FACTORS INFLUENCING SMALLHOLDER FARMING HOUSEHOLDS' ADAPTIVE CAPACITY TO CLIMATE CHANGE AND VARIABILITY IN THE SAVELUGU/NANTON MUNICIPALITY OF GHANA

Issah Suhuyini Alhassan[a], Mohammed Tiyumtaba Shaibu[b], Osman Tahidu Damba[c]
[a] *Department of Agricultural and Resource Economics, Faculty of Agribusiness and Communication Sciences (FACS), University for Development Studies (UDS), Tamale, Ghana.*
[b] *Council for Scientific and Industrial Research – Animal Research Institute (CSIR-ARI), Tamale, Ghana.*
[c] *Department of Climate Change and Food Security, Faculty of Agribusiness and Communication Sciences, University for Development Studies, Tamale.*
Corresponding author: otahidu@uds.edu.gh

ABSTRACT

Agriculture in northern Ghana is largely rain-fed dependent within current climate variability. Generally, adaptive capacities of smallholder farming households to climate change are low. This study investigated factors influencing the adaptive capacity of smallholder farming households to climate change and climate variability in the Savelugu/Nanton Municipality in the Northern Region of Ghana. The adaptive capacity index for farming households were computed and a Tobit regression model was employed to determine the factors influencing the adaptive capacity of farming households to climate change. Empirical results reveal that male headed households, membership of a farmer-based organisation, households' participation in adaptation programs, off-farm activities, educational level of household heads, land ownership, number of extension contacts and access to credit significantly influence the adaptive capacity of smallholder farming households in adapting to climate change positively; while age of household head negatively influence the adaptive capacity of smallholder farming households. Smallholder farming households should therefore form associations for experience sharing; and extension agents should intensify contacts with farmers to enhance new technology adoption. Farmers should further be guided to adopt climate smart intervention technologies from their participation in adaption programs to enhance resilience to climate change.

Keywords: Adaptive capacity, climate change, climate variability, smallholder farming households, Savelugu-Nanton, Ghana.

INTRODUCTION

Climate change is undoubtedly a major global issue that has drawn the attention of many stakeholders. Historical data shows that the African continent has experienced an average warming of 0.7 °C in the 20th century (Folland, 2006). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) also revealed that warming in Africa is likely to be higher than the global annual mean warming throughout the continent and in all seasons, with drier sub-tropical regions warming more than the moister tropics (Chritensen et al., 2007). The Environmental Protection Agency (EPA) reported an increase in temperature by 1°C across Ghana with 1960 as a baseline (Agyemang-Bonsu, 2008). Nonetheless, the effect is expected to differ based on agro-ecological regions as well as socio-economic clusters such as gender differentials. Regions which rely heavily on rain-fed and subsistence agriculture are noted for their high climate-sensitivity in relation to systems of agricultural production and are thus, more vulnerable to climate variability especially when their adaptive capacities are low.

In Africa, investment in climate change adaptation strategies has been low and needs to be augmented to improve the adaptive capacity of organizations, institutions and individuals (Denton, 2002). The Intergovernmental Panel on Climate Change (Harvey, 2014) observed that the occurrence of multiple stresses and low adaptive capacity makes Africa one of the most vulnerable continents to climate change and variability. Across the tropical region of which Ghana is located, agricultural productivity of smallholder farmers is hindered by climatic stressors.

Climate change and variability is predicted to unduly affect smallholder farmers, making their livelihood more precarious (IPCC, 2014). In Ghana, Northern Region is relatively vulnerable to climate variability compared to the rest of the country mainly because of the high rate of illiteracy and relatively underdeveloped infrastructure (Alhassan et al., 2019a; Etwire et al., 2013; Smit and Pilifosova, 2003). In terms of adaptive capacity to climate variability, smallholder farmers in Northern Region are known to possess very low capacity (Alhassan et al., 2019b; Alhassan et al, 2019b; Nabikolo et al., 2012).

Agriculture is often affected negatively by the erratic rainfall patterns with the perennial variability in rainfall resulting in droughts, flood and bushfires in the Northern Region. The results are often a decline in the moisture level of soil leading to decreasing agricultural productivity and farmers' incomes (Molua and Lambi, 2006). According to Alhassan et al. (2018b), smallholder farmer households do not have the requisite resources compared to large scale farmers. This difference affects efficient capacity of smallholder farming households to adequately adapt to the adverse effects of climatic stressors (FAO, 2011, Alhassan et al., 2019c).

Smallholder farmers in the Savelugu/Nanton Municipality have limited capabilities to adapt and there exist limited information in the literature on the extent of farmers' vulnerability and adaptive capacity (Alhassan et al., 2019a; Alhassan et al., 2018b; Hahn, 2009). The findings of Asante et al., (2012); IPCC, (2009) and Egyir (2015) showed that smallholder farming households in Sub Saharan African countries have low adaptive capacity and are more hit with the impact of climate change. There is need to explore the factors influencing smallholder farming households' adaptive capacity to climate change in various parts of the country fo informed policy formulation aimed at improving the livelihood of smallholder farmers. The purpose of this study was to investigate the factors influencing smallholder farming households' capacity to adapt to the effects of climate change in the Savelugu/Nanton Municipality. The findings will unearth the relevant drivers of farmers' adaptive capacity peculiar to farmers in the Municipality for specific interventions by stakeholders.

METHODOLOGY

Study area

This study was conducted in the Savelugu/ Nanton Municipality in the Northern Region of Ghana. Just like the other districts in northern Ghana, the Municipality is relatively dry with a single rainy season which begins in May and ends in October. The area records an annual rainfall of between 750mm and 1050mm (GSS, 2012). November marks the beginning of the dry season and ends in late March to early April with maximum temperatures ranging between 40 ^{o}C – 43 ^{o}C (GSS, 2012), occurring between March and April. The area records its minimum temperatures in December and January. The municipality experiences the southwest monsoons winds (harmattan) between December and early February. These winds have a considerable effect on the temperature in the region, which may vary between 14^{0}C at night and 40^{0}C during the day (Alhassan *et al.*, 2018b). There is very low humidity in the area. Savannah grassland is the main vegetation of the region, interspersed with the guinea savannah woodland. This area is characterised by drought-resistant trees such as baobab, acacia, dawadawa, shea, mango and neem (GSS, 2014). Also, the area is typified by harsh climatic conditions. This condition serves as a limiting factor for the north as regards attracting both material resources and human capital.

Determinants of Adaptive Capacity

Adaptive capacity of farmers and vulnerability to climate change are conversely related. Thus, given the same level of exposure and sensitivity to climate change and variability, farmers with low adaptive capacities are more
vulnerable to climate change than farmers with high adaptive capacities. A system's adaptive capacity to climate change is a ratio scale and varies based on resource endowment, time and location (Asante et al., 2012). Adaptive capacity is the ability of a system to adjust to climatic stressors and reduce the likely damages, by adopting available opportunities (Asante et al., 2012, Alhassan et al., 2019b).

The determinants of adaptive capacity have been classified into hazard specific and generic factors, and into endogenous and exogenous factors (Brooks, 2003). Generic determinants of adaptive capacity in social systems comprise non-climatic factors such as economic resources, technology, information and skills, infrastructure, institutions, and equity (Stanturf et al., 2014). Endogenous factors refer to the physiognomies and behavior of a given population group whereas exogenous factors include the wider economic and geopolitical context.

There exist considerable factors influencing the adaptability of households which cut across socio economic, technological and institutional. Socio – economic factors such as age, gender, educational level of the adaptor and households' characteristics such as household size, income and land size accessible by the household are key significant determinants of farmers'' adaptive capacity (Nti, 2012). Also, technology availability, farmers' awareness of the existence of technology, access to financial service and farmers' association with social networks or groups are factors enhancing farmers' ability to adapt to climate change and variability (Asante et al., 2012). Lack of collateral security to borrow, absence of good yielding seed, land tenure insecurity and inaccessibility of market are some constraints to effective adaptation among farmers (Nabikolo et al., 2012). It has been reported that large farm size had a significant positive influence on the adoption of tree planting, new seed varieties and soil and water conservation strategies (Flint et al., 2009). Land size is a proxy for measuring wealth and is a vital determinant of farmers' capacity to adapt to climatic stressors (Deressa et al., 2009).

In examining determinants of adaptive capacity of farmers in northern Ghana, Alhassan et al. (2017) first computed farmers' adaptive capacities based on Mazyimavi et al. (2014) adaptive capacity model premised on the risk management approach and classified farmers into low, moderate and high adaptive capacities. The ordered logistic regression was then employed to determine factors influencing farmers' adaptive capacity using the categorized computed adaptive capacity as the dependent variable with socio-economic, infrastructural, technological and institutional factors as independent variables. This study could not employ the ordered logistic regression model in determining the factors influencing adaptive capacity of farmers because the computed adaptive capacity is a ratio rather than nominal scale variable.

Sources of Data and Sampling Procedure

This study was a survey type and the required data was mainly primary, sourced from farming households. A multi-stage sampling technique was used to select 200 farming households, from which data was collected. The study population was farmers in Savelugu/Nanton Municipality in the Northern Region of Ghana. The first stage of sampling involved seven farming communities which were selected using simple random sampling technique. Given that the communities vary in terms of size and population, proportionate sampling was used to ensure that all communities were represented proportionally (Kukuobila – 30, Tampion – 35, Pong – 25, Nakpanzoo – 30, Libiga – 30, Kpaling – 20 and Zoggu - 30). In all, 200 farmers were selected for the study. Simple random sampling was then used to select the households from each community to constitute the sample. The data was obtained through interviews using questionnaire. Questionnaire was administered to household heads or their representatives on their socio-demographic characteristics and climate change adaptive capacity.

Model Specification for Determinants of Adaptive Capacities

To determine the factors influencing farming households' adaptive capacity to climate change, farming households' adaptive capacity index was first computed using a Composite Adaptive Capacity Index (CACI) (Alhassan et al., 2018b). The elements of farmers' adaptive capacity were first categorized into seven main indicators: human, natural, physical, financial, social, information accessibility and livelihood diversity (Asante et al., 2012; Alhassan et al., 2019a). The main indicators of adaptive capacity consist of sub-indicators. Each of these sub-indicators is measured on different scales and contribute either positively or negatively to households' adaptive capacity. Thus, the first step in computing farming households' adaptive capacity was to normalize the sub-indicators to a common

scale using equation 1 (if sub-indicator contributes positively to adaptive capacity) or equation 2 (if sub-indicator contributes negatively to adaptive capacity):

$$Index_{Si} = \frac{S_s - S_{Min}}{S_{Max} - S_{Min}} \quad \text{(Eq. 1)}$$

$$Index_{Si} = \frac{S_{Min} - S_s}{S_{Max} - S_{Min}} \quad \text{(Eq. 2)}$$

Where $Index_{si}$ is one of the sub-indicators of one of the seven adaptive capacity indicators, S_s is the observed value for sub-indicator s, S_{Min} and S_{Max} are the minimum and maximum values respectively for the sub-indicator in the combined data.

The index for each main indicator of adaptive capacity was ascertained by summing the weighted indices of sub-indicators constituting the main indicator. This was done using equation 3:

$$Index_{mi} = \sum_{i=1}^{N} Index_{si} \quad \text{(Eq. 3)}$$

Where $Index_{mi}$ is the computed index for one of the seven main indicators of adaptive capacity (human, natural, physical, financial, social, information accessibility and livelihood diversity), N is the number of sub-indicators constituting the main indicator.

The adaptive capacity index (ACI) for each household was than obtained by summing the weighted indices of the seven main indicators as:

$$ACI_h = \sum_{i=1}^{7} M_{wi} \quad \text{(Eq. 4)}$$

The ACI is scaled between 0 (least adaptive capacity) to 1 (highest adaptive capacity).

Given that the dependent variable (ACI) ranges between 0 and 1, some farmers may have zero ACI. The need to censor farmers with zero ACI is essential for robust results. The Tobit regression model, Ordinary Least Squares (OLS), Generalized Least Squares (GLS), and the Two Stage Least Squares (2SLS) models can be used in determining the factors influencing farming households' adaptive capacity to climate change (Gujarati, 2008). This study employed the Tobit regression model ahead of the other regression models on the premise that it yields a relatively better econometric estimates due to the censored nature of the data set (Amemiya, 1973).

James Tobin (1958) proposed the Tobit model to describe the relationship between a non-negative dependent variable y_i and an independent variable x_i. The Tobit model presumes that there is a latent (unobservable) variable y_i. This variable depends linearly on x_i via a parameter vector β. Additionally, there is normally distributed error term u_i to capture random influence on this relationship. The observed variable y_i is defined as being equal to the latent variable whenever the latent variable is above zero and zero otherwise (equation 5).

$$y_i = \begin{cases} y_i^* & if \quad y_i^* > 0 \\ 0 & if \quad y_i^* \leq 0 \end{cases} \quad \text{(Eq. 5)}$$

Where y_i^* is a latent variable:

$$y_i^* = \beta x_i + \mu_i, \; \mu_i \sim N(0, \sigma^2) \quad \text{(Eq. 6)}$$

If the relationship parameter β is estimated by regressing the observed y_i on x_i, the resulting Ordinary Least Squares (OLS) regression estimator is inconsistent. It yields a downwards-biased estimate of the slope coefficient and an upwards-biased estimate of the intercept (Gujarati, 2008). Amemiya (1973) found that the maximum likelihood estimator suggested by Tobin for this model is consistent. Following Chebil *et al.* (2009), the likelihood function of the model (6) is given by L, and presented as follows:

$$L = \prod_0 F(y_a) \prod_1 f_i(y_i) \quad \text{(Eq. 7)}$$

$$L = \prod_{0}[1 - F(x_{ii}\beta / \sigma)]\prod_{1}\sigma^{-1} f[y_{i} - x_{i}\beta) / \sigma] \quad \text{(Eq. 8)}$$

Where f, and F are the standard normal density and cumulative distribution functions respectively. The log-likelihood function can be written as:

$$LogL = \sum_{0}\log(1 - F(x_{i}\beta / \sigma)] + \sum_{1}\log\left\{\frac{1}{(2\prod\sigma^{2})^{1/2}}\right\} - \sum_{1}\frac{1}{2\sigma^{2}}(y_{i} - \beta x_{i})^{2} \quad \text{(Eq. 9)}$$

The parameters β and σ are estimated by maximizing the log-likelihood function

$$\begin{cases} \dfrac{\partial Log}{\partial \beta} = \sum_{0} \dfrac{x_{i} f(x_{i}\beta) / \sigma)}{2} + \dfrac{1}{\sigma^{2}}\sum_{1}(y_{i} - \beta x_{i})x_{i} = 0 \\ \dfrac{\partial LogL}{\partial \sigma^{2}} = \dfrac{1}{2\sigma^{2}}\sum_{0}\dfrac{\beta x_{i} f(x_{i}\beta) / \sigma}{1 - F(x_{i}\beta) / \sigma} - \dfrac{n_{i}}{2\sigma^{2}} + \dfrac{1}{2\sigma^{4}}\sum_{1}(y_{i} - \beta x_{i})^{2} = 0 \end{cases} \quad \text{(Eq. 10)}$$

Since the two equations (5) are non-linear, the maximum likelihood estimators must be obtained by an iterative process, such as the Newton-Raphson or Davidson-Flecher- Powell (DFP) or Berndt-Hall-Hall-Hausman (BHHH) algorithm (Greene, 2003). To study the explanatory power of the model, a statistic based on likelihood ratio (LR) is appropriate. This ratio is defined as follows:

$$LR = 2(\log L_{r} - LogL_{\mu}) \quad \text{(Eq. 11)}$$

Where $LogL_{\mu}$ is the log-likelihood for the unrestricted model and $LogL_{r}$ is the log-likelihood for the model with k parametric restrictions imposed. The likelihood ratio statistic follows a chi-square (χ^2) distribution with k degrees of freedom. The dependent variable indicating a farming household's adaptive capacity level is the proportion of area of farm land cultivated to the improved rice varieties.

The empirical model is given by equation 12:

$$y_{i}(ACI > 0) = \beta_{0} + \beta_{1}Age + \beta_{2}Edu + \beta_{3}Weather + \beta_{4}Exp + \beta_{5}FBO + \beta_{6}Extention + \beta_{7}farmsize + \beta_{8}\text{Pr}ogram + \beta_{9}Off - farm + \beta_{10}Sex + \beta_{11}Credit + \beta_{12}Land + \varepsilon_{i} \quad \text{(Eq. 12)}$$

Where y_i, the dependent variable is the adaptive capacity index for a household, β_0 is the intercept (constant), β_1 to β_{12} are the parameter coefficients to be estimated and ε_i is the error term which is independent, identical and normally distributed with zero (0) mean and constant variance. Table 1 presents the description, measurements and *a priori* expectations of the variables considered in the model.

Table 1: Description of dependent and independent variables for the Tobit regression model

Variable	Description	Means of Measurement	*A prior* expectation
y_i	Adaptive Capacity Index of farming households	$0 \leq ACI \leq 1$	+
Age	Age of household head	Years	+/-
Edu	HHH years of Education	Years	+
Weather	Access to weather information	Dummy: 1=yes, 0= Otherwise	+
Exp	Farming experience of HHH	Years	+
FBO	Member of Farmer-based Organisation	Dummy: 1=yes, 0=Otherwise	+
Extension	Extension contacts	Number of times p.a.	+
Farmsize	Farm size	Acres	+/-
Program	Participation in adaptation program	Dummy: 1=yes, 0=Otherwise	+
Off-farm	Engagement in off-farm activities	Dummy: 1=yes, 0=Otherwise	+
Sex	Sex of household head	Dummy: 1 = male, 0 = female	+
Land	Ownership of land	Dummy: 1= yes, 0 = Otherwise	+
Credit	Access to credit	Dummy: 1= yes, 0 = Otherwise	+

Agricultural Extension Services: The most reliable source of training and information to farmers on new technologies aimed at adapting to climate variability is agricultural extension services. These services are either formal or informal (farmer-to-farmer). Extension services contribute to efficient technology adoption decisions of farmers (Gbetibouo, 2009). The expected influence of access to extension services on farmers' adoption decisions on adaptation strategies is positive.

Access to credit: Farming is becoming very expensive and farmers need to complement own capital with borrowed capital (formal and informal) to meet the increasing investment and transaction costs associated with adaptation technologies. In this study, access to credit is measured as a dummy with 1 denoting farmer receiving credit within the 2016 farming season and 0 for otherwise. Access to affordable credit increases the financial capacities of farmers to adopt adaptation strategies. It is hypothesized that a negative relationship exists between farmers' access to credit and their overall vulnerability to climatic stresses.

Farm size: Due to the high initial investment cost and risks associated with certain technologies, large scale farm enterprises are more likely to adopt such technologies given their strong financial resources relative to small scale farm enterprises (Daberkow and McBride, 2003 cited in Gbetibouo, 2009). Also, the larger the farm size of a farmer, the larger the proportion of land allocated for the cultivation of other crops and the greater the chances of adopting adaptation strategies to avert the effects of climatic shocks (Feder *et al*., 1985).

Educational level of household's head: Deressa *et al*., (2010) and Maddison, (2006) reported that an increase in a household head's years of education increases the probability of their adoption of adaptation strategies to and have a [positive effect on the household's adaptive capacity. However, Mandleni and Anim (2011) found that education has no significant influence on farmers' adaptation to climate variability.

Age of household head: The influence of age on households' adaptive capacity is not straight forward in the literature (Adesina and Forson, 1995 cited in Gbetibouo, 2009). Whereas some old farmers may be more conservative, risk-adverse, lack the strength and flexibility to easily adopt new adaptation strategies to adapt to climate change compared to younger farmers; it could also be the case that given their vast farming experience, older farmers are more able to assess, understand and adopt new technologies to adapt to climate variability than younger farmers. The expected influence of age on households' adaptive capacity is therefore a matter of empirical evidence. This study has hypothesized age to have either a positive or negative influence on the adaptive capacity of farming households.

Farming Experience: It is believed that an experienced farmer who lived in a particular locality over a period of time is more acquainted with the climatic conditions in the area and easily adapt to the changing environment by adopting either or both indigenous and introduced technologies compared to a less experienced farmer (Deressa *et al*., 2009). This study hypothesized that the higher the experience of a farming household, the higher its' adaptive capacity.

Farmer-based Group or Organisation: A farmer-based organization is a group of farmers who come together purposefully to share farming ideas and to assist it members in fostering good farming practices. Such groups functions as platforms for information exchange, learning and sharing new innovations and perceived challenges among members in agricultural and non-agricultural activities (Udry, 2010; Fafchamps, 1992). It was hypothesized that farmers who belong to farmers-based groups are more likely to adopt adaptation strategies and thus, less vulnerable to climatic stresses than those who are not.

Off-farm income: farming households' adaptation to climate change requires some level of financial commitments (Derresa *et al.*, 2009). Thus, farmers who have other sources of income apart from the farm easily adapt to climatic stress than farmers who solely depend on their farms as the source of livelihood. In this study, off-farm income was hypothesized to have a positive influence on farmers' capacity to adapt to climate change.

Land ownership: Ownership of land is a panacea to farmers' farm investments including investments in adaptation and good crop and livestock management practices. Adaptation strategies have higher chances of been adopted when farmers feel secured on land ownership. The adoption of innovations linked to land which require huge investments are thus stimulated by land tenures (Gbetibouo, 2009). This study hypothesized land ownership to have a positive influence on farmers' adaptive capacity.

Access to weather information: Farmers with information on the likely dates for the onset and offset of rainfall for a given season are better placed to adjust to the effects of climatic stress than those who do not. Access to weather information through television, radio and other communication channels increases farmers' awareness to take up measures such as growing varieties of crops suitable to the forecasted weather conditions, changing planting dates and using irrigation as adaptation responses to climatic stresses. Access to weather information was hypothesized to have a direct a positive effect on farming households' climate change adaptive capacity relationship (Mbakahya & Ndiema, 2015).

RESULTS AND DISCUSSIONS

Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics of farming households were analysed using descriptive statistics (Table 2). The results showed that the minimum and maximum age of household head interviewed were 26 years and 62 years respectively with an average age of 38.43 years. This indicates that the respondents are youthful and energetic to employ adaptation strategies that require more physical strength. Given that 1 denoted male household head, the mean value of 0.84 for sex of household head denotes that majority of households interviewed are headed by males. This is consistent with the GSS (2012) report that about 86 percent of households in the northern region of Ghana are headed by males. Also, the average years in school of household heads were 5.45. This suggests that most household heads interviewed have had at least primary school education. The average response of households to access to weather information was 0.32 which indicate that minority of farming households are informed about weather information early enough to adequately prepare for the occurrence of climatic shocks.

Results of the descriptive statistics revealed that minority of households interviewed reported having access to credit and also participated in any adaptation program. On the other hand, majority of households interviewed were members of farm-based organisations, engage in off-farm activities and also own their farm lands. The average farming experience of household head is 8.21 years. The average number of extension contacts and farm size per household are 1.12 per annum and 3.21 hectares respectively. The implication is that most of the households selected are small-scale farming households and each household has had a contact with an extension agent for extension services to boost their adaptive capacity to climate change and variability. Finally, the computed adaptive capacity index showed that the minimum and maximum adaptive capacity indices for farming households are 0.24 and 0.84 respectively with an average of 0.46. This indicates that most farming households selected have adaptive capacity which is below average. Thus, majority of farming households interviewed reported medium level of climate change adaptive capacity.

Table 2: Descriptive statistics of respondents' socio-demographic characteristics

Socio-demographic characteristic	Minimum	Maximum	Mean
Age of household head	26	62	38.43 (12.11)
HHH years of Education	0	15	5.45 (2.32)
Access to weather information	0	1	0.32 (0.09)
Farming experience of HHH (years)	2	42	8.21 (6.32)
Member of Farmer-based Organisation	0	1	0.62 (0.11)
Extension contacts	0	5	1.12 (1.62)
Farm size (acres)	1	8	3.21 (2.01)
Participation in adaptation program	0	1	0.32 (0.05)
Engagement in off-farm activities	0	1	0.68 (0.10)
Sex of household head	0	1	0.84 (0.04)
Ownership of land	0	1	0.73 (0.22)
Access to credit	0	1	0.41 (0.02)
Adaptive Capacity Index	0.24	0.84	0.46 (0.11)

Note: () indicates Standard Deviations
Source: Author's Estimation, 2018.

Factors Influencing Farming Households' Adaptive Capacity

The goodness of fit of the Tobit model was established by using the log likelihood ratio of the chi square (x^2=131.23). The Tobit regression model was significant which confirmed the goodness of fit of the model. This implies that the error term is normally distributed and variation in the adaptive capacity of households of farmers to climatic stresses is significantly explained by variations in the independent variables considered in the model.

The robust regression of the Tobit model was selected and the robust standard error command in the STATA version 14 software was also enabled to ensure homoscedasticity.

The Tobit regression results, presented in Table 3 revealed that male household head, membership of a farmer-based organisation, households' participation in adaptation programs, off-farm activities, educational level of household head, land ownership, number of extension contacts and access to credit significantly influence the adaptive capacity of smallholder farming households in adapting to climate change positively while age of household head negatively influences the adaptive capacity of smallholder farming households. The study further revealed farming experience, farm size and access to weather information have no significantly influence on smallholder farming households' adaptive capacity to climate change. This is congruent with the findings of Mehta (2003) who revealed that farm size was an insignificant predictor of farming households' adaptive ability to climate change in Eastern Uganda.

Age has a significant negative effect on the adaptive capacity of farmers to climate change. This implies that younger farming households have high adaptive capacity than elder farming households. The younger farmers are capable of adopting labour intensive strategies to adapt to climate change and variability because they are still energetic. According to Bayard (2007), younger farmers in Haiti easily adapted to climate change than older farmers due to difference in physical strength.

Table 3: Results of Tobit regression on determinants of adaptive capacity to climate change

Variable	Coefficient.	Std Error	P>|t|
Constant	0.515***	0.578	0.000
Age	-0.001***	0.065	0.004
Sex	0.017*	0.294	0.076
Farmer-based Organisation	0.223***	0.143	0.000
Farm size	-0.001	0.054	0.392
Participation in adaptation intervention programs	0.130***	0.194	0.000
Off-farm activities	0.191***	0.197	0.000
Education	0.093***	0.692	0.000
Weather information	0.009	0.452	0.183
Experience	0.004	0.008	0.562
Land ownership	0.037***	0.173	0.003
Extension service	0.030***	0.217	0.000
Access to credit	0.234*	0.590	0.064
Number of observations = 196	F = 131.23		Prob > F =0.000
Pseudo R^2 = 0.3831	Log likelihood = -154.8279		

Note: * and *** denote statistically significant at 10% and 1% respectively.
Source: Author's Estimation, 2018.

The regression results also revealed that being a member of a farmer-based organisation significantly and positively influences households' adaptive capacity to climate change. Apart from sharing ideas among each other, smallholder farmers get the opportunity to learn new adaptation measures from other agricultural-based NGOs.

This finding agrees with Egyir et al., (2015) who attributed the low adaptive capacity of farming communities in the Protected Coastal Savanna and Transitional Zones in Ghana to minimal association with farmer-based institutions where they could learn new knowledge and skills to improve upon their adaptive capacity.

The Tobit regression results showed that smallholder farming households' adaptive capacity to climate change is significantly and positively improved if they participate in adaptation programs sponsored by governmental and non-governmental organisations. Smallholder households' participation in climate change adaptation programs is vital and affords them the opportunity for their adaptation challenges to be heard and addressed by relevant institutions and persons. This agrees with Alhassan et al. (2017) who found that women farmers in northern Ghana who have benefited from contract farming with NGOs are able to access tractor service in time to adapt to climate change.

Off-farm activities have significant positive influence on the adaptive capacity of smallholder farmers to climate change. This suggests that smallholder farmers who engage in off-farm income generation activities such as shea nut processing, fishing, char coal burning and food vending as supplementary sources of livelihood are more capable of adapting to the impact of climate change and variability. This contradicts Egyir et al. (2015) who found that full-time farmers without off-farm engagement were more capable of adopting modern productivity enhancing technologies in Coastal Savanna and Transitional zones in Ghana than farmers who engaged in other off-farm activities. The reason could be due to difference in locations of both study areas. Thus, the contribution of off-farm activities to livelihood could be insignificant in the coastal savanna and transitional areas where bi-modal rainfall pattern exists, therefore have very shorter periods to engage in off-farm activities. However, in the Guinea Savannah where the dry season is longer than the rainy season, smallholder farmers have longer periods to engage in off-farm activities which make significant contribution to their livelihood.

Smallholder farming households' ownership of farmland has a significant positive effect on farmers' adaptive capacities. This implies that farmers who own their farmlands increase their adaptive capability to climate change and variability. The empirical results are contrary to Mehta (2003) who reported negative effect of land ownership on farmers' adaptive capacity in Eastern Uganda.

Extension service also had a significant positive influence on farmers' adaptive capability. Therefore, the higher the extension contacts with smallholder farmers, the higher their capability to adapt to the effect of climate change. This is not different from the finding of Egyir et al (2015) who attributed the low adaptive capacity of farmers in the Protected Coastal Savanna and Transitional Zones of Ghana to low agricultural extension agent – farmer ratio and contacts. This is further explained by the Pseudo R-square of 0.383 and confirms that about 38% variation in the independent variables explains a household's adaptive capacity to climate change in the Savelugu/Nanton Municipality.

CONCLUSION

The study investigated the determinants of smallholder farming households' adaptive capacity to climate change and variability in the Savelugu/Nanton Municipality in the Northern region of Ghana. The empirical findings reveal that male headed households, membership of farmer-based organization, participation in adaptation programs, off-farm activities, education of household head, ownership of farm land, access to extension services and credit by smallholder farming household positively influence their climate change adaptive capacity while age of the household head negatively influences the adaptive capacity of farming households.

Based on these findings, the study recommends the strengthening of smallholder farming households' participation in farm-based associations to share farming experiences and through the Ministry of Food and Agriculture, be linked to the appropriate markets for the sales of their products. Also, agricultural extension agents should intensify contacts with smallholder farming households in particular to stimulate their capacity to adapt to the adverse effects of climate change and variability by educating them on modern agronomic practices and recommended periods for agricultural activities such as when to start clearing the farm, when to plough, when to sow and when to harvest. Finally, government should identify an independent monitoring team to ensure an effective participation of smallholder farmers in the government of Ghana planting for food and jobs program and other income generation projects by NGOs in the region to increase their resilience to climate change and variability. This will enhance participation through maximum output of produce in the municipality. Although there are existing farmer-based organizations, extension delivery service through the NGO and the Ministry of Food and Agriculture (MoFA) coupled with the implementation of the Planting for Food and Jobs (PFJ), government should provide effective monitoring towards adaptive efficiency in the municipality.

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