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FACTORS TO CONSIDER IN PROMOTING HIGH ADOPTION OF CLIMATE CHANGE ADAPTATION STRATEGIES: EVIDENCE FROM NORTHERN GHANA

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Abstract

This paper identified and examined the factors that climate change policy makers and implementers need to consider in their attempts to promote high adoption of climate change adaptation strategies in Ghana, with specific focus on northern Ghana where endemic poverty is exacerbated by the adverse effects of climate change. Based on multiple stage sampling the paper considered 300 farm households from 17 farming communities for the analyses. The study employed a binary model (Probit) to identify the determinants of high adoption of climate change adaptation strategies among farmers in northern Ghana. Gender of household head, household head education level, household size, participation in climate change trainings, perception of yield increases, geographic location, access to credit and membership to farmer-based organisations were the factors considered in the Probit model. The result revealed that many farmers are high adopters of climate change adaptation strategies (CCASs) and this is good news for policy makers and implementers. Gender of household head, awareness or access to information on climate change, yield increases and membership to farmer-based organisations are the critical factors that significantly influence the decisions of farmers to adopt high levels of climate change adaptation strategies. Farmer-based organisations should be used as springboards and/or platforms for the promotion of adoption of climate change adaptation strategies among farmers. Interventions to promote and sustain high adoption of CCASs must take into consideration the heterogeneity and geographical locations of beneficiary farmers and communities.

Keywords: **Adaptation, Climate Change, Probit Model, Farm Households**

Introduction

Climate change denotes any significant change in the expected patterns of a specific region's average weather for any significant period, typically decades or longer (Intergovernmental Panel on Climate Change, 2007). The concern for climate change continues to evoke academic discourse in view of its negative impacts on livelihoods of present and future generations. This is particularly so in developing counties including Sub-Saharan Africa, because majority of the populace depend on nature-based economic activities with low adaptive capacities (Akudugu *et al.,* 2012; Yaro, 2013). A report by the Inter-governmental Panel on Climate Change (IPCC) estimates that globally the rate of warming over the average combined land and ocean surface temperature data as determined by a linear trend, show a warming of 0.85 [0.65 to 1.06] °C over the period 1880 to 2012 (IPCC, 2014). These figures obviously raise serious concerns on the need to develop adaptive strategies to mitigate the negative impact of climate change. Climate change was a threat, especially to Sub-Saharan African's efforts towards the attainment of the Millennium Development Goals (MDGs) and will be a threat to the attainment of the Sustainable Development Goals (SDGs). It is against this backdrop that SDG 13 specifically recognizes the need to "take urgent action to combat climate change and its impacts". Increasing temperatures and changing rainfall patterns across Africa reduce access to food and create effects that impact regions, farming systems, households, and individuals in varying ways.

Human activities such as bush burning, tree felling, and emission of gasses from factories and vehicles contribute to climate change (Nzuma *et al*., 2010). Climate change is evident in Ghana where farmers and other vulnerable people who depend on agriculture for survival perceived it as the change in climatic elements, especially rainfall which negatively affects agricultural production (Arku *et al*., 2017; Arku, 2013). According to a study conducted by the Environmental Protection Agency (EPA) in 2008 on "Ghana Climate Change Impacts, Vulnerability and Adaptation Assessment", average annual temperatures have been rising steadily in 5 of the 6 agro-ecological zones over a 40-year (1960-2000) period. The negative impacts of climate change mostly felt in Ghana include droughts and floods (Kankam-Yeboah, 2010). Northern Ghana is particularly threatened by the effects of climate change due to its proximity to the Sahara Desert. For instance, Dokurugu (2010) reported that the Sahara Desert is advancing at the rate of 0.8 percent per year towards Northern Ghana, which has a serious implication for the rural poor whose livelihood is dependent on the natural environment. Poor women tend to be more vulnerable to climate change due to their greater dependence on natural resources, which are affected by floods, drought and other impacts of climate change (Akudugu *et al*., 2012).

As climate change impacts are felt, community members, especially the poor and vulnerable are compelled to adapt and to cope with its negative effects. Thus, smallholder farmers take on new roles and responsibilities and work together with other locally based organisations to withstand or manage the increasing threats of climate change in ways that moderate harmful effects or take advantage of positive opportunities (IUCN *et. al*., 2004). The need to employ various strategies including increased capacity of community members to curb or mitigate the effects of climate change in Northern Ghana is essential for sustainable development and future economic growth of Ghana.

Climate change adaptation has become one of the topical issues and rural peasants employ different innovative strategies to manage climate change uncertainties and impacts (Laube *et al*., 2012; Eguavoen, 2013; Derbile and Laube, 2014). Community level climate change adaptation strategies are well known (ibid) but there is little empirical evidence about the factors that govern the effectiveness of these strategies. Despite the prominence of climate change and its debilitating effects on food security and livelihoods in general, there seems to be little empirical studies on identifying factors affecting its adaptation in northern Ghana. Thus, identifying factors influencing climate change adaptation strategies is critical for policymakers to be able to make more informed decisions in helping build the capacities of communities to adapt to climate change.

Climate Change Adaptation Strategies (CCASs) in the context of this paper, therefore, refers to changes that local communities have to make in response to changing patterns in their local climatic conditions relying heavily on local resources, knowledge and expertise. In other words, climate change adaptation strategies are institutional, structural, behavioural and attitudinal changes that local people and communities employ to deal with the negative impacts or take advantage of opportunities created by climate change. There are two components of climate change adaptation strategies within the context of this paper and these are the on-farm and off-farm components. The on-farm components include planting drought tolerance, early maturing and indigenous crop varieties; early planting, mixed cropping/farming, staggering between multiple farms, use of indigenous organic manure, using strips and stone terracing to manage soil erosion, and water harvesting for dry season gardening as well as watering of farm animals among others. The off-farm components include diversification into non-farm income generating activities such as petty trading, seasonal migration, and reliance on relatives as well as philanthropic individuals and organisations in times of bad weather (e.g. droughts and floods). These identified components are consistent with the works of Laube *et al*. (2012), Antwi-Agyei *et al.,* (2012), Djagbletey *et al.* (2012) and Derbile (2013) among others.

The main novelty of this paper is that it adopts a bottom-up approach of understanding the factors that influence adaptation. As argued by Kerry *et al.* (2012), local knowledge is critical in enhancing climate change adaptation. Most climate change research papers focus on national and global trends (Bulkeley *et al.,* 2014) while paying little attention to local communities that bear the greatest brunt of climate change. The objective of this paper therefore is to understand the factors that influence the high or low adoption of CCASs by rural farmers in Northern Ghana.

Empirical Issues on Climate Change

Available evidence indicate that climate change affects the African continent more than any other continent despite its least contribution to anthropogenic factors responsible for causing climate change (IPPC, 2007). The Intergovernmental Panel on Climate Change (IPCC) observed that the African continent is slow in response to fighting the climate change menace (IPCC, 2007). According to the report of climate change variability index for 2015, Africa still dominates with 7 out of the 10 most affected countries in the world.

Weather related disasters such as floods, and drought have over the past 25 years doubled in Africa, making the region the most prone to drought related mortality than any other region in the globe (Deonarain, 2014). According to the African Water Development Report (AWDR) (2006), disastrous floods in Algeria claimed over 800 lives and destruction of property worth about $400 million. An estimated 90,000 cattle were lost in Swaziland in 1992 to weather related causes, which greatly affected the economy, since cattle are a major source of income for the nation (Urama and Ozor, 2010). As noted by the IPCC (2014), children in Africa are often prone to deaths related starvation and malnutrition when their countries experience long droughts. Africa therefore needs to step up action in fighting the climate change menace by drawing experiences from other parts of the globe. In the view of Archer (2016) building partnership between community members and bodies fighting climate change using bottom up approach holds a key to addressing climate change resilience and adaptation deficits.

At the national level, there have been a considerable number of studies on climate change in Ghana (e.g. Arku *et al.,* 2008; Arku and Arku, 2010; Arku *et al*., 2011; Laube *et al*., 2012, Akudugu *et al.,* 2012; Antwi-Agyei *et al.,* 2012; Djagbletey *et al.,* 2012; Arku, 2012, 2013; Eguavoen, 2013; Derbile & Laube, 2014, Arku *et al*., 2017). While some of these studies analysed the effects of climate change, others looked at the coping or adaptation strategies to climate change. Djagbletey *et al.* (2012) described in detail how farmers in Offinso North and Offinso South Districts in Ashanti Region of Ghana adapt to climate change. They indicated that coping strategies used by farmers in the two districts include shifts in planting period to coincide with the start of rainy season, planting on raised ridges, planting drought resistant crop varieties and fruits such as water melon, irrigating crops with water from streams, cropping around streams and farming during minor rainfall season. They further observed that certain dangerous practices and activities exacerbate climate change. These include illegal logging, farming along riverbanks, excessive use of agrochemicals and unsustainable farming practices. Akudugu *et al.*(2012) examined the implications of climate change for food security and rural livelihoods in Northern Ghana and concluded that climate change is real, and is threatening the very existence of rural communities and people who depend largely on nature for survival. The authors reported that communities that never experienced adverse climatic events are now saddled with the double tragedy of droughts and floods within cropping seasons. Akudugu and Alhassan (2012) examined climate change, food security, livelihoods and social safety in Northern Ghana and noted that policy makers and implementers need to develop and implement a holistic adaptation framework to mitigate the effects of the climate change menace on livelihoods of the poor and vulnerable across the country and Northern Ghana in particular.

Derbile (2013) found that farmers in North-East Ghana use adaptive strategies such as planting indigenous drought resilient crop varieties, staggering between multiple farms, applying indigenous organic manure, checking soil erosion by using strips, stone terracing and adopting paddy farming to conserve water. Similarly, Laube *et al.* (2012) while investigating smallholder adaptation to climate change in Northern Ghana observed that farmers used shallow groundwater irrigation for vegetable gardening to minimise climate vulnerability. The study further observed that all the cocoa growing regions in the country are much aware of climate change and its impact on their farming activities ranging from the time of planting cocoa to the time of harvesting and drying cocoa beans. On the other hand, Yaw (2013) identified the coping strategies used by farmers to include soil fertility management, shade management, land preparation, farm size and lining and pegging. Moreover, a study by Nyantakyi-Frimpong (2013) found that up to 85 per cent of rural farmers prefer to use indigenous varieties of seeds for planting over improved ones because they claimed the former are more resilient to climate variations and easily accessible to them than the latter. A more recent study by Arku *et al.* (2017) found that some of the climate change adaptation strategies employed by local people include dependence on family and friends, and engaging in menial jobs in order to cope with the adverse effects of climate change on their livelihoods. Thus, local farmers indeed employ different adaptive measures to mitigate the adverse climate change effects.

Farmers generally have a fair understanding of climate change in Ghana. However, their knowledge and perception about the occurrences of climate change is quite diverse and depend on their level of exposure. For instance, while disaggregating the understanding of smallholder and commercial farmers in Ghana, Yaro (2013) found that the small-scale farmers presented the traditional views of climate change. On the other hand, the commercial farmers demonstrated scientific and deeper knowledge on the subject matter. Similarly, Yaw

(2013) found mixed views about farmers' perception about the causes of climate change in Ghana. According to the study respondents' views included God's plan signifying the end of time, usage of heavy machines on land, air and water, deforestation, indiscriminate bush burning before farming or in search of game, farming alongside river bodies and illegal mining.

Adaptive capacity of farmers according to Mabe *et al.* (2012) depends on certain factors or attributes such as their knowledge and number of times they use a particular adaptation strategy, availability and accessibility of the adaptation strategy, and the number of consultations that a farmer makes on a particular adaptation strategy. The authors concluded among others that farmers are highly adaptive to the use of chemical or organic fertilizers, mulch, fallow farming, irrigation, cropping along water bodies and using early maturing rice varieties and that farmers with higher adaptive capacities get more rice output than those with low adaptive capacities. Other studies (e.g. Gyasi *et al*., 2006) on climate change in Ghana focused on the effects of climate change on land management, especially on the savannah transitional, the semi-deciduous forest and the high rainforest zones. The study found that the biodiversity of the savannah is high and therefore perennial dry climate causes extensive annual biomass burning leading to unstable trees and grass. Under this condition, small changes in climate or land use can have a large impact on biomass and soil properties. The authors concluded that large losses of topsoil constitute a threat to agriculture because it has both biophysical and socio-economic effects. These include land degradation resulting from increasing demographic pressure, land misuse, soil mismanagement and a decline in soil quality.

Methodology

Selection of study areas, sampling and model specifications

The study was conducted in the Northern, Upper East and Upper West Regions of Ghana. The three regions were selected for two main reasons. Firstly, they are the poorest and most deprived regions of Ghana and secondly they have experienced more devastative effects of climate change than any of the other regions of the country over the past two decades. These devastative effects include the double tragedy of floods and droughts within seasons, which had significant impacts on livelihoods and welfare of the Ghanaian people, majority of whom depend on the natural environment and climate for agricultural production (Akudugu *et al.*, 2012).

The study followed a multiple sampling process, wherein random selection of two districts from Northern region and one district each from the Upper East and Upper West Regions was done in the first stage. In the second stage, all districts in each region were numbered sequentially and the appropriate number randomly sampled. In the third stage, all communities in the selected districts were numbered and the required number randomly sampled. The study randomly selected 5 communities from each of the sampled districts in the Upper East and Upper West Regions, 3 communities from the first district of Northern Region and 4 communities from the second district. This gave a total of 17 farming communities across the sampled districts. In the fourth stage, all households in the sampled communities were enlisted, numbered sequentially and a non-proportional sample of 18 households randomly selected from each community. This gives a total of 306 sampled households across the 17 communities. However, during data editing and cleaning 6 households were dropped for incompleteness leaving 300 farm households used for the analyses. Household heads were then interviewed because they are the key decision makers within the context of the studied communities. The survey was supplemented with Stakeholder Consultations, Focus Group Discussions and Key Informant Interviews. These provided the opportunity for the authors to gain better insights into the issues studied.

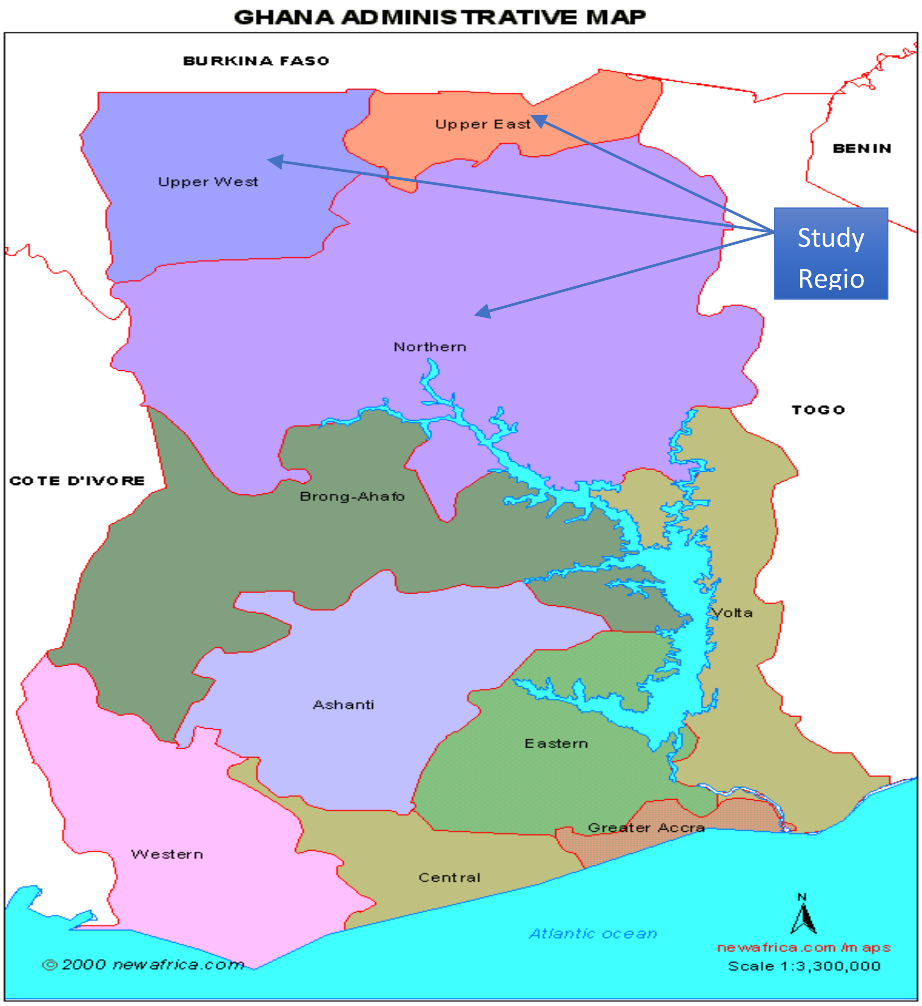


Figure 1: Map showing study regions with arrows

Although the utility associated with the adoption of each climate change adaptation strategy by farmers is not directly observable, the adaptation choices made are observable, and unordered thus suggesting that adoption of CCASs may be explained by the random utility maximization theory. In this regard, a farm household will only be a high adopter of CCASs if the utility derived thereof is higher than the utility derived from being a low adopter. This means farm households will only be high adopters if the utility (U) derived thereof is higher than the default threshold. As to whether or not a farm household will be a high adopter or not depends on a set of socio-economic factors. These factors include whether the household head is a male or female, educational level and access to information on the effects of climate change on livelihoods among others. Thus, the factors that influence the probability of being a low or high adopter of CCASs were estimated based on the following basic model establishing the relationship between utility derived from being a low or high adopter of CCASs and the socio-demographic characteristics of farm households:

$$U_i = U(X) \qquad (1)$$

where U_i is the utility the i^{th} farm household derives from being a high or low adopter; U represents function of, and X is a vector of observable farm household socio-demographic characteristics.

Within the context of this study, there are eight CCASs for farm household to adopt. Given that this presents count data, models such as Poisson, Negative Binomial where there are zero adopters or Tobit could be used for the analysis. However, the objective is to get farmers to move towards being full adopters of these CCASs. Thus, using count data models will only indicate that when any there is a unit change in any of the explanatory variables, the number of CCASs adopted will increase or decrease by a corresponding margin. This will not help us understand what to do to move people to adopt at least above average. To circumvent this dilemma, we used the approach adopted by Agula, Akudugu, Dittoh and Mabe (2018) in the paper entitled, "Promoting Ecosystem-Friendly Irrigation Farm Management Practices for Sustainable Livelihoods in Africa: The Ghanaian Experience", where respondents were divided into low and high adopters of Ecosystem-friendly irrigation farm management practices. As such, those that adopted less than half (i.e. less than four CCASs) were considered low adopters and those who adopted four or more are considered high adopters. Thus, a farm household is either a low or high adopter of CCASs. Thus, at time *t*, the farm household is either a low or high adopter but not both. In other words, a farm household cannot be a low and a high adopter at the same time and this results in a mutually exclusive outcome thereby requiring the use of binary models. The logit and probit models are the most common forms of binary choice models. The probit was used to estimate the factors that determine whether a farm household in northern Ghana will be a low adopter of CCASs or not. The choice of the probit model over the logit model is based on the fact that it produced superior results compared to the logit model and this implies that the underlying distribution of CCASs adoption is normal in nature. Utilities derived by farm households for being high or low adopters can be decomposed as:

$$U_{i1}(X) = \beta_1 X_i + \varepsilon_{i1}\ for\ high\ adopters\ of\ \text{CCCASs} \quad (2)$$

$$U_{i0}(X) = \beta_0 X_i + \varepsilon_{i0}\ for\ low\ adopters\ of\ \text{CCCASs} \quad (3)$$

Where U_{i1} is utility derived when the i^{th} farm household is a high adopter of CCASs; U_{i0} is utility derived when the i^{th} farm household is a low adopter of CCASs; X represents a vector of observable characteristics of the i^{th} farm household; ε_{i1} and ε_{i0} represent the random errors associated with the estimation of utilities for high adopters and low adopters respectively; and β_1 and β_0 are unknown parameters to be estimated.

With the assumption that the utilities are random (random utility maximization theory), the household will be a high adopter if the utility derived thereof is greater than the utility derived by being a low adopter. Note that utility in the context of this paper is the increased crop yields, food consumption and incomes among other household objectives and aspirations derived from adoption of CCASs. The probability[1] of being a high adopter of CCASs is empirically specified as:

$$Prob(\text{CCCASs} = 1|X) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon \quad (4)$$

Variable Selection and Hypotheses

The selection of variables (Table 1) for the probit model estimation was based on intuition and the empirical literature. Sex of household head (X_1) was chosen based on the fact that it influences resource access, which in turn affects the capacity of farm households to be a high adopter of CCASs or otherwise. As noted by Kirsten and Verhagen (2007), gender issues are important in dealing with the climate change menace and must therefore be reflected as an indicator of progress on climate change adaptation. It has been reported that women tend to have different coping strategies and constraints to climate change and related disasters than men (Fothergill, 2004;). It was hypothesized that male-headed households would have higher probability of high adopters of CCASs than female-headed households. Education or literacy (X_2) was selected because it improves the human capital base of farmers to adequately respond to climate change issues. This could be achieved through adult education and extension services (Mustapha *et al.*, 2012). It was hypothesized that households with literate heads would have higher probability of being high adopters than households with illiterate heads. Household size (X_3; X_4) is an important factor in climate change adaptation. It is thought that households with large family members are most likely to be high adopters of strategies to mitigate the adverse effects of climate change on livelihoods. It was hypothesized that households with large sizes will be high adopters of CCASs.

Awareness or access to information through climate change training (X_5) is important in helping farmers adopt and implement appropriate climate change adaptation strategies (Ziervogel *et al.*, 2010; Boyd *et al.*, 2013). Those with access to climate change information were hypothesized to be more likely to be high adopters than those who did not have. How farm households perceive climate change to be affecting their yields (X_6) ultimately influences whether they will adopt more adaptation strategies to cope with it or not. Those perceiving climate change to be negatively affecting their yields were hypothesized to be more likely to be high adopters than those who did not think so.

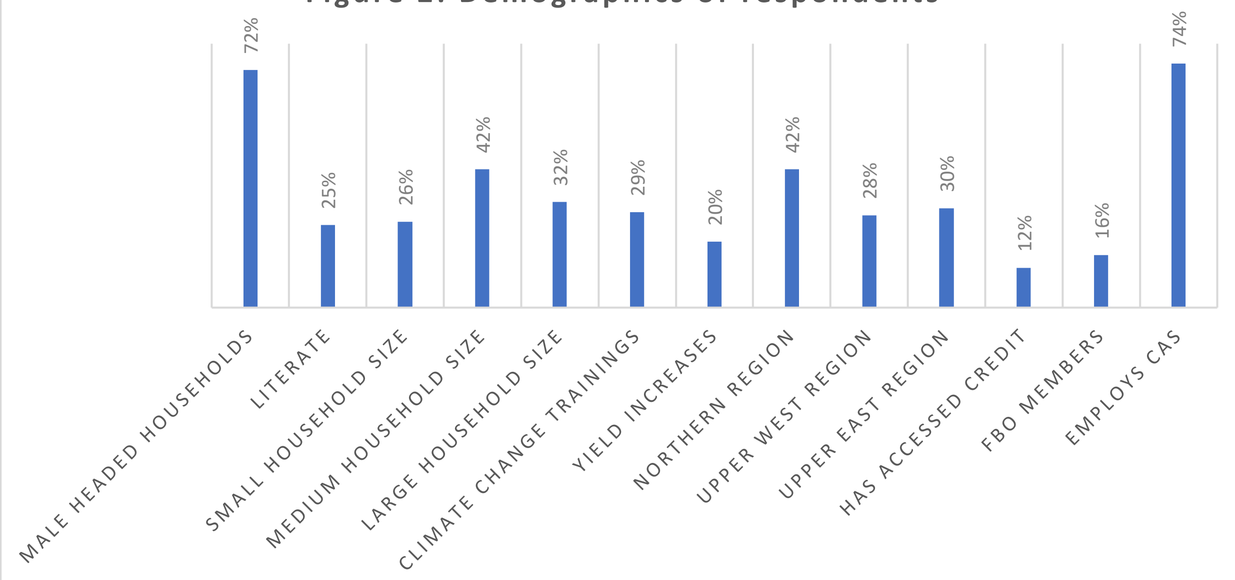
The geographical location (X_7; X_8) of farmers, which is, linked to their belief systems affect their climate change adaptation strategies. The geographical location variables were included to capture the cultural differences that exist across the study areas. This is informed by the empirical literature that culture and belief systems play critical roles in climate change adaptation strategies (Jones and Boyd, 2011; Swim *et al.*, 2011; Stafford-Smith *et al.*, 2011; Rademacher-Schulz and Mahama, 2012; Adger *et al.*, 2012). It was hypothesized that geographical location of farm households might determine whether a farm household is a high or low adopter of CCASs. Access to financial resources, particularly credit (X_9) has been reported to affect the adoption of climate change adaptation strategies (e.g. Antwi-Agyei *et al.*, 2012;). It was thus hypothesized that households with access to credit will be more likely to be high adopters compared to those with no access to credit. Membership to farmer groups and organizations (X_{10}) was included in the model estimation as it is thought to influence climate change adaptation strategies of farmers. It was hypothesized that farm households belonging to social groups are more likely to be high adopters of CCASs than those not belonging to any social group.

Results and Discussion

Demographic characteristics of respondents

Figure 1 revealed that almost seven in ten households sampled in this study were male headed while three in ten were female headed. This pattern is understandable because Northern Ghana is largely a patrilineal community with majority of households being headed by men. Three in four respondents were found to be illiterate with the remaining one in four respondents being literate (Figure 1). It was further found that three in ten households had small household size (the reference category), and four in ten households had medium household size) and three in ten households had more than ten people (i.e. large household size). This implies that farm households across Northern Ghana are heterogeneous in terms of household size.

Figure 2: Demographics of respondents



Source: Field survey, 2013.

The level of awareness through participation in climate change trainings among the respondents was found to be low. Only three in ten respondents said they were aware of climate change through participation in trainings and workshops organized by local government authorities and non-governmental organizations (NGOs) with seven in ten saying they never had access to any of the trainings on climate change (Figure 1). One in five respondents said their yields per hectare have increased over the last decade with four in five saying they have not experienced yield increases (i.e. yields have either decreased or stagnated). Only a few (12%) households had access to credit with majority (88%) indicating that they had no access to credit. Also, about one in five responding household heads were members of farmer-based organisations (FBOs) with the remaining four in five of them not belonging to any FBOs. The results further indicate that about seven in ten respondents are high adopters of CCCASs (Figure 1). The CCASs households employ planting of short maturing and drought resistant crop varieties, water harvesting for dry season gardening, afforestation, mixed cropping, crop rotation, mixed cropping, diversification into non-farm livelihood activities such as petty trading activities and seasonal migration to the southern part of Ghana for menial jobs among others. This finding is consistent with that of Arku *et al.* 2017).

The probit model results

The probit model regression results indicate that there are different factors that influence the level of adoption of CCASs by farm households across Northern Ghana. These factors have different directions, magnitudes and significance of influence on farm households' probability of being high or low adopters of CCASs. The probit results gave a log-likelihood ratio (LR) of about 46, which is statistically significant at 1%, and this implies that all the variables included in the model estimation jointly influence the probability of farm households being low or high adopters of CCCASs. Also, the Pseudo R^2 of 0.1486 means that the model is able to explain about 15% of the variability in farm households' probability of being high adopters of CCCASs. The overall probability of farm households being high adopters of CCASs given the factors modelled was predicted to be about 84% (Table 2). This means that if all the factors included in the probit model estimation are considered, the probability of households in Northern Ghana adopting high numbers of CCASs can be increased by about 10% (i.e. from 74% as in Figure 1 to 84% as in Table 2), *ceteris paribus*.

As hypothesized, the gender of household head was found to have positive and significant influence on farm households' probability of adopting high numbers of CCASs. It was found that the probability of male-headed households being high adopters of CCASs is about 12% higher than that of female-headed households and this is statistically significant at 1%. This finding is consistent with the empirical literature that gender issues are important in tackling the negative consequences of climate change (*see for instance* 2004; Kirsten and Verhagen, 2007). Literacy level of household heads had no significant influence on the level of adoption of CCASs. This means that whether a literate or illiterate person heads a given household, it has no significant influence on the number of CCASs adopted. This finding is contrary to the view expressed in the empirical literature (e.g. Mustapha *et al.*, 2012) that literacy/education is important in climate change adaptation.

Household size was found to have positive and significant influence on the probability of farm households being low or high adopters of CCASs. The probit results show that having a medium household size (6-10 people) has no significant influence on the probability of being a low or high adopter of CCASs. Thus, there is no difference in probability of being a high adopter by the reference category (i.e. small household size) and medium sized farm households. However, as hypothesized, large household size has a positive and significant influence on farm households being high adopters of CCASs. Thus, the probability that a farm household with large size will be a high adopter of CCASs is about 11% higher than the reference category and this is statistically significant at 1%. The implication of this is that the number of people that a farm household has to take care of is critical in determining the number of strategies to be adopted in circumventing the adverse effects of climate change.

The level of awareness through climate change trainings was also found not to have any significant influence on farm households being high adopters of CCASs. Contrary to the view expressed in the empirical literature (e.g. Patt and Gwata, 2002; IPCC, 2007; Lee, 2007; Adger *et al*., 2009; Ziervogel *et al*., 2010; Boyd *et al*., 2013), this finding shows that awareness creation through climate change training is not a significant determinant of the level of adoption of CCASs by farm households in Northern Ghana. Furthermore, perceptions of yield changes and credit access were all found not to have any significant influence on the probability of being a high adopter of CCASs. Geographical location (i.e. whether a farm household is located in the Northern, Upper East or Upper West regions) had some level of influence on the probability of being a high adopter of CCASs. Whereas there is significant difference between farm households in the reference category (i.e. Northern region) and Upper West region in the probability of being a high adopter of CCASs, there is no significant difference between those in Northern and Upper East regions. Specifically, the probit model results show that the probability of farm households in the Upper West region being high adopters of CCASs is about 11% lower than those in the reference category and this is statistically significant at 5%. This finding is consistent with the empirical literature (e.g. Jones and Boyd, 2011; Stafford-Smith *et al.*, 2011; Adger *et al*., 2012; Moser and Ekstrom, 2010; Nielsen and Reenberg, 2010; Rademacher-Schulz and Mahama, 2012; Swim *et al.*, 2011; Stafford-Smith *et al.*, 2011) that variations in geographical settings culminating in differences in culture and belief systems influence the adoption of climate change adaptation strategies.

Table 2: Probit regression results

Dependent variable: CCCASs			
Independent Variable	**Coefficient**	**Standard error**	**Marginal effect (dy/dx)**
Gender	0.4879***	0.1977	0.1195
Literacy level	0.0594	0.2042	0.0148
Medium household size	0.3490	0.2231	0.0838
Large household size	0.4893**	0.2403	0.1115
Awareness	0.1303	0.2193	0.0312
Yield changes	0.1812	0.2088	0.0467
Northern region	0.0299	0.1926	0.0073
Upper West region	-0.4521**	0.1850	-0.1136
Credit access	0.1971	0.2973	0.0449
FBO membership	1.4043***	0.4280	0.2163
Constant	0.0866	0.3021	-

n = 300
Log likelihood = -132.3944
LR $Chi^2(10)$ = 46.21
Prob> Chi^2 = 0.0000
Pseudo R^2 = 0.1486
Predicted probability of CCCASs use = 0.8383

*** & ** Stand for 1% and 5% respectively.
Source: Field survey, 2013.

Access to credit was found not to be a significant determinant of level of adoption of CCASs by farm households in Northern Ghana. This contradicts the views expressed by earlier studies (e.g. Dasgupta and Baschieri, 2010; Antwi-Agyei *et al*., 2012; Bryan *et al.,* 2009; Kithiia, 2011) that access to financial resources including credit is very important in adopting climate change adaptation strategies. However, for adaptation measures that would require significant capital outlay in terms of inputs and services, the findings of the other authors could be consistent with fact. Membership to farmer-based organisations (FBOs) was found to have positive and significant influence on the probability of farm households' being high adopters of CCASs. Thus farm households that belong to farmer-based organisations are about 22% more likely to be high adopters of CCASs than those not belonging to any FBO and this is statistically significant at 1%. The implication of this finding is that FBOs play critical roles in climate change adaptation.

Conclusion and policy recommendations

The paper examined the factors that determine the level of adoption of climate change adaptation strategies in Northern Ghana. Based on the evidence adduced, it is generally concluded that farm households across Northern Ghana are continuously employing different strategies in adapting to the adverse effects of climate change. Some of the most commonly adopted CASs include planting of short maturing and drought resistant crop varieties, water harvesting for dry season gardening, afforestation and diversification into non-farm livelihood activities. The use of these CCASs is influenced by a number of factors that were modelled and estimated using the probit model. The probit regression results revealed that gender of household head, household size, geographical location (i.e. being located in the Upper West Region) and FBO membership are the factors that significantly influence the level of adoption of CCASs among farmers and farm households across Northern Ghana.

On the basis of the findings, it is recommended that policy makers step up efforts to design and implement policy interventions such as formation and strengthening of FBOs among others to enhance and sustain the capacity of farm households to adopt more climate change adaptation strategies. In designing and implementing such policy interventions, the bottom-up approach should be employed. This will ensure that people whose livelihoods are adversely affected by climate change and who will be the direct beneficiaries of the interventions are involved right from the inception. The essence is to ensure that policy interventions are compatible to local norms as well as aspirations, objectives and circumstances of the target people. Thus, the capacity of women in climate change adaptation measures needs to be built and strengthened since the probability of they being high adopters of CCASs is lower than men. Besides, they are the hard hurt in times of climate related disasters such as floods and droughts as they perform their triple roles of production, procreation and nurturing. Given that membership to FBOs facilitates high adoption of CCASs, there is the need for policy transformation in the organisation and performance of farmer based organisations to serve as incubators and critical platforms for dissemination of climate change adaptation strategies.

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