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FACTORS INFLUENCING ADAPTATION STRATEGIES TO COPE WITH CLIMATE VARIABILITY: A STUDY OF MAIZE FARMERS IN MION DISTRICT OF NORTHERN GHANA

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Abstract

The study seeks to examine the factors that influence the choice of climate variability adaptation strategies employed by maize farmers in the Mion District of the Northern Region of Ghana. Based on unfavourable climate experience, maize farmers in Ghana including farmers in the Mion District of the Northern region of Ghana, have been introduced to climate variability adaptation strategies to increase the resilience of smallholder farmers to climate variability. The study used a multi-stage sampling technique to select 140 household respondents for the study. Ordered logit regression model was applied to identify factors influencing the choice of climate variability adaptation strategies. The findings revealed that the smallholder farmers in the district practice a range of climate variability adaptation strategies, which include changing planting dates, improved maize varieties, inorganic fertilizer application, making ridges, and diversifying into non-farm activities. The ordered probit model results revealed that the factors influencing farmers' choice of climate variability adaptation strategies include age, gender, income level, level of education of household head and membership of FBO. The study recommends policy focus on the adaptive capacity of maize farmers through input subsidy, access to credit, encouraging farmers to form groups, and sensitization of farmers on climate variability and climate change.

Keywords: Climate Variability, Adaptation Strategies, Influential Factors, Maize Farming, Extension Services

Introduction

Climate variability is a serious phenomenon that is widely known for its threat to the development of agricultural productivity (Intergovernmental Panel on Climate Change [IPCC], 2014). The IPCC (2007; 2014) has argued that climate change cannot be attributed to natural causes alone; and has provided strong evidence of accelerated global warming as a result of climate reliant sectors such as agriculture. The agriculture sector is considered to be the major contributor to climate variability and change (Stern, 2000; Paul, Ernsting, Semino, Gura & Lorch, 2009). Existing studies have established that decreasing rainfall and continuous temperature increases have impacted negatively on agricultural production and food shortages in developing countries (Parry, Canziani, Palutikof, Van Der Linden & Hanson, 2007). These changes in climatic patterns are expected to have adverse socio-economic impacts primarily on rural farmers, because these categories of farmers depend on agriculture for their source of livelihoods, thus, making them more vulnerable to climate variability and change (Mannak, 2009; Owusu, 2015). For instance, in a situation where the majority of the population is heavily dependent on rain-fed agriculture, rural livelihoods and food security are highly vulnerable to these climatic changes (Kurukulakusuriya & Rosenthal, 2003; Daniel, 2015).

In the agricultural sector, maize is one of the staple crops that is cultivated and consumed in virtually all regions in Ghana (Barimah, Doso & Twumasi-Ankrah, 2014) and accounts for more than 50% of the country's total cereal production (International Food Policy Research Institute [IFPRI], 2014). Maize is produced on nearly 100 million hectares in developing countries (Food and Agriculture Organisation [FAO], 2009). In a rain-fed farming situation, farmers await the coming of rains before planting their crops. A good maize cropping is highly dependent on sustained rainfall, especially during its critical development stages (Reyes, Domingo, Mina & Gonzales, 2009). To this end, good seasonal precipitation can therefore be correlated to a good maize production, while climatic irregularities could spell disaster to local maize farmers. Climate adaptation strategies in maize production include using improved maize seeds, fertilizer application, crop rotation and sometimes mechanization and irrigation in years with favourable rainfall (Klutse, Owusu, Adukpo, Nkrumah, Quagraine, Owusu and Gutowski, 2013; Akudugu, Al-hassan & Adam, 2018). Klutse *et al*. (2013) indicated that adoption of adaptation technologies such as improved seeds like hybrid and open pollinated varieties, proper spacing, timely planting, minimum or zero-tillage, timely harvesting and weeding has increased maize yields to as high as 5.0 – 5.5 metric tons per hectare. Significant factors influencing the choice of adaptation strategies by farmers to cope with climate extremes and adversities have been identified by existing studies on climate adaptation. These factors include but are not limited to household and farm characteristics, infrastructure, and institutional factors (Obayelu, Adepoju and Idowu, 2014). The household factors include age, education, farming experience, marital status, gender of the head of household, and income level. The farm features include the size, slope of farm, and the fertility of the soil. Institutional factors also have to do with uptake of extension information, as well as credit services while infrastructure includes inadequate capacity for irrigation, cost of farm inputs, and no ready markets for farm outputs. However, there is dearth of knowledge regarding factors that influence maize farmers' choice of climate adaptation strategies in Mion District, which is located in the Northern Region of Ghana. The main objective of the paper therefore is to examine the factors that influence the choice of adaptation strategies by maize farmers in Mion District of Northern region of Ghana.

Study Methodology

Study Design

The study employed the survey research design, where quantitative methodology was used to ascertain and determine the factors influencing farmers' choice of adaptation strategies.

Sample Size and Sampling Procedure

The population from which the sample was selected as the unit of analysis covered all maize farmers within the communities in Mion district of the Northern region of Ghana. Mion district is one of the high maize producing districts in the Northern region (MoFA, 2011). To ensure generalization and a research worth replicating, a sample size of one hundred and forty (140) household respondents was selected and computed with the use of the formula formulated by Fisher (Fisher *et al*., 1998):

$$n = \frac{pqZ^2}{d^2} \quad (1)$$

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

The Fisher formula is in two folds; the first formula is used for the calculation of sample size for an infinite population. The outcome of the first formula is then fed into the second formula to calculate for the sample size of the known (finite) population.

Where;

n = sample size for infinite population

Z = 1.96 (at 95% Confidence level)

p = estimated proportion of maize farmers (0.1)

q = 1-p d = precision of the estimate at 5% (0.05)

The sample size will be;

$$n = \frac{(1.96)^2 \quad 0.1 \times 0.9}{(0.05)^2}$$

n =138

n = sample size for infinite population n =138

n^1 = adjusted sample size

n = estimated sample size for infinite population

N = Finite population size

Using the adjusted sample size for the finite population of 8,143 farmers, 136 household respondents were selected in the Mion district as follows:

$$n^1 = \frac{1}{\left(\frac{1}{138} + \frac{1}{8,143}\right)}$$

= 135.7

≈ 136 household respondents will be selected.

However, the sample size was increased to one hundred and forty (140) for easy data collection and analysis.

The study employed a multi-stage sampling technique in selecting farmers for investigation. First, the entire district was stratified into four MoFA operational zones to enable fair representation across all zones. Second, simple random sampling technique was used to select two communities from each zone to get a total of eight (8) communities. Third, farming households in the various communities were selected for investigation by simple random sampling process. Table 1 below is the representation of the sampling procedure.

Table 1: Sample of Adult Households

Operational zones	Selected communities	No of respondents
Sang	1. Kpabia 2. Kulinkpegu 1&2	35
Jimle	3. Jimle 4. Kpalkore	35
Zakpalsi	5. Zakpalsi 6. Sakpei	35
Sambu	7. Sambu 8. Warivi	35
Total	8 communities	140

Data Collection and Analysis

The data for the study was collected using one-on-one interview with a structured questionnaire. Analysis of data was possible using the Statistical Package for Social Scientists (SPSS Version 20) as well as STATA Version 13 software and presented through the use of tables, figures, frequencies and percentages. Ordered logit regression (OLM) model was used to analyze the factors influencing the choice of climate variability adaptation strategies by farming households while descriptive statistics was used to analyze adaptation strategies used by households in the district.

Analytical Framework

Ordered Logistic Regression (OLM) model was used to analyze the factors influencing households' ordered number of climate change adaptation strategies. This regression technique was performed using influential factors which include sex, age, educational level, farmers' household size, income from other livelihood activities, membership of Farmer-Based Organizations (FBO), access to credits, farm size and farmland ownership as independent variables (Table 2). The number of adaptation strategies were ordered and used as the dependent variable. The adaptation strategies considered were irrigation, minimum tillage, shifting planting dates, crop rotation, diversification of non-farm activities, inorganic fertilizer application (animal manure), improved/drought tolerant maize varieties. These two variables were used in analyzing the factors influencing households' choice of climate change adaptation strategies. According to Osei-Owusu, Alhassan and Doku-Marfo (2012), in trying to model the factors that affect the choice of an adaptation strategy, the study has to use qualitative response regression models because the endogenous variable, which is a set of adaptation strategies, is not measured quantitatively.

The Logit model considers the relationship between a binary dependent variable and a set of independent variables which can be a binary or a continuous. For such a dichotomous outcome, the Logit model is appropriate. Count data models such as standard Poisson, Negative Binomial, Zero Inflated Negative Binomial etc. can be used to analyze the determinants of number of climate change adaptation strategies. However, ordered logit model is appropriate in the current situation where the dependent variable is counted and ordered from lowest to highest (Mabe, Talabi, & Danso-Abbeam, 2017). It is assumed that the more adaptation strategies one uses, the higher the impact. Also, the factors that determine the low number of adaptation strategies are different from those that influence high number of adaptation strategies. An ordered logit model allows for multiple ordered values for the dependent variable (Greene, 2008). A farmer who does not use any adaption strategy scores 0. Farmers who adopted 1, 2, 3, 4, 5, 6, 7, and 8 adaptation strategies are respectively scored 1, 2, 3, 4, 5, 6, 7 and 8. The ordered Logit model can predict choice probability that is readily interpretable.

The ordered logit model is a regression model for an ordinal response variable. The model is based on the cumulative properties of the response variable.

Let y_i be an ordinal response variable with category C categories for the $ith,$ alongside with vector covariates x_i.The ordered regression model establishes the relationship between the covariates and the set of category variables. The ordered logit model expresses the relationship between the covariates and the set of probability categories such that:

$$P_{ci} = \Pr(Y_i = \mathrm{Y_c}|\mathrm{X_i}), \mathrm{c} = 1 \ldots \ldots \mathrm{C} - 1 \qquad (3)$$

An ordered logit model for ordinal responses Y_i with C categories is defined with $C-1$ categories where where the cumulative properties $g_{ci} = P_r(Y_i \leq Y_c|X_i)$ is related to the linear predictors $\beta' X_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i}$ through the logit function

$$\mathrm{Logit}((g_{ci}) = \log\left(\frac{g_{ci}}{1-g_{ci}}\right) \quad c = 1,2 \ldots . C - 1$$

The relationship between the latent variable y^* and the set of the independent variables is expressed in the eqn(5).

$$y^* = X'\beta + e_i \qquad (4)$$

Such that

$$y = \begin{cases} 0 \; if \; y^* < u_1 \\ 1 \; if \; u_1 < y^* < u_2 \\ 2 \; if \; u_2 < y^* \leq u_3 \\ 3 \; if \; u_3 < y^* \leq u_4 \\ N \; if \; u_n < y^* \end{cases}$$

Table 2: Measurement of Explanatory Variables

Explanatory Variables	Measurements
Gender of household head	Dummy; 1=female and 0=male
Age of household head	Years
Education Level of household head	Dummy; 1=at least basic education and 0=otherwise
Household Size	Numbers
Non-farm Income status of household head	Ghana cedis
Access to credit	Dummy; 1=Yes and 0=No
Farm ownership	Dummy; 1=Yes and 0=No
Farm size	Hectares

Results and Discussions

Descriptive Statistics of Respondents

The ages of adult households of the sampled respondents ranged from 30 and 75 years with mean age of 42.85 years for the maize farmers. Table 3 indicates that the majority of household heads in the district were within the age category of 35-44 (39.3%), followed by the category within 44-54 (25%), while the least category fell within 65+ (6.4%). This implies that the growth and development of the agricultural sector lies on the youthful age category in the district. Age distribution is one of the most important demographic characteristics that are used to analyze and interpret the pattern and its impact on the development of various sectors of the community. The results in this study conform with the research findings of Owusu (2015), where over 60% of the labour force (20-40years) were involved in agriculture in the Sisili-Kulpawn Basin of Northern Ghana. Moreover, it is rarely a case that older age-groups (55-65+) dominate in the agricultural sector in Northern Ghana.

Table 3 also indicates that 67.1% of the adult household respondents were males while the female household farmers were 32.9%. This implies that the majority of the respondents engaged in agriculture were males. Several other studies on climate change, agriculture and adaptation strategies have shown that the agricultural sector is male dominated especially in Northern Ghana (Owusu, 2015; Jinbaani, 2015). In a study conducted by MoFA in 2011, it was revealed that the economically active population (15 - 49years) engaged in agriculture in the Northern Region had more males (55.9%) than females (MoFA, 2011).

Table 3: Demographic Characteristics of Respondents

Variable Definition		Frequency	Percentage (%)
Gender	Male	94	67.1
	Female	46	32.9
Level of Education	No formal education	94	67.1
	Primary	19	13.6
	Junior high	18	12.9
	Senior high	7	5.0
	Tertiary	2	1.4
Marital status	Married	106	75.7
	Widowed	12	8.6

	Single	22	15.7
Age group	25-34	31	22.1
	35-44	55	39.3
	45-54	35	25.0
	55-64	10	7.1
	65+	9	6.4
Farmer-Based Organization	Yes	88	62.9
	No	52	37.1
Access to credit	Yes	35	25.0
	No	105	75.0
Access to extension services	Yes	91	65
	No	49	35

Source: *Field study, 2018*

Adaptation Strategies by Maize Farmers

Maize farmers within communities in the Mion district have been practicing some adaptation strategies to maintain resilience in their production and productivity (Table 4). In the communities, it was found that the majority (86.4%) of the farmers practiced more than one adaptation strategy, and the idea is mainly to maximize productivity amidst the adverse effects of the variability and change of climate (Table 4). The least adaptation strategy practiced is irrigation (1.4%), and this could be attributed to the reason that there are limited irrigation facilities in the region for farmers to access for use. According to Gbetibouo (2009), since any adaptation strategy or practice falls under the overall framework of utility and profit maximization, a rational farmer would only choose to practice an adaptation if it has greater perceived net benefits.

Table 4: Adaptation Strategies Distribution by Farmers

Adaptation Strategies	Frequency	Percentages
Changing planting dates	138	98.6%
Using improved maize varieties	121	86.4%
Making of ridges/mounds	99	70.7%
Crop rotation	81	57.9%
Application of inorganic fertilizers	78	55.7%
Diversify into non-farm activities	15	10.7%
Minimum tillage	12	8.6%
Bonding	7	5.0%
Irrigation	2	1.4%

Source: *Field study, 2018*

Factors Influencing the Choice of Climate Variability Adaptation Strategies

Ordered Logistic Regression (OLM) model was used to analyze factors influencing the farmers' choice of climate variability adaptation strategies. Gender, age, education level, household size of farmers, income from other livelihood activities, membership of Farmer-Based Organizations (FBO), access to credits, farm size and farmland ownership represented the independent variables, while the dependent variables included the identified climate adaptation strategies such as improved maize varieties, application of organic fertilizers, crop rotation and minimum tillage. The ordered logit regression model was significant at one percent, signifying that all the independent variables jointly influenced the dependent variables. Also, the likelihood ratio statistics as indicated by Chi-square statistics is highly significant, which is represented by a p-value of 0.0065. This implies that the ordered logit model has a strong explanatory power. The following results were obtained in Table 5.

Table 5: OLM Regression Results

Variable	Marg. Effect	Robust Std Error	Average Marg. Effect	Robust Std Error	Marg. Effect	Robust Std Error	Marg. Effect	Robust Std Error	Marg. Effect	Robust Std Error
					Low Adopter		Medium Adopter		High Adopter	
Gender	0.146	0.371	0.020	0.023	-0.008	0.013	0.000	0.002	0.008	0.077
Age	0.038**	0.019	0.005**	0.002	-0.008	0.023	0.000	0.015	0.007	0.052
Education level	1.582***	0.423	0.243***	0.051	-0.238	0.233	-0.126	0.527	0.364	1.003
Household size	-0.072**	0.035	0.010**	0.005	0.015	1.44	-0.000	0.045	-0.014	0.317
Farmer Based Organization	0.818**	0.369	0.113**	0.051	-0.158	0.345	-0.012	0.081	0.170	0.526
Access to credit	0.245	0.400	0.034	0.172	-0.049	0.081	-0.002	0.005	0.050	0.039
Farm size	0.199***	0.119	0.027***	0.006	-0.041	0.544	0.001	0.009	0.040	0.043
Other Income sources	-0.004	0.003	0.000	0.012	0.001	0.294	-0.000	0.008	-0.001	0.003
Wald chi2(11) = 25.99 Prob > chi2 = 0.0065 Pseudo R2 = 0.0755 Log pseudolikelihood = -141.186			L A = 1-3; M A = 4-5; H A = 6-8 Adaptation Practices							

From the regression results (Table 5), it can be deduced that household's gender head had a positive influence on the likelihood of the farmers adopting the adaptation strategies, however, it is statistically insignificant with a p-value (0.694). This implies that a male household head had a higher probability of adopting the indigenous strategies as a way of adapting to the variability of climate as compared to their female counterparts. While it does not agree partially with the findings of Gutu (2014), it is in line with Obayelu *et al* (2014), where gender of the household head had a positive relationship on the likelihood of adopting adaptation strategies. For instance, Tenge and Hella (2004) found that being a female head of a household had negative influence on the adoption of adaptation measures such as soil and water conservation measures, because women have restricted access to information, land and other resources due to traditional social barriers.

Age of the household head tends to be statistically significant to the adaptation strategies and has a positive influence on adaptation to climate variability (Table 5). It means that as the age of a farmer increases, he is more likely to adopt climate change adaptation strategies. This is consistent with the findings of Gutu (2014), who explains that the positive relation is that as the age of the household head increases, the household head will likely acquire more knowledge about weather characteristics and climate pattern and at the end have a weather pattern in mind, thus, increasing one's chances of adopting different adaptation strategies. The level of education (both literate and non-literate) of the household head was shown to have a positive relationship with the various adaptation strategies. it was significant at one percent level, with p-values (p-value >0.000) (Table 5). It shows that farmers with higher years of education are more likely to adapt many and better climate variability adaptation strategies such as diversifying to non-farm activities, crop rotation and the application of compost manure, than those with less or no formal education. Indication from other sources show that there is a positive relationship between the education level of the household head and climate adaptation measure (Maddison, 2006; Obayelu *et al.*, 2014; Deressa, Ringler & Hassan, 2010). On the contrary, Mandleni and Anim (2011) found education not to have an influence on climate adaptation mechanisms. The implication is that maximizing farmers' years of formal education would highly maximize their likelihood of diversifying to non-farm activities, changing of planting period and other related strategies.

Membership of a Farmer-Based Organization (FBO) as an influential factor to climate change adaptation had a positive sign showing a direct relation to the practice of various adaptation to climate variability with p-value (0.027) in the Mion district. This implies that being a member of an FBO increasingly exposed a farmer to knowledge and skills with respect to innovative technologies to climate variability delivered to them by stakeholder institutions and organizations such as MOFA and other NGOs. The results are consistent with the findings of Sharif-Zadeh, Sharifi and Mohammadzadeh (2008). Sharif Zadeh *et al.* (2008) found that there is a positive significant relationship between the practices of indigenous climate adaptation strategies by farmers with membership in cooperatives. According to Larbi (2015), FBO training has a significant positive effect on the adoption of a good number of adaptation mechanisms and strategies, implying that a unit increase in FBO training will increase the probability of farmers considering a strategy or two. This is likely to be accurate because it links the individual to the larger society and exposes them to a variety of ideas on improved farming methods. Members of FBOs are in a privileged position with respect to other farmers, in terms of their access to information on improved agricultural technologies (Larbi, 2015; Akudugu Al-hassan & Adam 2018).

Access to credit by maize farmers in the Mion district has a positive effect on the practices of adaptation strategies although it is not significant. This shows that maize farmers with access to credit are less likely to increase the effectiveness of climate adaptation practices. This can be justified mainly by the fact that, increase in access to credit enables the purchase of farm inputs by farmers (Mumuni & Oladele, 2016) rather than intensifying the adaptation practices. The result conforms to findings of Mugisha, Ogwal, Ekere and Ekiyar (2004) that as access to credit improves, it does not necessarily indicate an equal improvement in adaptation strategies.

Marginal Effects

The adopters of 1-3, 4-5 and 6-8 adaptation strategies were respectively classified as low adopters (LA), medium adopters (MA) and high adopters (HA). This categorization was based on the fact that farmers are grouped based on homogeneous characteristics. Farmers who adopt 1-3 adaptation strategies may have similar characteristics, whereas those using 6-8 strategies might also have similar characteristics. Educational level of farmers had a significant effect on the decision of a farmer to adopt climate change adaptation strategies. This implies that farmers with basic education had about 0.24% less probability of being lower adopters and 0.36% likelihood of being high adopters of the adaptation strategies. The implication is that as farmers attain higher levels of education, they are better exposed to the adverse effects of climate variability and change, likewise the importance of adaptation strategies. These exposures therefore, influence their decisions to adopt the number of strategies that would maximize their agricultural output.

The marginal effect of household size as an explanatory variable was positive for high adopters and negative for low adopters. This implies that if a household increases by one person, there is 0.02% less probability of the household becoming low adopters than high adopters and a 0.01% probability of becoming high adopters. This means that as household size increases, farmers become higher adopters than lower adopters, *ceteris paribus*. Being a member of a Farmer-Based Organization (FBO) had a positive marginal effect for high adopters, implying that a farmer is more likely (0.17%) to adopt more if they belonged to an FBO than if they did not (0.16%). If a farmer had access to credit, the marginal effect of adopting more than five adaptation strategies is 0.05% as compared to farmers without access to credit, with marginal effect (0.05%) of adopting less than three strategies. Farm size has a positive marginal effect for adopting high number of strategies and low number of strategies respectively. It implies that if a farm size increases by one hectare, the marginal effect of adopting a higher number of adaptation strategies was positive at 0.04% as compared to negative marginal effect of adopting lesser number of strategies (0.04%) if farm size increases by one hectare. Maximizing the farm income may not encourage the adoption of high number of adaptation strategies, implying that if the farm income increases, there is negative marginal effect of adopting more adaptation strategies at 0%. This indicates that the marginal effect is not significant. However, an increase in farm income has a marginal effect (0%) of adopting less than three adaptation strategies.

Conclusion

The paper determined factors influencing the choice of adaptation strategies to cope with climate variability by maize farmers. Based on the established findings, it can be concluded that smallholder maize farmers in the Mion district of the Northern region of Ghana practice a range of climate variability adaptation strategies. These adaptation strategies include changing planting dates, improved maize varieties, inorganic fertilizer application, making ridges and diversifying into non-farm activities. The results of the regression showed that age, level of education, household size, membership of FBO and farm size of farmers significantly influenced the adoption of adaptation strategies. Based on the findings, it is recommended that maize farmers' capacity needs to be built on education, since farmers' exposure to formal education is likely to enhance their capacity to appreciate the benefits of innovations, including adoption of climate variability adaptation strategies. The paper also recommends the need to pay attention to the formation of FBOs, since that plays a significant role in increasing maize farmers' choice of climate variability adaptation strategies. The FBOs can serve as a social capital for members of the group, which they can use to benefit from diverse support such as credit and training, among others. Furthermore, it is important for MoFA and private development institutions to collaborate to provide financial support to smallholder farmers to expand their farms, since maize farmers are motivated to adopt climate adaptation strategies when they cultivate large farm sizes.

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