatory variables. The model allows evaluation of choices made among multiple dependent variables. The three key agrarian strategies that were chosen by the farmers were used to compute the model: planting of cover crops, rain harvesting and mixed farming. The MNL model was specified as follows:

$$Pro\ (Yj) = (\beta o + \beta 1X1 + \cdots \beta kXk + \varepsilon i)$$

Where Prob (Yj) is the probability of a farmer choosing a given set of desired agrarian strategies, which can be represented by planting of cover crops, rain harvesting and mixed farming. $\beta o$ = the intercept. $\beta(1,2,3)$ = the coefficients associated with the independent variables; X1=age of respondent, measured in years (+); X2= gender, measured as a dummy (1 for male and 0 for otherwise) (+/-); X3= marital status, measured as a dummy (1 for married and 0 for otherwise) (+/-); X4=education, measured in years of school (+); X5= membership in FBO, measured as a dummy (1 for members and 0 for otherwise) (+); X6=farm size, measured in acres (+/-); X7= years of experience, measured in years of farming (+); X8= access to climate information, measured as a dummy (1 for access and 0 for otherwise) (+).

## III. RESULTS AND DISCUSSION

### 3.1 Socio-demographic Characteristics of Respondents

Table 1 contains information on the socio-economic characteristics of the smallholder maize farmers. The gender distribution of the respondents shows that the majority of the respondents are males, as they constituted 52.50% of the total number of respondents whilst 47% were females, indicating that males are the dominant gender of households in maize farming in the study area. Majority of the respondents (86.25%) were married. According to Hainmueller *et al.*, (2011), Danso-Abbeam *et al.*, (2012), Lawal *et al.*, (2005) and Adeogun *et al.*, (2010) also reported that a lot of maize farmers are married.

The data presented in the Table shows that 87.00% of respondents had education from primary level up to Junior High School. Education is generally believed to increase farmers' ability to analyse information disseminated by different sources and helps them have certain perception on utilization of agricultural information through reading and analyzing in a better way. The results show that the farmers in the study area have at least formal educational level which could help them have some level of knowledge on agricultural information particularly on climate change. This finding is not different from what has been reported in Ghana that majority of maize farmers in Ghana end their formal education at Junior High / Middle school and below (Hainmueller *et al.,* 2011). About 96.75% of the maize farmers were members of farmer-based organizations while 3.25% did not belong to any farmer association.

**Table 1: Background Information of Respondents**

| **Discrete Variables** | **Frequency** | **Percent** |
|---|---|---|
| Gender | | |
| Male | 210 | 52.50 |
| Female | 190 | 47.50 |
| **Marital Status** | | |
| Married | 345 | 86.25 |
| Divorced | 13 | 3.25 |
| Single | 16 | 4 |
| Widowed | 26 | 6.50 |
| **Educational Level** | | |
| No formal education | 39 | 9.75 |
| Primary/Junior High School | 348 | 87.00 |
| Above Senior High School | 13 | 3.25 |
| **Membership in FBO** | | |
| Yes | 387 | 96.75 |
| No | 13 | 3.25 |
| **Awareness of climate change** | | |
| Yes | 400 | 100.0 |
| No | 0 | 0.0 |
| **Sources of Information** | | |
| Fellow farmers | 118 | 29.5 |
| Extension agents | 94 | 23.5 |
| Radio set | 9 | 2.25 |
| Television set | 2 | 0.5 |
| Internet/social media | 1 | 0.25 |
| Newspaper | 1 | 0.25 |
| Family members/Relatives | 79 | 19.75 |
| Neighbours | 32 | 8 |
| NGO workers | 47 | 11.75 |
| Personal involvement in Training | 13 | 3.25 |
| Religious leader | 4 | 1 |
| **Continuous Variables** | **Mean** | **Std. Deviation** |
| Age | 45.01 | 3.97 |
| Farm size | 4.65 | 1.45 |
| Years of experience | 11.54 | 5.66 |

Source: Field Data, 2021

The Table also represents the awareness of climate change. Out of the 400 farmers interviewed, 100% indicated ‘yes’, suggesting that all the famers are aware of climate change. A large number of developing countries like Ghana relying on agriculture for their national economy are facing severe threats of climate change. Awareness is the ability to directly know and perceive, to feel, or to be conscious of events, thoughts, emotions and sensory patterns. Therefore, all the farmers in the study area were aware of climate change. This could be helpful in withstanding the negative fallout of the extremities linked with climate change. This result agrees with Ali and Erenstein (2017) that climate change awareness is a determinant of development in the agriculture sector as it enhances knowledge about climate change and builds the capacity of farmers for undertaking more effective, efficient and relevant interventions (Legesse *et al.,* 2013; Tambo and Abdoulaye, 2013; Roco *et al.,* 2014).

Majority of the farmers got to know about climate change from their fellow farmers (29.5%). The farmer-to-farmer extension approach (F2FE) is gaining popularity as an effective form of information for farmers. It is playing a complementary role to formal extension services in facilitating the spread of agricultural technologies and improving farmers' capacities. It is more inclusive, low-cost, effective and offers a wide-reaching alternative in supporting agricultural innovation (Ssemakula and Mutimba, 2011).

The results revealed that the mean age of the farmers interviewed was 45 (SD =3.97) years. This result obtained shows that the farmers are quite strong to undertake most of the difficult activities of farming. A mean farm size of 4.65 (SD =1.75) acres was recorded indicating that farmers generally do not have very large lands but at least cultivated enough lands. This finding is consistent with Danso-Abbeam *et al.*, (2012) who stated that, majority of maize farmers operate farm sizes of 4 acres and above. The data in the Table also revealed that the mean farming experience of the farmers was 11.54 (SD =5.66) years. Longer years in farming come with experience thus familiar with most practices on the farm. This is confirmed by Danso-Abbeam *et al.,* (2012) who report that majority of farmers (79%) have an experience of greater than 10 years. Engaging in cocoa farming for a period above five years is long enough to gather all the experience needed. Thus, conclusion can be drawn that most farmers interviewed had great experience.

### 3.2 Farmers' Perception of Climate Change Variability

Farmers were asked if they had experienced variations in rainfall, atmosphere, flooding, temperature, harmattan and wind over the years that were perceived to be related to climatic changes (Table 2).

In terms of rainfall, the average perception index of 1.66 (SD=0.47) was recorded for the farmers, implying that farmers were neutral with regard to the variability in rainfall. In a study by Cudjoe *et al.,* (2021), it was rather found that most of the respondents noticed changes in the duration of rainfall in recent years compared with the past. The overall perception index shows that farmers were neutral about climate variability in rainfall. The implication is that most of the rural farmers, particularly maize farmers, in order to stay in farming business or sometimes for livelihood or maintenance reasons, tend to adjust to operational conditions such as seasonal planting dates in order to fit the rainy seasons or tend to cultivate other crops that can withstand the climate change variability trend of the recent rainfall pattern. This supports that of Ntiamoah and Afrane (2008) that this mechanism helps especially maize farmers to cope with the erratic nature of the recent rainfall patterns. Countries in Africa are also experiencing observable shifts in rainfall and temperatures (Mubiru *et al.,* 2012). When rainfall is unreliable, crops that require water at critical phases of development suffer greatly. Moisture stress during flowering, pollination and grain filling is harmful to staple crops such as maize, thus making rain-dependent agriculture challenging. Where natural conditions required for the growth of food are no longer suitable, irrigation options must be explored. The demand for water, in this case, would also increase in a warming climate, resulting in competition among water uses (Nyenje and Batelaan, 2009).

**Table 2: Perception of Smallholder Farmers on Climate Change Variability**

| **Rainfall** | **Mean** | **Std. Dev.** |
|---|---|---|
| Above normal rainfall | 2.95 | 0.65 |
| Low intensity rainfall | 2.49 | 0.45 |
| Decreased rainfall days | 2.35 | 0.64 |
| Delay in the onset of rainfall | 2.29 | 0.17 |
| Erratic/unusual rain | 2.07 | 0.55 |
| High intensity rainfall | 1.97 | 0.11 |
| Erratic/torrential rainfall | 1.95 | 0.80 |
| Shorter than normal rainfall | 1.85 | 0.35 |
| Rivers and stream overflowing their banks | 1.83 | 0.21 |
| Late onset of rainfall and early cessation | 1.38 | 0.51 |
| Early onset of rain and late cessation | 1.37 | 0.70 |
| Unusual patterns of precipitation | 1.37 | 0.51 |
| Below normal rainfall | 1.29 | 0.80 |
| Increase in rainfall | 1.29 | 0.50 |
| Increase rainfall days | 1.29 | 0.20 |
| Early onset of rainfall and early cessation | 1.14 | 0.48 |
| Late onset of rain and late cessation | 0.97 | 0.50 |
| Longer than normal rainfall | 0.07 | 0.29 |
| Perception Index: (Mean=1.66, SD=0.47) | | |
| **Atmosphere** | **Mean** | **Std. Dev.** |
| Constant drought | 1.66 | 0.45 |
| Frequency of cloudiness | 1.22 | 0.92 |
| Constant fog | 0.72 | 0.23 |
| Presence of frost | 0.54 | 0.92 |
| High humidity | 0.55 | 0.01 |
| Low humidity | 0.83 | 0.12 |
| Perception Index: (Mean=0.92, SD=0.44) | | |
| **Flooding** | **Mean** | **Std. Dev.** |
| Rainstorms | 2.24 | 0.67 |
| Flash flooding | 1.01 | 0.11 |
| Unusual flooding | 0.98 | 0.35 |
| Perception Index: (Mean=1.41, SD=0.37) | | |
| **Temperature** | **Mean** | **Std. Dev.** |
| Increase in earth surface temperature | 2.84 | 0.70 |
| High sunshine intensity | 2.61 | 0.52 |
| Low sunshine intensity | 1.16 | 0.01 |
| Longer hours of sunshine | 1.45 | 0.30 |
| Perception Index: (Mean=2.01, SD=0.38) | | |
| **Harmattan** | **Mean** | **Std. Dev.** |
| Short-lived Harmattan | 1.16 | 0.72 |
| Early onset and early cessation of Harmattan | 0.07 | 0.54 |
| Late onset and late cessation of Harmattan | 1.87 | 0.77 |
| Early onset and late cessation of Harmattan | 1.14 | 0.55 |
| Late onset and early cessation of Harmattan | 0.73 | 0.83 |
| Constant drought | 2.96 | 0.74 |

| **Rainfall** | **Mean** | **Std. Dev.** |
|---|---|---|
| Perception Index: (Mean=1.32, SD=0.69) | | |
| **Wind** | **Mean** | **Std. Dev.** |
| Typhoon wind | 1.24 | 0.69 |
| Erratic wind | 1.89 | 0.27 |
| High wind speed | 1.50 | 0.97 |
| Low wind speed | 1.13 | 0.46 |
| Perception Index: (Mean=1.44, SD=0.60) | | |

Source: Field Data, 2021

In terms of atmosphere, the average perception index of 0.92 (SD=0.44) was recorded for the farmers, implying that farmers disagreed with the perception statements of variability in atmosphere. Recent experience of worsening circumstances under periodic and severe droughts may drive a belief in a climate that has significantly changed over a period of time. According to Whitmarsh (2018), the human tendency to readily trust this as reality and as such causal attribution may not be well-managed. However, this perception still remains relevant to climate change related policy and decision-making as it prompts smallholders to take adaptive action and their willingness to cooperation with others.

In terms of flooding, the average perception index of 1.41 (SD=0.37) was recorded for the farmers, implying that farmers disagreed with the perception statements of variability in flooding. Even though leaching as a result of flooding is the direct effects of climate variability and change experienced in Ghana and Africa at large and it contributes to low fertility of soil, yet the farmers in this study did not experience such effects from flooding. Cudjoe *et al.*, (2021) also indicated that about 28.3% of farmers in their study had noticed increased flooding compared with the past.

A perception index of 2.01 (SD =0.38) was recorded for the farmers on climate change variability related to temperature. This finding implies that farmers neither agreed nor disagreed on climate change variability relating to temperature. However, farmers agreed that there has been an increase in earth surface temperature and high sunshine intensity. Nyenje and Batelaan (2009) found an interesting relation of near-surface temperatures and their impact on ground water systems in Uganda. The effect of an increase in temperature, however small, will have a disastrous impact, for example on crop growth (Jassogne *et al.*, 2013).

In terms of harmattan, the average perception index of 1.32 (SD=0.69) was recorded for the farmers, implying that farmers disagreed with the perception statements of variability in harmattan. In terms of wind, a perception index of 1.44 (SD=0.60) was recorded. Generally, farmers disagree that there has been changes in wind with respect to climate change. Findings of Schauffler (2021) agrees with this result and indicate that climate predictions do not generally factor in surface winds, despite some indications they may be changing and has the potential to signal and accelerate climate disruptions. It can increase wildfire risks, aggravate drought and endanger boaters. Even with abundant data, the influence of the changing climate on wind patterns may be hard to discern.

A perception index of 1.44 (SD =0.60) was recorded for the farmers on climate change variability related to wind. This finding implies that farmers disagreed on climate change variability relating to wind.

### 3.3 Factors that Influence Farmers' Perception on Climate Change Variability

Table 3 contains information on the factors that influence smallholder maize farmers' perception on climate change variability. Multi-collinearity among the explanatory variables was tested separately for continuous and dummy/discrete variables before the analysis was conducted using the multinomial logistic regression. Variance Inflation Factor (VIF) was used to detect multi-collinearity among the continuous independent variables whereas contingency coefficient (CC) was used for the dummy or discrete variables. As a rule of thumb, if the VIF of the association among the variables exceeds 10, there is a strong multi-colinearity problem and should be excluded from the analysis. The CC values vary between 0 and 1; in which zero indicates there is no association between variables while values close to 1 indicates high degree of association between variables. In this study, the analysis showed that the values of VIF and CC among the independent variables were within the lower level of association (data not shown) which indicates that there is no serious problem of multi-collinearity effect among most of the explanatory variables. Strong multi-collinearity was only detected between the variables (access to credit, type of farm and household size) and they were excluded from the analysis as these non-significantly influenced the dependent variable.

**Table 3: Regression Coefficients on Farmers' Perception Climate Change Variability**

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | 1.36 | 0.66 | | 2.07 | 0.05 |
| Gender | 0.41 | 0.22 | 0.26 | 1.85 | 0.07* |
| Marital | -0.23 | 0.32 | -0.12 | -0.72 | 0.48 |
| Educational level | 0.09 | 0.04 | -0.43 | -2.21 | 0.03** |
| FBO Membership | 0.92 | 0.56 | 0.24 | 1.62 | 0.09* |
| Age | -0.01 | 0.02 | -0.17 | -1.20 | 0.24 |
| Farm size | 0.05 | 0.05 | 0.18 | 0.93 | 0.36 |
| Years of experience | -0.00 | 0.04 | -0.01 | -0.04 | 0.97 |
| Access to climate information | 0.28 | 0.13 | 0.33 | 2.23 | 0.03** |

Source: Author's Construction, 2021

P=0.00; R=0.69; $R^2$=0.47; Adjusted $R^2$=0.36; Std. Error: 0.60

The Table above shows that four of the independent variables are statistically significant. This means that they are the factors that influence the perceptions of the maize farmers on climate change variability. These factors are gender, FBO membership, educational level and access to climate information. Gender strongly influences the perception of maize farmers on climate change variability. Consequently, male maize farmers are likely to have a strong perception (awareness) on climate change variability. Membership in the FBO was also found to be a significant factor in influencing maize farmers' perception. Consequently, maize farmers who belonged to FBOs were likely to have a strong perception on climate change variability. Educational level and access to climate information were also found to be significant factors in influencing farmers' perception on climate change variability. The issue of educational level and access to information is confirmed by Mustapha *et al.*, (2012) and Ndambiri *et al.*, (2012) who agree that years of schooling and access to climate information strongly influence and increase perception of climate change and its impact on local agriculture. A higher level of education may slightly result in a greater awareness of climate change as a real issue of global and immediate concern, thus increasing the likelihood that changes in farming practices are attributed to the impact of climate change. Smallholders who are more educated are more likely to be able to interpret and apply climate information to their lives making them aware of local climate change or variability which becomes crystallized into a perception of climate change. The impact of education and access to climate information (i.e., a higher level of education is associated with a greater probability of perception of climate change) is common among smallholder farmers across African farming systems. Studies in Kenya, Ghana and Zimbabwe indicate the significant benefits that accrue from local climate information (e.g., weather updates) which increases the awareness of climate change in terms of more informed adaptive decisions and improved technology uptake among smallholder farmers (Kalungu *et al.,* 2013).

### 3.4 Farmers' Perception on the Drivers of Climate Change

Farmers' perceptions of drivers of climate change were also discussed in Table 4. A perception index of 2.51 (SD =0.51) was recorded. This shows that generally, farmers agree on the drivers of climate change. Apart from frequent cyclone or tidal wave which had farmers disagreed that it is a cause of climate change, the results revealed that farmers agreed with most of the drivers, burning of bush, deforestation, rapid urbanization, use of pesticides and herbicides, population growth, and improper disposal of farm wastes. From the results above, it could be said that the three key drivers of climate change are burning of bush, deforestation and rapid urbanization. In relation to deforestation, Nyanga *et al.,* (2011) also found that majority of their respondents acknowledged that climate is changing and also associated the change with deforestation. It is not strange that in Africa, some attribute the changes in climate to spiritual or supernatural forces. For instance, Patt and Schröter (2008), Tambo and Abdoulaye (2013) and Teka *et al.,* (2013) indicated that African farmers consider that humanity is cursed, and supernatural forces are the primary cause of climate change. Disobedience and unfaithfulness to God's rules, failure to glorify him and divergence from the age-old local traditions have led to divine punishment, especially, drought events.

**Table 4: Perception on the drivers of climate change**

| Drivers | Mean | Std. Dev |
|---|---|---|
| Burning of bush | 2.96 | 0.48 |
| Deforestation | 2.93 | 0.38 |
| Rapid urbanization | 2.85 | 0.50 |
| Use of pesticides and herbicides | 2.82 | 0.49 |
| Population Growth | 2.76 | 0.50 |
| Improper disposal of farm wastes | 2.62 | 0.55 |
| Use of fossil fuels (fuel, kerosene, etc.) | 2.47 | 0.44 |
| Use of inorganic fertilizers | 2.43 | 0.52 |
| Black smoke of vehicles | 2.14 | 0.61 |
| Intensive agricultural land use | 2.13 | 0.50 |
| Frequent cyclone or tidal wave | 1.49 | 0.61 |
| Perception Index: (Mean=2.51, SD=0.51) | | |

Source: Field Data, 2021

### 3.5 Farmers' Perception of Effects of Climate Change

Table 5 contains information on the perception of the smallholder maize farmers on the effects of climate change. A perception index of 2.55 (SD=0.33) was recorded for farmers' perceptions of the effect of climate change on their basic household needs. Generally, farmers perceive that there is a relatively high level of effect of climate change on their household basic needs. This is most evident in increased cost of food (Mean=2.79). Climate change continues to manifest its effects among farmers affecting their household income, increasing food insecurity and vulnerability, contrary to sustainable livelihoods for rural poor postulated in sustainable livelihood approach (Scoones, 2015).

**Table 5: Perceptions of Farmers on Effect of Climate Change**

| **Household Basic Needs** | **Mean** | **Std. Dev.** |
|---|---|---|
| Increased cost of food | 2.79 | 0.48 |
| Increased health care expenditure | 2.77 | 0.46 |
| Increased repairs of accommodation | 2.64 | 0.61 |
| Damage to household assets | 2.59 | 0.18 |
| Loss of resilience of buildings | 2.57 | 0.26 |
| Loss of life and injury | 2.55 | 0.10 |
| Increased cost of drinking water | 2.35 | 0.19 |
| Increased cost of clothing | 2.14 | 0.39 |
| Perception Index (Mean=2.55, SD=0.33) | | |
| **Environment** | **Mean** | **Std. Dev.** |
| Decrease in crop yield | 2.94 | 0.69 |
| Loss in soil fertility | 2.91 | 0.66 |
| Increased erosion | 2.82 | 0.68 |
| Water logging | 2.82 | 0.68 |
| Excessive cold | 2.77 | 0.46 |
| Increased crop pest and diseases | 2.66 | 0.57 |
| Increased runoff | 2.62 | 0.62 |
| Frequent flood | 2.54 | 0.39 |
| Excessive temperature | 2.46 | 0.38 |
| Increased loss of topsoil and nutrients | 2.39 | 0.57 |
| Increased evaporation | 2.29 | 0.48 |
| Reduced infiltration | 2.29 | 0.69 |
| Perception Index (Mean=2.63, SD=0.57) | | |

Source: Field Data, 2021

A perception index of 2.63 (SD=0.57) was recorded for farmers' perceptions of the effect of climate change on their environment. Generally, farmers perceive that there is a relatively high level of effect of climate change on their environment. This is most evident in decrease in crop yield (Mean=2.94). The study findings seem to agree with earlier studies by Arnell *et al.,* (2002). The mentioned studies established the correlation between climate change and crop yield., Climate change and its potential future pathways are likely to reduce agriculturally suitable areas, vary the length of growing seasons, and reduce the potential crop yield. Wabwire *et al.,* (2020) also suggested a decrease in crop yield from subsistence farming. In their study, about 47% of the respondents indicated that the crop yield had decreased, while still, other respondents argued that their crop production had increased a little (23%). The factors attributed to decrease in crop yield included pest infestation, change in rainfall patterns i.e., unreliable rainfall.

### 3.6 Farmers' Use of Adaptive Agrarian Strategies for Climate Change

A perception index of 2.26 (SD=0.52) shows that maize farmers fairly used the various adaptive agrarian strategies Table 6). Three of the agrarian strategies with the highest mean scores by the respondents were planting cover crops (Mean=2.97, SD=0.55), rain harvesting (Mean=2.95, SD=0.35) and mixed farming (Mean=2.89, SD=0.27). Dickie *et al.*, (2014) agree that strategies such as reducing tillage, expanding crop rotations, planting cover crops and reintegrating livestock into crop production systems have all been proven to reduce agriculture's own footprint, as well as capture the excess carbon generated by other industries. Planting cover crops is a successful farming method that helps to prevent soil erosion, promotes water retention, and nitrogen fixation. Thus, legumes are known as nitrogen producing crops participating in the conversion of the atmospheric nitrogen to forms that can be ingested by plants. Cover crops also serve as organic manure or material for fodder and grazing cattle.

**Table 6: Farmers' use of adaptive agrarian strategies for climate change**

| Strategies | NU | FU | AU | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Planting of cover crops | 54 (13.50) | 297 (74.25) | 49 (12.25) | 2.97 | 0.55 |
| Rain harvesting | 29 (7.25) | 359 (89.75) | 12 (3.00) | 2.95 | 0.35 |
| Mixed farming | 2 (0.50) | 369 (92.25) | 29 (7.25) | 2.89 | 0.27 |
| Climate predictions | 36 (9) | 180 (45) | 184 (46) | 2.37 | 0.64 |
| Crop diversification | 39 (9.75) | 296 (74.00) | 65 (16.25) | 2.29 | 0.51 |
| Use organic fertilizers | - | 284 (71.00) | 116 (29.00) | 2.29 | 0.45 |
| Diversification to non-farming activities | 77 (19.25) | 192 (48) | 131 (32.75) | 2.14 | 0.71 |
| Change in fallow period | 11(2.75) | 310 (77.50) | 79 (19.75) | 2.07 | 0.54 |
| Improved crop variety | 117 (29.25) | 181 (45.25) | 102 (25.50) | 1.96 | 0.74 |
| Changing harvesting date | 83 (20.75) | 267 (66.75) | 50 (12.50) | 1.92 | 0.57 |
| Changing tillage methods | 62 (15.50) | 316 (79.0) | 22 (5.50) | 1.90 | 0.45 |
| Changing planting dates | 103 (25.75) | 255 (63.75) | 42 (10.50) | 1.85 | 0.58 |
| Precision agriculture | 291 (72.75) | 90 (22.50) | 19 (4.75) | 1.82 | 0.49 |
| Perception Index (Mean=2.26, SD=0.52) | | | | | |

Source: Field Data, 2021

NU (1) = Never Used; FU (2) = Fairly Used; AU (3) = Always Used

Precision agriculture (Mean=1.82, SD=0.49) had the lowest mean score. It was also the strategy that had the highest number of farmers who indicated that they had never used it before. Concerning precision agriculture, Aubert *et al.*, (2012) indicated that it plays an important role in sustainable intensification, and it is recognized as a contributor to farming efficiency and environmentally friendly farming practices. It allows crop farmers to recognize variations in the fields and to apply variable rate treatments with a much finer degree of precision than earlier possible. With the technology, farmers can control all the processes remotely with a precision agriculture system. It dramatically improves the efficiency of crops and saves financial costs while increasing production. Optimizing soil use preserves its quality, allowing for a stable food supply. Therefore, precision farming in agriculture plays an essential role in solving the global problem of hunger (Dickie *et al.*, 2014).

### 3.7 Factors Influencing Farmers' Choice of Adaptive Agrarian Strategies

Table 7 contains information on the factors that influence smallholder maize farmers' choice of adaptive agrarian strategies. The explanatory variables that were significant in influencing farmers' choice of adaptation strategy were age, gender, educational level, membership in FBO, farm size, years of experience and access to climate information. Apart from marital status, all the other variables were significant in relation to either of the three agrarian strategies. Farm size was responsible in influencing farmers' choice of planting of cover crops and rain harvesting as adaptation strategies.

**Table 7: Multinomial logistic regression estimation for the choice of adaptation strategies**

| Adaptation | Planting of cover crops | | | Rain harvesting | | | Mixed farming | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef | Std. Err. | P>z | Coef | Std. Err. | P>z | Coef | Std. Err. | P>z |
| Age | -0.15 | 0.09 | 0.06** | 0.63 | 0.53 | 0.09** | 0.07 | 1.00 | 0.09** |
| Gender | 0.42 | 0.13 | 0.43 | 0.72 | 0.60 | 0.20 | 1.25 | 0.12 | 0.03* |
| Marital status | -0.28 | 0.36 | 0.13 | -0.11 | 0.15 | 0.65 | 0.61 | 0.44 | 0.16 |
| Educational level | 0.10 | 0.25 | 0.03* | 0.07 | 0.05 | 0.01* | 1.28 | 0.92 | 0.04* |
| Membership in FBO | 0.37 | 0.65 | 0.09** | 0.10 | 0.60 | 0.45 | 0.66 | 0.76 | 0.39 |
| Farm size | 0.27 | 0.20 | 0.01* | 0.33 | 0.12 | 0.07** | 0.05 | 0.27 | 0.83 |
| Years of experience | 0.42 | 0.53 | 0.43 | 0.77 | 0.61 | 0.02* | 1.25 | 0.72 | 0.04* |
| Access to climate information | 0.89 | 0.96 | 0.06** | 0.66 | 0.07 | 0.52 | 0.16 | 1.30 | 0.02* |
| _cons | -0.23 | 0.31 | 0.58 | -7.04 | 1.14 | 0.99 | 1.55 | 0.01 | 0.16 |

Note: *5% Sig, **10% Sig.
Base category: not adapting
Number of observations: 400

Age was responsible in influencing farmers' choice of planting of cover crops, rain making and mixed farming as adaptation strategies. Years of experience was responsible in influencing farmers' choice of rain harvesting and mixed farming as adaptation strategies. Dasmani *et al.,* (2020) found that age and farming experience have a significant influence on farmers' choice of growing improved varieties. Age/experience of the farmer increased the likelihood of growing improved varieties by 32% in coastal areas while reduced the chances of growing improved varieties in the forest areas. Discussions with farmers indicated that the more years a farmer adds, the more the level of experience on a kind of crop variety to grow.

Gender was responsible in influencing farmers' choice of mixed farming as an adaptation strategy. Gender is positively and significantly related to the choice of the adaptation strategy of farmers, showing that men better adapt to climate change. This can be associated with the fact that women are usually constrained by labour because they are responsible for both farming and household activities. Moreover, they have less access to resources, information and other socio-economic opportunities and bear more burdens of household responsibilities than males (Guteta and Abegaz, 2015; Deresa *et al.,* 2011).

Educational level was responsible in influencing farmers' choice of planting of cover crops, rain harvesting and mixed farming as adaptation strategies. This suggests that educated farmers tend to better recognize the risks associated with climate change. Education also more likely enhances the reasoning capability and awareness of farmers about new technologies and hence induces them to adopt (Deresa *et al.,* 2011; Asrat *et al.,* 2004).

Access to climate information was responsible in influencing farmers' choice of planting of cover crops and mixed farming as adaptation strategies. This study showed a significant positive role for access to climate information in promoting farmers' investment or choice of adaptation measures. Providing agricultural extension services helps increase the implementation of adaptation measures as farmers can acquire new skills and hence ensures sustainable use of the techniques. Farmers' choice of adaptation strategy is reliance on extension officers as a source of climate change information (Lobell *et al.,* 2008).

Membership in FBO was responsible in influencing farmers' choice of planting of cover crops as an adaptation strategy. Knowledge gained through training can also provide farmers with the technical know-how required to implement adaptation measures in their agricultural production system and make them farsighted in looking for long-term benefits rather than immediate gains obtained at the expense of land degradation (Beshir *et al.,* 2012).

## IV. CONCLUSION

All the maize farmers were aware of climate change variability through their fellow farmers. An analysis of the perception of farmers on climate change variability showed that temperature recorded the highest mean. The factors that influence the perceptions of the maize farmers on climate change variability are gender, FBO membership, educational level and access to climate information. The three key drivers of climate change variability are burning of bush, deforestation and rapid urbanization. The effect of climate change on farmers' household basic needs was found to cause an increase in cost of food. In terms of the effect of climate change on the environment, the highest perceived effect was found in decrease in crop yield. Three of the agrarian strategies used by the respondents were planting of cover crops, rain harvesting and mixed farming. The explanatory variables that were significant in influencing farmers' choice of adaptation strategy were age, gender, educational level, membership in FBO, farm size, years of experience and access to climate information.

There is a need for government, MoFA and other relevant stakeholders and organizations to improve farmers' awareness and build their capacity on climate change adaptive agrarian strategies. Continued efforts should be geared towards educating farmers about the negative effects of bush burning and deforestation. The media can be used as a platform to create such awareness and help make the adaptive agrarian strategies for climate change easily available and accessible to smallholder maize farmers for them to always practice them to improve their production. Smallholder maize farmers must be supported in terms of funds, education, skills and hands on training for them to practice adaptive agrarian strategies to improve their yields. Factors such as FBO membership, educational level and access to climate must be promoted by the government, MoFA and other relevant stakeholders since they have an influence on the perception of farmers towards climate change variability. With the reduction in climate change variability through the various adaptive agrarian strategies, farmers can enjoy decrease in food cost and increase in crop yield. Finally, although there is vast literature on agrarian strategies, the study recommends that specifically, the effectiveness of agrarian strategies such as planting of cover crops, rain harvesting and mixed farming etc. must be studied in order to ascertain its empirical impact on farmers' livelihood and household food security so that they can be given more consideration by researchers and farmers.

## REFERENCES

Abera, K., Crespo, O., Seid, J. and Mequanent, F. (2018). Simulating the impact of climate change on maize production in Ethiopia, East Africa. *Environmental System Research*. 7:4

Adeogun, S.O., Olawoye, J.E. and Akinbile, L.A. (2010). Information Sources to Cocoa Farmers on Cocoa Rehabilitation Techniques (CRTs) in Selected States of Nigeria. *Journal Media and Communication Studies*, 2(1): 009 - 015.

Adjei-Nsiah, S. and Kermah, M. (2012). Climate change and shift in cropping system: From cocoa to maize-based cropping system in Wenchi Area of Ghana. *British Journal of Environment & Climate Change*, 2(2): 137-152.

Ahenkan, A., Chutab, D.N. and Boon, E.K. (2021). Mainstreaming climate change adaptation into pro-poor development initiatives: evidence from local economic development programmes in Ghana. *Climate and Development*, 13(7): 603-615.

Ali, A. and Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*, 16: 183-194.

Apata, T. (2011). Factors influencing the perception and choice of adaptation measures to climate change among farmers in Nigeria.

Arnell, N.W., Cannell, M.G.R., Hulme, M. Kovats, R.S., Michell, J.F.B., Nicholls, R.J., Parry, M., Livermore, M.J. and White, A. (2002). The consequences of CO2 stabilization for the impacts of climate change. *Climatic Change*, 53: 413-446.

Asrat, P., Belay, K. and Hamito, D. (2004). Determinants of farmers' willingness to pay for soil conservation practices in the southeastern highlands of Ethiopia. *Land Degrad Develop*, 15: 423–438

Aubert, B. A., Schroeder, A. and Grimaudo, J. (2012). IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. *Decision Support Systems*, 54: 510–520.

Beshir, H, Emana, B. and Kassa, B.H.J. (2012). Determinants of chemical fertilizer technology adoption in Northeastern highlands of Ethiopia: the double hurdle approach. *J Res Econ Int Fin*, 1: 39–49

Cudjoe, G.P., Antwi-Agyei, P. and Gyampoh, B.A. (2021). The Effect of Climate Variability on Maize Production in the Ejura-Sekyedumase Municipality, Ghana. *Climate*, 9: 145.

Danso-Abbeam, G., Aidoo, R. and Ohene-Yankyera, K.A.K. (2012). Technical efficiency in Ghanas cocoa industry: evidence from Bibiani-Anhwiaso-Bekwai District. *Journal of Development and Agricultural Economics*, 4(10): 287-294.

Dasmani, I., Darfor, K. N. and Karakara, A. A. (2020). Farmers' choice of adaptation strategies towards weather variability: Empirical evidence from the three agro-ecological zones in Ghana. *Cogent Social Sciences*, 6:1

Deresa, T.T, Hassan, R.M. and Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile Basin of Ethiopia. *J Agric Sci*, 149:23–31

Dickie, A., Streck, C., Roe, S., Zurek, M., Haupt, F. and Dolginow, A. (2014). Strategies for Mitigating Climate Change in Agriculture: Abridged Report. Climate Focus and California Environmental Associates, prepared with the support of the Climate and Land Use Alliance.

Fosu-Mensah, B., Vlek, P. and MacCarthy, D. (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana, Environment, Development and

Sustainability: A Multidisciplinary Approach to the Theory and Practice of Sustainable Development, *Springer,* 14(4): 495-505.

Guteta, D. and Abegaz, A. (2015). Factors influencing scaling up of agroforestry-based spatial land- use integration for soil fertility management in Arsamma Watershed, Southwestern Ethiopian Highlands. *J Environ Plan Manag*, 59(10): 1795-1812.

Gutu, P. (2014). An Analysis of Factors Affecting Climate Change Adaptation Strategies on Maize Production by Household. Case of Seke District. A thesis for Bachelor of Science Honours degree in Agricultural Economics and Development.

Hainmueller, J., Hiscox, M.J. and Tampe, M. (2011). Sustainable Development for Cocoa Farmers in Ghana. Baseline Survey: Preliminary Report: Humanity United and the William and Flora Hewlett Foundation.

IPCC (2014). Summary for policymakers in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge Cambridge, United Kingdom and New York, NY, USA) ed C B Field et al. (Cambridge University Press) pp 1–32

Jassogne, L., Laderach, P. and Van Asten, P. (2013). The impact of climate change on coffee in Uganda. Lessons from a case study in the Rwenzori Mountains, Oxfam Research Reports, IITA, CIAT, Oxfam, ISBN 978-1-78077-262-2, UK (accessed 10 April 2021 at 10:25 GMT).

Kalungu J.W, Leal, F.W. and Harris D. (2013). Smallholder farmers' perception of the impacts of climate change and variability on rain-fed agricultural practices in semi-arid and sub-humid regions of Kenya. *Journal of Environment and Earth Science*, 3:129–140.

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., ... and Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk analysis*, 8(2), 177-187.

Kemausuor, F., Dwamena, E. and Appiah, D.O. (2012). Assessment of farmers' adaptation to climate change in Ghana; the Case of Ejura Sekyeredumase District. *J. Arts Humanit*, 1: 1–2.

Klutse, N.D.M., Owusu, K., Adukpo, D.C., Nkrumah, F., Quagraine, K., Owusu, A. and Gutowski, W.J. (2013). Farmer's observation on climate change impacts on maize (Zea mays) production in a selected agro-ecological zone in Ghana. Res. J. *Agric. Environ. Manag*, 2: 394–402.

Kpotor, P., Akromah, R., Ewool, M. B., Kena, A.W., Owusu-Adjei, E. and Tuffour, H.O. (2014). Assessment of the Relative Yielding Abilities and Stability of Maize (Zea mays L) Genotypes under Different Levels of Nitrogen Fertilization across Two Agro-Ecological Zones in Ghana, *International Journal of Scientific Research in Agricultural Sciences*, 2(7):128-141.

Lawal, B.O., Torimiro, D.O., Banjo, A.D. and Joda, A.O. (2005). Operational habits and health hazards associated with pesticide usage by cocoa farmers in Nigeria: lessons for extension work. *Journal of Human Ecology*, 17(3): 191-195.

Legesse, B., Ayele, Y. and Bewket, W. (2013). Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, West Hararghe, Ethiopia. *Asian Journal of Empirical Research*, 3: 251–265.

Leiserowitz, A. (2007). International public opinion, perception, and understanding of global climate change. *Human development report*, 2008: 1-40.

Lobell, D., Burke, M., Tebaldi, C., Mastrandrea, M., Falcon, W. and Naylor, R. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science*, 319(5863): 607–610.

Maddison, D.J. (2007). The perception of and adaptation to climate change in Africa. In Policy Research Working Paper 4308; The World Bank: Washington, DC, USA; pp. 21–35.

Manyeruke, C., Hamauswa, S. and Mhandara, L. (2013). The effects of climate change and variability on food security in Zimbabwe: A socio-economic and political analysis. *International Journal of Humanities and Social Science,* 3(6): 270-286.

Mertz, O., Mbow, C., Reenberg, A. and Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environ. Manag*., 43, 804–816.

MiDA. (2010). Investment opportunity Ghana. Maize, Soya and Rice Production and Processing, Millennium Development Authority, Accra.

MoFA. (2013). Agriculture in Ghana: Facts and Figures. Accra: Ghana Ministry of Food and Agriculture.

MoFA. (2014). District Agricultural Profile. Pru District of the Brong Ahafo Region of Ghana. Statistics, Research and Development-Ministry of Food and Agriculture, Accra, Ghana

Morton J.F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences*, 104(50): 19680-19685.

Mubiru, D.N., Komutunga, E., Agona, A., Apok, A. and Ngara, T. (2012). Characterizing agro meteorological climate risks and uncertainties: crop production in Uganda. *South African Journal of Science,* 108(3/4): 108-118.

Mustapha, S.B, Sanda, A.H. and Shehu, H. (2012). Farmers' perception of climate change in central agricultural zone of Borno state, Nigeria. *Journal of Environment and Earth Science,* 2: 21-28.

Ndambiri, H.K., Ritho, C., Ng'ang'a, S., Kubowon, P.C., Mairura, F.C., Nyangweso, P.M., Muiruri E.M. and Cherotwo, F.H. (2012). Determinants Of Economic Growth in Sub-Saharan Africa: A Panel Data Approach. *International Journal of Economics and Management Sciences,* 2(2): 18-24.

Niang, A., Amrani, F., Salhi, M., Grelu, P. and Sanchez, F. (2014). Rains of solitons in a figure-of-eight passively mode-locked fiber laser. *Applied Physics B,* 116(3): 771-775.

Ntiamoah, A. and Afrane, G. (2008). Environmental impacts of cocoa production and processing in Ghana: Life cycle assessment approach. *J. Clean. Prod.*, 16: 1735–1740.

Nyanga, P.H., Johnsen, F.H., Aune J.B. and Kalinda, T.H. (2011). Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. *Journal of Sustainable Development,* 4: 73–85.

Nyenje, P.M. and Batelaan, O. (2009). Estimating the effects of climate change on groundwater recharge and base flow in the upper Ssezibwa catchment, Uganda, *Hydrological Sciences Journal,* 54(4): 713-726.

Patt, A. and Schröter, D. (2008). Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. *Glob Environ Chang.* 18: 458–467.

Roco, L.E.A., Bravo-Ureta, B. and Jara-Rojas, R. (2014). Farmers' perception of climate change in Mediterranean Chile. *Reg Environ Change*, 15: 1–13.

Schauffler, M. (2021). Wind: The overlooked wild card in climate change, https://www.themainemonitor.org/wind-the-overlooked-wild-card-in-climate-change/

Schliep, R., Bertzky, M., Hirschnitz, M. and Stoll-Kleemann, S. (2008). Changing climate in protected areas? Risk perception of climate change by biosphere reserve managers. *GAIA-Ecological Perspectives for Science and Society*, 17(1), 116-124.

Scoones, I. (2015). Sustainable livelihoods and rural development (Agrarian change and peasant studies 4). Bourton on Dunnesmore, Rugby: Practical Action Publishing,

Simelton, E., Claire, H., Quinn, C.H, Antwi-Agyei, P., Batisani, N., Dougill, A.J., Dyer, J., Evan, D.G., Fraser, E.D.G. and Mkwambisi, D. (2011). African Farmers' Perceptions of Erratic Rainfall;

Sustainability Research Institute Paper No. 27; Working Paper No. 73; Centre for Climate Change Economics and Policy: Leeds, UK, 2011; pp. 70–79.

Ssemakula, E. and Mutimba. J.K. (2011). Effectiveness of the Farmer-to-farmer Extension Model in Increasing Technology uptake in Masaka and Tororo Districts of Uganda. *African Journal of Agricultural Extension,* 39 (2): 30–46.

Tambo, J. and Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Reg Environ Change,* 13: 375–388.

Teka, O, Houessou, G.L, Oumorou, M., Vogt, J. and Sinsin, B. (2013). An assessment of climate variation risks on agricultural production: perceptions and adaptation options in Benin. *International Journal of Climate Change Strategies and Management,* 5: 166–180.

Wabwire, E.O., Mukhovi, S. and Nyandega, I.A. (2020). The Perception of Rural Households on Climate Change Effect on Rural Livelihoods in Lake Victoria Basin, Ghana. *Journal of Geography,* 12 (2): 62- 83

Whitmarsh, L. (2018). Are flood victims more concerned about climate change than other people? the role of direct experience in risk perception and behavioural response. *Journal of Risk Research,* 11: 351–374.

Winter-Nelson, A. and Aggrey-Fynn, E. (2008). Identifying opportunities in Ghana's agriculture: Results from a policy analysis matrix. GSSP Working Paper 12. Accra: IFPRI.

Wongnaa, C.A. and Boachie, W.K. (2018). Perception and adoption of competency-based training by academics in Ghana, *International Journal of STEM Education,* 5(52).

World Bank. (2010). Economic of Adaptation to Climate Change: Social Synthesis Report. 1818 H Street NW Washington DC, USA

Yamane, T. (1973). Statistics: an introductory analysis. New York: Harper & Row. Harvard (18th ed.)