Determinants of Adaptive Capacity to Climate Change among Smallholder Rural Households in the Bongo District, Ghana

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Abstract

This study examined the determinants of adaptive capacity of smallholder rural households to climate change in the Bongo District of the Upper East Region of Ghana. It employed a mixed method approach involving questionnaire survey of 150 households randomly selected from two communities within the district, focus group discussions and key informant interviews. The results of a binary logistic regression model indicates that five predictor variables (education of the household, farming experience, farm size, belief system and training) out of 11 tested determinants were significant at 1%, 5% and 10% probability levels. Forward stepwise (likelihood ratio) showed that these five variables had explained 61% of the total variances in households' adaptive capacity. The study concludes that attempts to support household adaptation strategies to climate change should pay considerable attention to understanding socio-economic factors, including education and belief systems, in order to develop sustainable strategies that will be culturally accepted by communities.

Keywords: Adaptation, Education and Training, Experience, Livelihood, Socio-cultural Factors

Introduction

It has been recognized that Africa is predominantly vulnerable to climate change and that this vulnerability is instigated by the continent's rising poverty levels, weak adaptive capacity, over reliance on rain-fed subsistence agriculture and weak institutional and economic capacity (Boko et al., 2007). Studies (Schlenker & Lobell, 2010; Antwi-Agyei, 2012) have highlighted that sub-Saharan Africa's (SSA's) agriculture production and related livelihoods will be severely compromised by climate change, a situation described as a new security threat. Forecast of climate impacts indicates progressively severe negative effects, such as protracted and more severe droughts (Boko et al., 2007; Christensen et al., 2007), increasing mean annual temperatures, increase evapo-transpiration losses and reduction in soil moisture content (Boko et al., 2007). These woeful predictions are expected to reduce net crop revenues by 90% by the year 2100 with rippling consequences that can further exacerbate current poverty levels and promote underdevelopment in SSA (Sissoko et al., 2011).

Sub-Saharan Africa is largely characterized by smallholder agricultural households living in rural areas and producing mainly to subsist. Sub-Saharan Africa's rural economy remains strongly based on agriculture relative to other regions. Agriculture in SSA (excluding South Africa) employed 63% of the population and generated 25% of the GDP of these countries in 2008 (IAASTD, 2009). These agricultural production systems are largely based on smallholder farms. Smallholder farms, when defined as being 2 ha or less, represent 80% of all farms in SSA and contribute up to 90% of the production in some SSA countries (Livingston et al., 2011). A large percentage of these smallholders are women, responsible for key components of household production such as weeding, harvesting and processing. The Food and Agriculture Organization (FAO, 2011) estimates that approximately half of SSA farmers are women and the share of female farmers rose slightly since 2008. Women often independently grow non-cereal crops for income and are increasingly heading rural households due to male urban migration. As in other regions, SSA's agricultural households have varying levels of diversification in income sources beyond agriculture – though agriculture remains the dominant source of livelihood in poorer countries and poor regions within less poor countries (Livingston et al., 2011).

Climate change is perhaps one of the most serious environmental threats facing agriculture and rural livelihoods in SSA today. It is projected that crop yield in SSA may fall by 10 – 20% by 2050 or even up to 50% due to climate change, particularly because the region's agriculture is predominantly rain-fed (World Bank, 2010) and hence fundamentally dependent on the vagaries of the weather. As governments of SSA countries strive to overcome poverty and advance economic growth, climate change threatens to deepen vulnerabilities, erode hard-worn gains and seriously

undermine prospects for development. According to Adebayor (2012), the effects of climate change, economically, socially and environmentally, have been a bane on sustainable agricultural production and food security in SSA endangering the livelihood of two-thirds of the population who work within the agricultural sector. Agriculture in SSA continues to suffer from climate change due to temperature rising and rainfall frequency and intensity fluctuating (Mendelssohn et al., 2000). Climate change has negatively impacted on SSA countries because of their low human adaptive ability to foresee increases in tremendous events resulting from widespread poverty, heavy reliance on rain-fed agriculture, lack of economic and technological resources, insufficient safety nets and educational progress (Bako, 2013).

Adaptation is one major policy option for reducing the negative impact of climate change (Adger, 2003; Kurukulasuriya et al., 2006). However, the ability to identify a climate problem and respond to it appropriately depends upon awareness of the existence of the challenge. Due to this, SSA is predicted to be among the most vulnerable regions to climate change (IPCC, 2014), and because of the reliance on rainfall and other natural systems, smallholder rural households, who constitutes 65% of the total population in SSA (FAO, 2011) are the primary victims of climate change.

Notwithstanding the considerable importance devoted to investigating the determinants of adaptive capacity to climate change around the world (Smith & Pilifosova, 2001; Adger, 2003; Adger et al., 2004; Jones et al., 2010; Moser & Ekstrom, 2010; Jones & Boyd, 2011; Piya et al., 2012; Young et al., 2009; Barnett et al., 2013), the available empirical evidence on determinants of adaptive capacity among smallholder rural households has so far been on large scale and extremely disintegrated. Determinants of adaptive capacity among smallholder rural households are better assessed at the household level, since adaptive capacity can vary dramatically between households, individuals, communities, and places (Yaro, 2006), making larger-scale analyses misleading. Also, insufficient pragmatic evidence is available on the determinants of smallholder rural households' adaptive capacity to climate change in the Upper East Region of Ghana and the country at large.

To ensure a better understanding of smallholder rural households' vulnerability and adaptive capacity to climate change necessitate detail assessment of the factors that determines their adaptive capacity to climate change. This study aims to identify and evaluate the main factors that determine the adaptive capacity of smallholder rural households to climate change at the local-level and to provide a comprehensive understanding of the extent of vulnerability and adaptive capacity of households to climate change. The significance of this study is that its findings will assist in targeting appropriate district-specific climate change adaptation strategies to ameliorate the vulnerability of smallholder households to climate change risks in the Upper East

Region and Ghana at large. This would help to provide improved guidance on appropriate interventions to enhance the resilience of agriculture-dependent households and communities.

Adaptation to Climate Change: An Overview of Literature

Previous research (Adger, 2003; Adger et al., 2004; Jones et al., 2010) on adaptive capacity to climate change (the ability or capacity of a system to modify or change its characteristics or functions so as to cope better with existing or expected/predicted climate stresses (IPCC, 2014; Adger, 2003; Adger et al., 2004) demonstrates that "adaptive capacity" covers a multitude of factors and there is no universal consensus as to what these factors should be. Communities have inherent capacities to adapt to climate change. These capacities are bound up in the ability of societies to act collectively. Decisions on adaptation are made by individuals, groups, organizations and governments on behalf of the community (Adger et al., 2004; Jones et al., 2010). Adger et al. (2004) asserted that the capacity of individuals to adapt to climate change is a function of their access to resources, their ability to act collectively (denoted as social capital) in the face of the threats posed by climate change, the institutions for resource management and their effectiveness, efficiency and legitimacy. Social capital is made up of the networks and relationships between individuals and social groups that facilitate economic well-being and security. By social capital here are the set of networks, agreements, and flows of information. At its core the concept encapsulates 'features of social organization such as trust, norms and networks that can improve the efficiency of society by facilitating co-ordinate actions' (Adger, 2003; Adger et al., 2007). Piya et al. (2012) highlighted technological options, resources and their distribution, Institutions/decision making, education and human insecurity, social capital/property rights, access to risk spreading, information management, and attribution/significance as elements of adaptive capacity.

The 'local adaptive capacity' (LAC) framework, which was developed as part of the Africa Climate Change Resilience Alliance (ACCRA) programme by Jones et al. (2010) attempts to incorporate intangible and dynamic dimensions of adaptive capacity, as well as capitals and resource-based components, into an analysis of adaptive capacity at the local level. The LAC framework identified five distinct, yet interrelated determinants; the asset base, institutions and entitlements, knowledge and information, innovation, and flexible forward-looking decision-making that are conducive to adaptive capacity (Jones et al., 2010). These elements influence and determine the degree to which a community is resilient and responsive to changes in the external environment. Smith and Pilifosova (2001) are of the view that determinants of adaptive capacity concern

the economic, social, institutional, and technological circumstances that accelerate or constrain the development and deployment of adaptive measures.

Adger et al. (2007) identified five universal classifications of impediments to adaptation, they include financial, technological, cognitive, cultural, and institutional. Moser and Ekstrom (2010) enumerated communication and information. According to Moser and & Ekstrom (2010), and Jones and Boyd (2011), values, beliefs, and norms as well as physical and ecological factors have been recognized as impediments to adaptation. Others have precisely supported the notion that the ability of smallholder households to conquer risk is influenced by circumstances such as access to crop insurance (Panda et al., 2013), the availability of credit (Bryan et al., 2013), local government and market based institutions (Wang et al., 2013), property ownership (Below et al., 2012), and access to technical information about agricultural management and climate variability through agricultural extension services (Bryan et al., 2013). All these circumstances augment adaptive capacity. The adaptive capacity at any given point in time characterizes the extent to which a community will "automatically" adapt, and will be a function of the recognition of the need for adaptation, belief that adaptation is possible and desirable, willingness to undertake adaptation, availability of resources necessary for implementation of adaptation strategies, ability to deploy resources in an appropriate manner and the external constraints on, or obstacles to, the implementation of adaptation strategies (Adger et al., 2004).

In SSA, farmers strongly believe that the lack of access to information about climate and adaptation strategies, and access to affordable credit are the barriers to climate change adaptation (Jones & Boyd 2011). Other barriers to climate change adaptation identified by Jones and Boyd (2011) include high cost of adaptation and insecure property rights in most parts of SSA. According to Kurukulasuriya et al. (2006), adaptation measures are expensive and highly technical for rural farmers in SSA, and lack of information/ extension services regarding climate change are some of the challenges encountered by farmers in adapting to the effects of climate. Deressa et al. (2011) identified small size fragmented landholding, low literacy levels, inadequate knowledge of how to cope or build resilience, poor extension services on climate risk management, non-availability of drought tolerant varieties, timely lack of access to weather forecasting technology (and poor reliability of it) dependent on monsoon as constraints farmers in SSA encounter in adapting to climate change effects. Other constraints that have been identified are high cost of farm land, inherited and communal systems of land ownership, and non-availability and high cost of farm labour (Benhin, 2006; Deressa et al., 2011; Ifeany-Obi & Issa, 2013). In Ghana, Yaro (2006) revealed that age, sex, assets, family size, size and type of land, skills/education and perception of climate change are vital elements that determine the adoption of adaptation strategies.

Study Context and Methodology

The Study Area

The Bongo District lies within the Sudan savannah agro-ecological zone (Figure 1). The uni-modal rainfall pattern permits one main farming season, from May/June – September/October (Antwi-Agyei et al., 2013). The average annual rainfall is 800 – 1000 mm with a maximum temperature of 35°C and a mean monthly minimum temperature of 21°C (EPA-Ghana, 2003). The major economic activity is subsistence agriculture with about 90% of the total population (76,091) in the district dependent on rain-fed agriculture for their livelihoods (GSS, 2013). The major crops grown include sorghum (*Sorghum bicolar*), millet (*Pennisetum glaucum*), rice (*Oryza sativa*), groundnut (*Arachis hypogea*), guinea corn (*Sorghum vulgare*) and maize (*Zea mays*) (Antwi-Agyei et al., 2013). A study by Antwi-Agyei et al. (2013) shows that the Bongo District is the most susceptible to climate change and related extremes in the Upper East Region of Ghana. The area is also vulnerable to drought with high poverty rates and poor soil fertility (GSS, 2013).

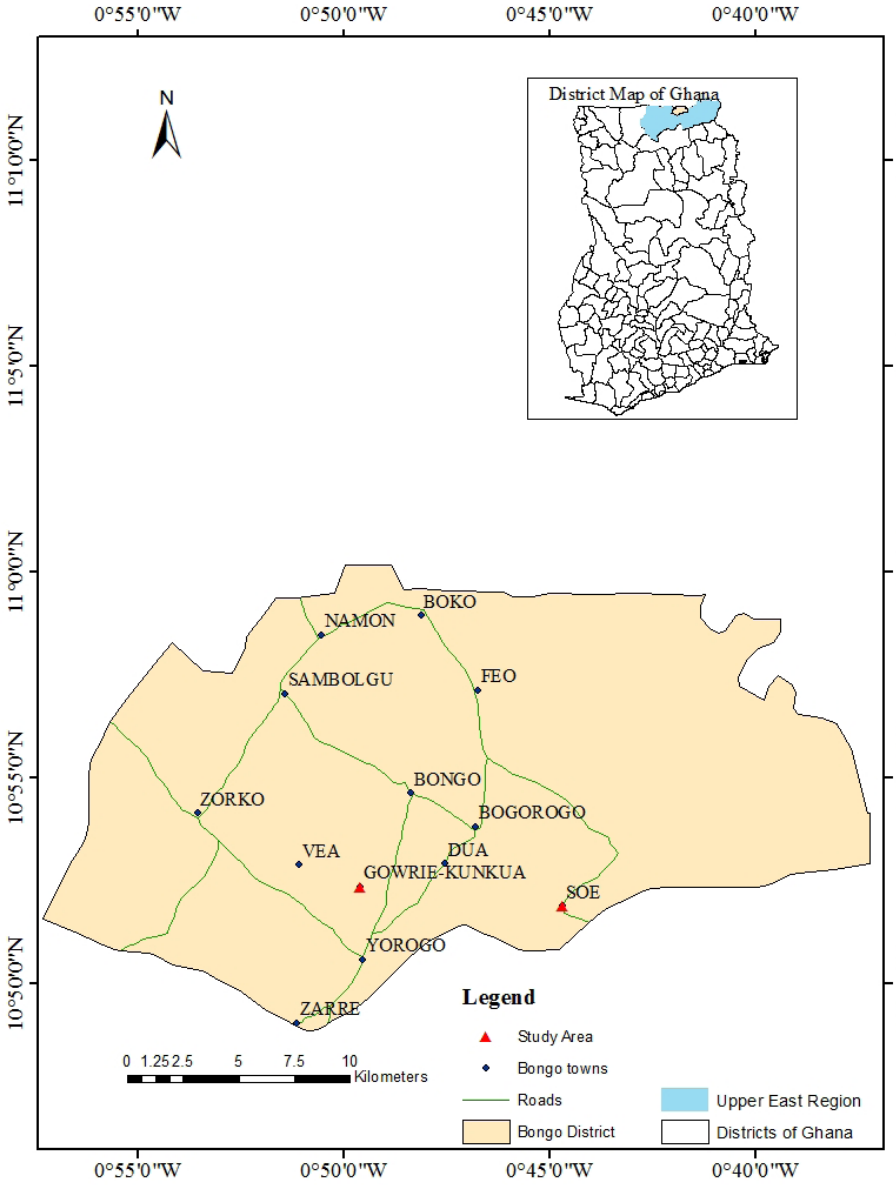

Figure 1: Map of the Bongo District showing the study communities

Data Collection

This study employed a mixed methods approach, which allows an integration of quantitative and qualitative approaches that facilitate the investigation of statistical

patterns of the determinants of households' adaptive capacity to climate change while, at the same time, capture the perspectives of stakeholders (key informants) on climate change adaptation (Stewart, 2007). The data used in this study were obtained from questionnaire survey of household heads, focus group discussions with selected farmers and key informant interviews. The focus group discussions were conducted to enable cross-fertilization of ideas by allowing participants to freely argue out issues. Two communities in the district (Gowrie Kunkua and Soe Kabre) were randomly selected for the study since all of them share similar socio-economic, agro-ecological and climatic characteristics.

The household survey involved selection of households within the sampled communities. A total of 150 households (95% confidence level and 5% margin of error) of an estimated 15,220 households (GSS, 2013) in the study area participated in the study. Buildings were randomly selected using building numbers to generate a random list of buildings in each community. Since the majority of buildings in the communities are multiple-occupancy, one household was selected for the survey. Respondents (household heads or their representatives) were then selected from each building based on availability and willingness to participate in the survey. A total of 150 semi-structured household questionnaires (75 questionnaires in each community) and six focus group discussions (three in each community) were undertaken in the two communities. To ensure triangulation of the key issues emerging from the household questionnaire, a total of 15 key informants were selected for detailed interviews into the issues raised at the focus group discussions. These key informants were selected based on their farming experience, indigenous knowledge and experience of climate change issues as revealed during the focus group discussions and household questionnaire survey.

Data Analysis

Data from the household survey were analyzed descriptively using frequencies and percentages. Logistic regression model (Wooldridge, 2006) was used to identify the determinants of adaptive capacity of smallholder rural households to climate change in the Bongo District. The probability of adopting adaptation strategies was expressed as:

$$P(Y_i = 1) = P_i = \frac{1}{1 + exp^{-z}} \quad \text{.....1}$$

This can be operationalized as,

$$\text{Logit } P(Y_i^*) = \beta_0 + \sum_{i=1}^{n} \beta_0 X_i + \varepsilon_i \quad \text{.....2}$$

$$\text{Logit } (Y_i^* = \text{Adopt} = 1) = \gamma' K + \varepsilon_i$$

Thus, the binary logit regression model is expressed as;

$$Y\ (Adopt = 1) = \beta_0 + \beta_1.\ sex_i + \beta_2.\ familySize_i + \beta_3.\ landSize_i + \beta_4.\ training_i + \beta_5.\ education_i + \beta_6.\ credit_i + \beta_7.\ climateInfo_i + \beta_8.\ farmingExperience_i + \beta_9.\ beliefSystem_i + \beta_{10}\ age_i + \beta_{11}\ memberOrg_i\ \varepsilon_i \quad \ldots\ldots 3$$

Y_i^* = a latent variable representing the propensity of a farm household i to adopt adaptation strategy (1 if farmer adopt, and 0 otherwise)

β_o = a constant term

X_i = K= the vector of farm households' assets endowments, household characteristics and location variable that influence the adoption decision (Set of variables explaining the adoption decision including respondent's perception on climate change, rainfall and exposure)

β_i = parameters to be estimated

Exp (β_i) indicates the odd ratio for a household having characteristics *i* versus not having *I*

ε_i = error term of the i^{th} farm households

i = 1, 2, 3 … n farm households.

Information obtained from the focus group discussions and key informant interviews were analyzed manually using content analysis. Manual method was employed because of the relatively small quantity of information involved. Content analysis refers to "a variety of techniques for making inferences by objectively and systematically identifying specified characteristics of messages" (Holsti, 1969:14). Topic coding was used to group the texts into various categories in accordance with the sub-themes of this study.

Results and Discussions

Decision on Adaptation Strategies

Smallholder rural households and communities in the Bongo District and the Upper East Region in general, employ several feasible strategies to reduce their vulnerability to climate change effects on their livelihoods. Coping or reactive mechanisms are the actual responses to negative impacts of climate change in the event of unwelcomed situations, and are considered as the short term responses. Smith and Pilifosova (2001) are of the view that autonomous or spontaneous adaptations are considered to be those

that take place, invariably in reactive response (after initial impacts are manifest) to climatic stimuli, whiles planned adaptations can be either reactive or anticipatory which are undertaken before impacts are apparent. In the Bongo District, every household employs reactive mechanisms when confronted with climate problems (e.g., food shortfall). However, not every household employs anticipatory or planned adaptations. In this study, households reported a diversity of adaptation strategies that included both modern and traditional methods. Those who implement adaptation strategies to climate change indicated different adaptation strategies (Figure 2). It was found that 40% of the sampled households in Gowrie Kunkua and 62.7% in Soe Kabre had implemented planned adaptation strategies to reduce the negative effects of climate change on their livelihoods whilst 60% in Gowrie Kunkua and 37.3% in Soe Kabre did not implement planned adaptation strategies. A chi-square test was performed and it is inferred that there is no significant association between implementing planned adaptation strategies in Gowrie Kunkua and Soe Kabre (X^2 [1, N = 150] = 7.712, p = 0.005). Pearson correlation (R = – 0.227) also show that there is a weak negative relationship between households implementing adaptation strategies in Gowrie Kunkua and Soe Kabre. This implies that changes in adaptation strategies in Gowrie Kunkua are not correlated with changes in adaptation strategies in Soe Kabre, as adaptation was high in Soe Kabre and low in Gowrie Kunkua.

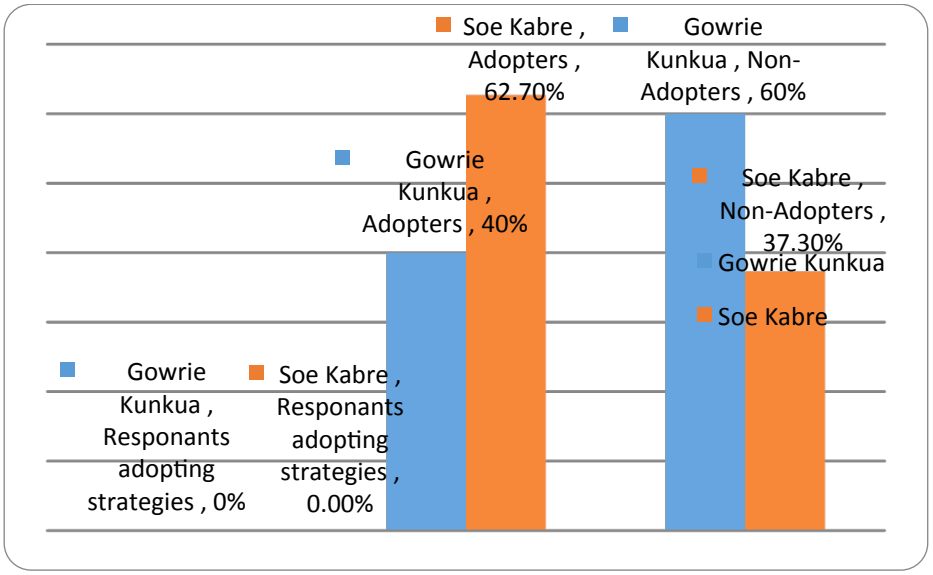

Figure 2: Adaptation of strategies by communities

Determinants of Household Adaptive Capacity

Adaptation to climate change and risks occur in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. This multifaceted blend of attributes determines the capacity of a household or society to adapt (Smit & Pilifosova, 2001). From this study, it is possible to identify the main features of smallholder households that seem to determine their adaptive capacity: age, sex, and education of household head; household size; farming experience; climate information; farm size; credit; belief system; membership of organization; and training. Previous studies (e.g Smith & Pilifosova, 2001; Adger, 2003; Adger et al., 2004; Jones et al., 2010; Moser & Ekstrom, 2010; Jones & Boyd, 2011; Piya et al., 2012; Young et al., 2009; Barnett et al., 2013; Yaro, 2006) have used similar variables in their characterization of determinants of adaptive capacity to climate change. The logistic regression model was used to establish the relationships between adaptive capacity and a set of predictor variables. The binary logistic regression model was selected because it can be used with continuous, discrete and dichotomous variables mixed together (Alemu, 2007). Eleven predictor variables were selected to explain the dependent variable (adaptive capacity). Out of the total predictor variables of 11, five were significant at 1%, 5% and 10% probability levels (Table 1). The omnibus test of the model coefficients has a chi-square value of 100.312 on 11 degrees of freedom, which is strongly significant at $p < 0.001$ indicating that the predictor variables selected have a high joint effect in predicting the status of household adaptive capacity. The predictive efficiency of the model showed that out of the 150 sampled households included in the model, 88.3% were correctly predicted. The sensitivity (correctly predicted adaptive capacity) and specificity (correctly predicted adaptive capacity) were found to be 86.3% and 87.3% respectively. The explained variation in the dependent variable based on the model ranges from 48.8% to 65.0%. The model explained 65% (Nagelkerke R^2) of the variations in adaptive capacity and correctly classified 87.3% of cases. The binary logistic regression results showed that education, belief system, farm size, farming experience and training were important determinants of adaptive capacity of households.

Table 1: Determinants of adaptive capacity

Predictor variable	Coeff (B)	S.E.	Wald	Sig	Odds ratio
Agehh	-0.299	0.390	0.586	0.444	0.742
Sexhh	0.385	0.566	0.462	0.496	1.471
Educationhh	0.424	0.168	6,398	0.011***	1.528
Belief systemhh	-0.472	0.238	3.940	0.024***	1.751
Farming experiencehh	0.770	0.413	3.473	0.022**	2.160
Climate infohh	1.361	2.165	0.395	0.530	3.900
Farm sizehh (resources)	0.418	0.305	1.886	0.010***	1.519
Credithh	-0.194	0.894	0.047	0.828	0.824
Family sizehh	0.111	0.194	0.327	0.568	1.117
Member of orghh	-2.336	1.605	2.116	0.146	0.097
Training	0.909	0.151	36.127	0.000***	2.482
Constant	-1.147	3.445	0.111	0.739	

Training is very important such that the more training a farmer receives, the more likely the household will adapt to climate change. As training increases by one unit, the odds of adapting increase by a factor of 2.482 which is significant (at $p < 0.005$). The regression result in this study shows strong relationship between training and household adaptive capacity significant (at $p < 0.001$). Keeping other variables constant, an increase in education of the household head by one unit, households' adaptive capacity increases by the odds ratio of 1.528. Farming experience of the household was found to be an important factor in households' adaptive capacity. As farming experience increases by one unit, the odd of a household adapting increase by a factor of 2.160, which is statistically significant (at $p < 0.05$). The result is consistent with previous studies which have reported similar results that education, farming experience, farm size, belief system and training has positively influenced households' adaptive capacity (Antwi-Agyei, 2012).

As regards farm size and being a member of an organization (CBO), it was found that farm size and belonging to a member of farmer organization increased the odds of adaptive capacity by factors of 1.519 and 0.097 respectively. However, contrary to the findings of this study, the regression result showed otherwise. Family size ($p = 0.568$), credit ($p = 0.828$), climate information ($p = 0.530$), sex ($p – 0.496$) and lastly age ($p = 0.444$) did not add significantly to the model. Forward stepwise (likelihood ratio) showed that the five most important variables training, education, belief system, farming experience and Farm size had explained 61% of the total variances in household adaptive capacity. The results also revealed that factors such as gender, age, education, family size, training, farming experience, farm size, member of an organization

and climate information of the household determines to some extent (although the degree to which each predictor determines the adaptive capacity varies) the choice of a particular climate adaptation strategy by a household (planned or autonomous). These results corroborate previous studies (e.g. Smith & Pilifosova, 2001; Deressa et al., 2009; Antwi-Agyei, 2012; Below et al., 2012; Bryan et al., 2013) that suggest that socioeconomic factors such as education and training, farming experience, farm size, resources, technology, infrastructure and skills could significantly influence a household's adaptive capacity. The following sections of the study discusses the predictors or factors such as education, belief system, training, farm size and farming experience.

Education of the Household Head

Education significantly determined adaptation strategies such as diversification of livelihoods, appropriate agronomic practices, indigenous knowledge, planting drought-tolerant varieties and planting various crops at different times ($p < 0.05$). Conversely, education did not significantly influence adaptation strategies such as changing planting time, reducing food consumption, governmental support and receiving assistance from family and friends. Smallholder rural households with relatively better formal education (i.e. secondary education and above) and training have a tendency to diversify their livelihood sources more than those without any formal education. Moreover, a larger number of the households without formal education testified reducing food consumption to cope with drought induced food and livelihood insecurity in contrast with households with secondary education or more. High education perhaps augment the income earning capacity of a household and its members thereby expanding adaptive capacity including the adoption of appropriate agronomic practices (AAP) and new agricultural technology, which can possibly decrease the total susceptibility of such farm households (Paavola, 2008). In this study, 78% of educated household heads implemented planned adaptations whiles 60% of uneducated households implemented planned adaptation strategies. Pearson R correlation shows a moderate correlation (coefficient of 0.523) between level of education and the decision to implement adaptation strategies, which is statistically significant at ($p < 0.01$). In addition, education, as confirmed by Antwi-Agyei (2012), can substantially influence migration because farmers who have at least secondary education are more probable to have alternative livelihood options and hence less prone to migrate to other parts of the country in search of work.

Farm Size

The landholding of a household (farm size) determines the adaptive capacity of a particular household via the choice of agro-forestry as an adaptation strategy ($p < 0.05$). The farm size of a household influences significantly the adaptive capacity to implement planned adaptation strategies such as planting different crops, AAP, indigenous

knowledge, planting drought tolerant crops, tree planting and agro-forestry. On the contrary, the farm size of a household did not influence significantly adaptive capacity of households in implementing adaptation strategies such as irrigation, reduction in food consumption, planting early maturing crop varieties and temporary migration. Responses from survey questionnaires and FGDs suggest that households with large size of farm lands are more likely to implement strategies such as soil conservation practices, terracing, contour bonds, stone/grass/mud bonds, fodder production whilst those who have smaller size of farm lands are likely to implement coping strategies such as applying fertilizer or manure when lands become infertile. For instance, the survey discovered that 65% of households that have farm sizes above 15 acres implemented planned adaptation strategies whiles 35% of those with farm holdings of less than 10 acres implemented planned adaptation. This finding supports studies suggesting that insecure land tenure systems and small landholding may hinder farmers from implementing planned and long-term adaptation strategies such as soil conservation techniques (Damnyag et al., 2012). Households with small farm holdings claimed that the costs of implementing some adaptation measures were high and hence not profitable to implement such strategies on small parcels of land. Households therefore choose to implement adaptation measures on a particular piece of land when the farm size is large. It was noted for instance that constructing contour bonds and stone/grass bond demands a lot of resources (including donkey carts). Households with small land sizes ignore planting trees and other agro-forestry practices because of limited land and trees planted will not yield immediate returns compared with the annual crops. Besides, trees forms canopy and crops usually do not do well when planted close to the trees. This has serious implications for adaptation to climate variability because land size in the study district restricts farmer's efforts at implementing appropriate adaptation strategies to mitigate the adverse effects of climate change. This finding is similar to the findings of Antwi-Agyei (2012).

Training and Skills

Households that successfully adapt to climate change recognize the need to adapt, have the requisite knowledge and skills about existing opportunities, have the ability to evaluate the opportunities and have the capacity to execute the apt opportunities. As training is offered to farmers/households about climate extremes and possible solutions, the weather hazards and extremes are better understood, hence households are in a better position to scrutinize, deliberate and execute adaptation measures hence increasing their adaptive capacity. This study highlights that fostering adaptive capacity entail a robust technical understanding of the problems, community involvement and development of solutions using both local and scientific knowledge and all these are attainable through training and capacity building for smallholder rural households.

This finding is consistent with Smith and Pilifosova (2001), who indicated that building adaptive capacity requires a strong unifying vision; scientific understanding of the problems, an openness to face challenges; pragmatism in developing solutions; community involvement; and commitment at the highest political level. Throughout the study, it was asserted that communities or households with higher levels of training exposure and human technical knowledge possess greater adaptive capacity than households or communities with lower amounts of training and technical knowledge. Lack of training on new improved farming methods perhaps is the result of the low adaptive capacity in Gowrie Kunkua. A key informant suggested that it is essential to ensure that communities and households have access to the dissemination of climate change and adaptation information for discussions, innovations and sharing of adaptation strategies at various levels. In this regard, in Gowrie Kunkua an NGO (SUFAEP) has established a Farmer Field School (model farm) for training of farmers on AAP, improved indigenous farming methods (soil conservation and management, contour bonding and terracing, fodder production, and alley cropping. Farmers from nearby communities are allowed to visit the Farmer Filed School for training and this has helped improve their yields. Pearson R correlation shows a strong positive correlation (coefficient of 0.723) between training and the decision to implement adaptation strategies (statistically significant at $p < 0.001$).

Lack of training implies possible non-adoption of improved/new technologies and this has the potential to seriously impede a communities' potential to implement adaptation options by limiting the range of possible responses. Adaptive capacity is likely to vary, depending on availability and access to training (new technologies) at various levels. Many of the adaptation strategies identified as viable in the management of climate change directly or indirectly involve technology (e.g., contour identification and stone/grass bonding, animal treatment, grain storage and preservation, composting, fodder production, crop residue management, dry season gardening). Therefore, a community's or household's access to training reflected in levels of learned technology and the ability to innovate technologies are significant determinants of adaptive capacity. In line with this assertion, Smith and Pilifosova (2001) confirm this by noting that openness to the development and utilization of new technologies is key to strengthening adaptive capacity.

Farming Experience

This study measured farming experience by the age of the household head and the number of years the household head has been engaged in farming. There is an indication that there are more experienced farm households in the resilient community than the vulnerable community. Farming experience of the household was found to be an important determinant of household adaptive capacity (statistically significant at $p <$

0.05). As farming experience increases by one unit, the odd ratio of a household adapting increases by a factor of 2.160. The minimum age of the sampled household heads was 34 and the maximum was 116. The results showed that living longer years were higher in Soe Kabre than Gowrie Kunkua. The study affirmed that the higher the age of a household head, the better the chances of reducing vulnerability hence becoming high income. This is attributed to the fact that such households have gained considerable farming experiences. The research findings further revealed a positive relationship (at $p < 0.001$) with a bivariate correlation between number of years engaged in farming (farming experience) of the household, and adaptive capacity. Young and female headed households were more exposed to vulnerability and livelihood insecurity since such households lack adequate farming experiences.

The study demonstrates that the farming experience of households was not statistically significant at influencing the choice of adaptation strategies such as planting late or early, dry season farming, planting various crops, relying on family and friends, temporary migration, assistance from government agencies and NGOs. Conversely, the farming experience of the household head was significant in determining the choice of adaptation strategies such as using indigenous knowledge, AAP and planting drought resistant crops (statistically significant at $p < 0.05$). The results reveal that more households that were headed by relatively younger farmers (i.e. 34 – 50 years) reported using chemical fertilizers to increase yields whilst households above 60 years extensively used indigenous agronomic practices. This could be attributed to the fact that older farmers were more inclined to use traditional methods and crop varieties handed to them by their ancestors, which they are used to, compared with improved varieties that may have been modified, even if they are high yielding and drought-tolerant.

Belief Systems

Adaptive capacity of households or communities was significantly influenced by their belief systems (belief about climate change). For instance, the belief system of a particular household influences their adaptation strategies such as planting drought resistant crop varieties, use of indigenous knowledge, livelihood diversification and general appropriate agronomic practices (statistically significant at $p < 0.05$). Contrary, the belief system of a particular household or community did not significantly determine adaptation strategies such as reducing food consumption, buying food, migration to work elsewhere, receiving assistance from family and friends, government agencies and NGO support (statistically significant at $p < 0.05$). The findings revealed that households who believed (perceived) climate change as being caused by human/anthropogenic factors such as bush burning and deforestation usually implement planned adaptation strategies to strengthen their resilience. The results further

illustrate those households that belief in climate change are more likely to diversify their livelihoods, plant trees and employ improved agronomic practices contrary to those who do not belief in the occurrence of climate change. It must, however, be noted that factors such as accessibility to alternative livelihoods options, access to education and training of the household, justifies the disparities in adaptive capacity between climate change believers and non-believers since these factors play a critical role in shaping the belief system. Menapace et al. (2014) also observed significant correlation between farmers' belief about the reality of climate change, concerns (risk perceptions) and their willingness to adapt or to carry adaptation/mitigation course of action. In this study, 51.7% of smallholder rural households that perceived changes in rainfall pattern implemented adaptation/coping strategies whilst 48.3% who perceived changes in rainfall pattern did not adopt or implement adaptation strategies. This is in conformity with the social representation theory (Moloney et al., 2014), which argues that "behavior is not causally related to beliefs. Rather, beliefs and behavior coexist as part of a system of meaning used to understand an issue".

Farmers' perceptions or belief of climate change are increasingly being used in climate change and adaptation studies (see Maddison, 2007; Mertz et al., 2009). This is because farmers' perceptions or belief based on their past experience and future expectations may influence the type of adaptation strategy used as a response to climate problems (Maddison, 2007). It has been suggested that farmers are more likely to adapt to climate change if they can perceive the changes in the climate (Maddison, 2007). Therefore, it is essential that these perceptions are noted in a study such as this that seeks to explore the determinants of adaptation pathways of smallholder households to climate change. Climate change adaptation entails first, that, the farmers should become aware that the climate has altered, understand the dynamic causes of climate change and, thereafter, recognize valuable adaptation strategies and execute these strategies to lower the harmful/damaging impact of climate change.

The study revealed that households' who believe (perceive climate change has been caused by human/anthropogenic factors such as bush burning and deforestation usually implement *planned adaptation* strategies to strengthen their resilience whilst households that belief climate variability is caused by the spiritual world (unexplained) mostly do not implement planned adaptation and rely on rituals and pouring of libation to the '*gods*' to avert the calamity. Close to 30% of the households who associate climate change to cultural factors, such as the will of the '*gods*' (unexplained), shedding innocent blood (killing people), sexual intercourse on farm lands, abortion, and disrespect for life forces (sacred groves, shrines, the earth priest and ancestors did not adopt or implement adaptation strategies. Majority (62.7%) of those who implemented adaptation measures associate climate change to anthropogenic factors such as bush burning, deforestation

and emission of fossil fuels. This finding is consistent with Antwi-Agyei (2012) study, where 58.02% of climate variability believers asserted that climate variability are as a result of anthropogenic reasons adopted to it.

Conclusion

This study adopted a mixed method approach to identify and examine the adaptive capacity of smallholder rural households to climate change. It has provided a comprehensive understanding of the extent of vulnerability and adaptive capacity of households to climate change. The study contends that climate change poses a number of challenges to the livelihoods of rural households in the Bongo district, which has one of the highest poverty levels in the country. In this district, droughts and floods have resulted in land degradation, soil erosion, soil infertility, and reduced seeding area with serious consequences, including reduced access to livelihoods insecurity. Within these constraints, it is important to enhance households' adaptive capacity to cope. This study has, therefore, identified five important variables – training, education of household heads, belief systems, farming experience, and farm size – as significant in determining adaptive capacity of smallholder rural households. Logistic regression model was used to identify the determinants of adaptive capacity of smallholder rural households to climate change. The findings is consistent with previous studies which have reported similar results that education, farming experience, land size, and training have positively influenced households' adaptive capacity. Previous studies, however, failed to recognize the belief system of a household/community as a significant determinant of adaptation to climate variability. In addition to the belief system of a particular household there are mediating/intervening factors, such as resources, technology, government policies and institutional support from government agencies and NGOs, which influence, to a large extent, the adaptation or mal-adaptation of households to climate variability.

This study highlights that fostering adaptive capacity entails a robust technical understanding of the problems posed by climate change, community involvement and development of solutions using both local and scientific knowledge and all these are attainable through training and capacity building for smallholder households. The study argues that households' belief systems (perception of climate change) determine their adaptive capacity. As argued by the social representation theory, behavior is not causally related to beliefs rather, beliefs and behavior coexist as part of the system of meaning used to understand an issue. As such, farmers who view climate change as caused by the breaking of taboos, '*gods*' or 'spirits' do not implement planned adaptation strategies. The conclusion can be drawn that in attempting to support households' adaptation strategies to climate change, considerable attention should be paid to understanding

socio-economic factors, including education and belief systems, in order to develop sustainable strategies that will be culturally accepted by households and communities.

References

Adebayor, A.A. (2012). Evidence of climate change in Taraba State: a preliminary report. A Paper Presented at the Faculty of Science Seminar Series held at the Lecture Hall on 13th September, 2012. Taraba State University, Jalingo, Nigeria.

Adger, W.N. (2003). Social aspects of adaptive capacity. In J.B. Smith, R.J.T. Klein and S. Huq (Eds.), *Climate change, adaptive capacity and development*, pp. 29-49. London: Imperial College Press.

Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme, M. (2004) Adaptation to climate change in the developing world. *Progress in Development Studies*, 3 (3), pp. 179-195.

Adger, W.N., Smith, J.B. and Takahashi, K. (2007). Assessment of adaptation practices, options, constraints and capacity. In M.L.Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hansn (Eds.), Climate change: impacts, adaptation and vulnerability: Contribution of Working Gropu II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 718-743. Cambridge: Cambridge University Press.

Alemu, S. (2007). Determinants of food insecurity in rural households in Tehuldre Woreda, South Wollo of the Amhara Region. Dissertation, Addis Ababa University, Ethiopia.

Antwi-Agyei, P. (2012). *Vulnerability and adaptation of Ghana's food production systems and rural livelihoods to climate variability*. Leeds: School of Earth and Environment, University of Leeds.

Antwi-Agyei, P., Andrew, J., Dougill, A.J., Lindsay, C. and Stringer, L.C. (2013). Barriers to climate change adaptation in sub-Saharan Africa: evidence from northeast Ghana and systematic literature review. Sustainability Research Institute Paper No. 52. Leeds: Centre for Climate Change Economics and Policy, University of Leeds.

Barnett, J., Waters, E., Pendergast, S. and Puleston, A. (2013). Barriers to adaptation to sea level rise. Melbourne: National Climate Change Adaptation Research Facility, Gold Coast.

Below, T.B., Mutabazi, K.D., Kirschke, D., Franke, C., Sieber, S., Siebert, R. and Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change*, 22, pp. 223-235.

Benhin, J.K.A. (2006). Climate change and South African agriculture: impacts and adaptation options. CEEPA Discussion Paper No. 21. Pretoria, South Africa: CEEPA, University of Pretoria.

Boko, M., Niang, I., Nyong, A., Vodel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, B. and Yanda, P. (2007). Africa climate change 2007: impacts, adaptation and vulnerability. In M. Parry, O. Canziani, J. Palutikof, P. van der Linde and C. Hanson (Eds.), Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 433–467. Cambridge: Cambridge University Press.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. and Herrero, M. (2013). Adapting agriculture to climate change in Kenya: household strategies and determinants. *Journal of Environmental Management*, 114, pp. 26-35.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, R., Jones, R., Kolli, R.K., Kwon, W. and Laprise, R. (2007). Regional climate projections: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Damnyag, L., Saastamoinen, O., Appiah, M. and Pappinen, A. (2012). Role of tenure insecurity in deforestation in Ghana's high forest zone. *Forest Policy and Economics*, 14 (1), pp. 90-98.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. and Yusuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 1, pp. 248-255.

Deressa, T.T., Hassan, R.M., Ringer, C., Alemu, T. and Yesuf, M. (2011). Perception of adaptation to climate change by farmers in the Nile Basin of Ethiopia. *Journal of Agricultural Science*, 149, pp. 23-31.

EPA-Ghana (2003). National action programme to combat drought and desertification. Accra, Ghana: Environmental Protection Agency.

FAO (2011). The role of women in agriculture. ESA Working Paper No. 11-02. Rome: Agricultural Development Economics Division of the Food and Agriculture Organization of the United Nations.

Ghana Statistical Service (2013). *2010 Population and housing census, Ghana. National Analytical Report*. Accra, Ghana: Ghana Statistical Service.

Holsti, O.R. (1969). Content analysis for the social sciences and humanities. Reading, UK: Addison-Wesley.

Ifeanyi-Obi, C.C., Issa, F.O. (2013). Barriers faced by cassava farmers in adapting to climate change in Oron agricultural zone of Akwa Ibom State. *IORS Journal of Agriculture and Veterinary Science*, 4 (6), pp. 19-26.

International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (2009). Sub-Saharan Africa (SSA) report: agriculture at the crossroads. Washington, D.C.: IAASTD.

IPCC (2014). Climate change 2014: impacts, adaptation and vulnerability. Summary for policy makers. Cambridge: Cambridge University Press.

Jones, L. and Boyd, E. (2011). Exploring social barriers to adaptation: insights from western Nepal. *Global Environmental Change*, 21 (4), pp. 1262-1274.

Kurukulasuriya, P., Mendelsohn, R., Hassan, R., Benhin, J., Deressa, T., Diop, M., Mohamed, E.H., Yerfi, K.F., Gbetibouo, G., Jain, S., Mahamadou, A., Mano, R., Kabubo-Mariara, J., El-Marsafawy, S., Molua, E., Ouda, S., Ouedraogo, M., Se´ne, I., Maddison, D., Niggol, S.S. and Dinar, A. (2006). Will African agriculture survive climate change? *The World Bank Economic Review*, 20 (3), pp. 367-388.

Livingston, G., Schonberger, S. and Delaney, S. (2011). Sub-Saharan Africa: the state of smallholders in agriculture. Paper presented at the IFAD Conference on New Directions for Smallholder Agriculture, 24-25 January, 2011. Rome: International Fund for Agricultural Development.

Maddison, D. (2007). The perception of adaptation to climate variability in Africa. CEEPA Discussion Paper No. 10. Center for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

Menapace, L., Colson, G. and Raffaelli, R. (2014). Farmers' climate change risk perceptions: an application of the exchangeability method. Paper prepared for presentation at the EAAE 2014 Congress on 'Agri-Food and Rural Innovations for Healthier Societies', August 26 to 29, 2014, Ljubljana, Slovenia.

Mendelsohn, R., Morrison, W., Schlesinger, M.E., Andronova, N.G. (2000). Country-specific market impacts of climate change. *Climate Change*, 45, pp. 553-569.

Mertz, O., Halsnæs, K., Olesen, J. and Rasmussen, K. (2009). Adaptation to climate change in developing countries. *Environmental Management*, 43 (5), pp. 743-752.

Moloney, G.Z., Leviston, T., Lynam, J., Price, S., Stone, J. and Blair, D. (2014) Using social representations theory to make sense of climate change: what scientists and nonscientists in Australia think. *Ecology and Society*, 19 (3), pp. 19.

Moser, S.C. and Ekstrom, J.A. (2010). A framework to diagnose barriers to climate change adaptation. Proceedings of the National Academy of Science, 107 (51), pp. 22026-22031.

Paavola, J. (2008). Livelihoods, vulnerability and adaptation to climate variability in Morogoro, Tanzania. *Environmental Science and Policy*, 11, pp. 642–654.

Panda, A., Sharma, U., Ninan, K.N. and Patt, A. (2013). Adaptive capacity contributing to improved agricultural productivity at the household level: empirical findings highlighting the importance of crop insurance. *Global Environmental Change*, 23 (4), pp. 782-790.

Piya, L., Maharjan, K.L. and Joshi, N.P. (2012). Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. *Regional Environmental Change*, 13 (2), pp. 437-447.

Schlenker, W. and Lobell, D.B. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters,* 5 (1), pp. 1-8.

Sissoko, K., van Keulen, H., Verhagen, J., Tekken, V. and Battaglini, A. (2011). Agriculture, livelihoods and climate change in the West African Sahel. *Regional Environmental Change*, 11(1), pp. 119-125.

Smith, B. and Pilifosova, O. (2001). Adaptation to climate change in the context of sustainable development and equity. In J.J. Mccarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (Eds.), Climate change 2001: impacts, adaptation and vulnerability, pp. 877-912. Cambridge: Cambridge University Press.

Stewart, R.M. (2007). Community perspectives of flood risk and social vulnerability reduction: the case of the Red River Basin. Dissertation, University of Manitoba, Winnipeg, Canada

Wang, X.J., Zhang, S., Shahid, E., Amgad, R., He, Z.B. and Mahtab, A. (2013). Water resources management strategy for adaptation to droughts in China. *Mitigation and Adaptation Strategies for Global Change*, 17, pp. 923–937.

Wooldridge, J. M. (2006). Introduction to Econometrics: A Modern Approach. Third Edition. South-Western Cengage Learning, Mason, USA.

World Bank (2010). Economics of adaptation to climate change: social synthesis report. Washington, D.C.: The World Bank.

Yaro, J.A. (2006). Is deagrarianisation real? A study of livelihood activities in rural northern Ghana. *Journal of Modern African Studies*, 44 (1), pp. 125-156.

Young, G., Zavala, H., Wandel, J., Smit, B., Salas, S., Jimenez, E. and Fiebig, M. (2009). Vulnerability and adaptation in a dryland community of the Elqui Valley, Chile. *Climate Change*, 98 (1-2), pp. 245-276.