Research Article

Clifford James Fagariba*, Shaoxian Song, Serge Kévin Gildas Soule Baoro

Climate change in Upper East Region of Ghana; challenges existing in farming practices and new mitigation policies

<https://doi.org/10.1515/opag-2018-0057>

received March 20, 2018; accepted October 3, 2018

Abstract: Countries and international organizations are making conscious effort to address climate change threat to humanity. Rising fossil fuel burning and land use changes to meet human demands continuously emit large quantities of greenhouse gases into the atmosphere thus causing climate change. The research used Talensi District as a case study to determine factors influencing farmers' adaptation response and the actual practices used to avert climate change impact. A total of 225 small-scale farmers were sampled for survey and 100 key informants were used in focus group discussions. Utilizing the logistic regression model, the study indicated that education, transportation, inputs cost and extension services were the factors with high tendency of undermining farmers' ability to adapt to climate change. In addition, Weighted Average Index used to measure weather extremes revealed that drought and temperature had the highest level of occurrence. Climate change adaptation practices assessed in the study showed that change in planting date, improved crops varieties and land rotation were the most preferred practices. The study concluded that farmers resilience could be enhanced if governments and concerned organizations intensify adaptation campaigns, increase access to weather information, and train farmers on adaptable practices including, timely planting and alternative sources of livelihood. In addition, intensifying government support for agriculture including input subsidies, and provision of irrigation facilities were also good interventions to improve climate change resilience.

Keywords: agriculture, climate change, adaptation practices, constraints, weather extremes

1 Introduction

National and international organizations are now making a determined effort to address the threat to humanity posed by climate change. Climate change refers to a change in average weather conditions or in the time variation and severity of weather events. This climate change is blamed both on increased consumption of fossil fuels and land use changes to meet a growing human population. Studies have shown that unsustainable exploitation of natural resources, especially in developing countries for economic growth, has profoundly advanced global warming, and caused weather extremes, health issues, poor yield and extinctions (McNeeley et al. 2012; Kithiia et al. 2011); the cause being increasing emission of greenhouse gases such as carbon dioxide (CO₂); methane (CH₄) and nitrogen dioxide (N₂O) into the Earth's atmosphere and these all trap the sun's heat in the atmosphere increasing global warming. Global warming has contributed to the heat stress, high temperature, frequent droughts and dry spells facing many countries today. In addition to increases in average global temperature (global warming); we are now seeing changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover. Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 parts per million to 379 parts per million in 2005, and the average global temperature rose by 0.74°C (Acquah 2011; Laube et al. 2012). An increasing rate of warming has particularly taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years (IPCC, 2007). Other IPCC reports give detailed projections for the 21st century and show that climate change will continue and even accelerate. Best estimates indicate that climate change

*Corresponding author: Clifford James Fagariba, School of Resources and Environmental Engineering, Wuhan University of Technology, Wuhan-Hubei Province, China, E-mail: cfagariba@yahoo.com

Shaoxian Song, Hubei Key Laboratory of Mineral Resources Processing and Environment, Wuhan University of Technology, Luoshi Road 122, Wuhan, Hubei, 430070, China

Serge Kévin Gildas Soule Baoro, School of Resources and Environmental Engineering, Wuhan University of Technology, Wuhan-Hubei Province, China

would warm the Earth by 3°C by 2100 (UN, 2007). Even if countries reduce their greenhouse gas emissions now, the Earth will continue to warm. Predictions have indicated that by 2100 global average temperature will increase from a minimum of 1.8°C to as much as 4°C (UNFCCC, 2007a). Such temperature increases will likely increase rates of extinction in many habitats and species by as much as 30% with a 2°C rise in temperature (IPCC, 2007). As a result of climate change, the type, frequency and intensity of extreme weather events, such as tropical cyclones (including hurricanes and typhoons), floods and droughts are expected to rise. Changes in some types of extreme events have already been observed, in for example, the frequency and intensity of heat waves and heavy precipitation events (Meehl et al. 2007). Research from Africa has also shown that climate change worsens drought and dry spell issues in most part of the continent hence threatening food security and poverty alleviation. (Boyd et al. 2013). Other research suggested that Africa's vast arable land is a great potential for economic growth if agricultural policies efficiently address climate change threat (Sissoko et al. 2011; Lobell et al. 2011). About 90% of African countries depend directly or indirectly on agriculture for employment, poverty alleviation and economic growth (Mabe et al. 2014). Related findings indicate that individual African governments piecemeal approach to climate change policies have reduced food security to the extent that countries within Sudan and the Sahel Region are likely to face severe famine and poverty by 2035 (Antwi-Agyei et al. 2013). In view of the fact that much of Sub-Saharan Africa has a similar climate, it is considered central to the fight against climate change that there should be formation of a regional climate change networking system to share ideas and research findings.

Ghana, being one of these Sub-Saharan African countries whose economic backbone is agriculture, needs to address climate change constraints holistically by bringing on board all stakeholders to tackle agriculture promotion. There is established empirical evidence that Ghana's agriculture sector is dwindling as a result of poor technical advice to the farmers and inadequate government support to tackle constraints brought about by global warming (Mabe et al. 2014; Acquah 2011). Similar research by Armah et al. (2010) established that the true impact of global warming experienced in Ghana is particularly acute in the farming communities of the savanna areas of Northern Ghana. Agriculture in Ghana is predominantly small scale with most of the farms comprising less than 2 hectares due to the high

cost of inputs and inadequate government support. A study by Stutly (2010) indicated that subsistence farmers are highly susceptible to climate change as a result of their low income and the lack of any alternative source of employment. Northern Ghana is noted for producing staple grains such as maize, millet, guinea corn and rice because its climatic conditions favour such crops. However, in recent times, unfavorable climatic conditions have exposed farms to severe drought, high temperature, and diseases. This compelled many farmers in the area to adapt by either migrating South for dubious employment opportunities or changing long-established planting practices from early April to late June to avoid drought or other unforeseen threats. Studies have proven that changing the planting period in areas with poor rainfall has affected maturity and yield of certain kinds of unimproved cereals especially maize and rice which is slow to reach maturity (Yengoh et al. 2010).

There are many constraints contributing to a farmer's ability to adapt his strategies prudently to reduce the impact of climate change on agriculture. A better understanding of how these constraints influence farmers' choices of adaptation strategy would enable researchers to suggest valid scientific measures of adaptation.

Coping with climate change will entail changes at every level from community to national and even international (Fagariba et al. 2018). Communities must build their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate uncertainty. Local coping strategies and traditional knowledge need to be used in synergy with government and local interventions with the choice depending on national circumstances. To enable workable and effective adaptation measures, ministries and governments, as well as institutions and non-government organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making

With regards to the above insight on adaptation strategy and the impact of climate change on agriculture in Ghana, the present research sought to assess factors influencing farmers' choice of adaptation strategies. The study also aimed at determining adaptation practices suitable for addressing constraints of climate change. The research would also look out for weather extremes affecting crop and livestock production in the study area. The study also attempted suitable interventions that could help address climate change issues.

2 Methodology

2.1 Study area

Talensi district is located in Upper East Region of Ghana with Tongo as the district capital. It shares a border with Bolgatanga Municipal, Mamprusi, Kassena- Nankana, Bawku West, and Nabdram districts. The District lies between 10° 32' and 10° 48' North of the equator and longitude 0° 56' and 0° 40' West of the Greenwich Meridian and comprises a total landmass of about 840km². The topography of the district is characterized by rocks and hilly land with gentle slopes and a few lowland areas. The soil is mainly clayey, sandy and shallow due to the rocky nature of the area. The soil fertility is poor, with low organic matter content. The clayey soil coupled with the sloping nature of the area causes erosion during heavy rainfall when the very fertile low-lying areas are mostly flooded.

The vegetation is Guinea Savannah woodland consisting of sparse short deciduous trees and tall savanna grasses. Trees of economic importance commonly include

sheanuts, dawadawa, baobab, and acacia. The area has dry and rainy seasons with unimodal rainfall starting from early June to late September with a dry season from October to May. The mean annual rainfall is 95mm but mostly between 88 -110mm (GSS, 2014). Annual mean temperature is between 29° to 38° Celsius with a maximum temperature of 45°C at the peak of the dry season around January to May. The total population of the district according to the updated report of Ghana Statistical Service 2014 is 81,986 with the sex ratio of 50.3% and 49.7% M/F. The district has a high rural population (84.1% compared to just 15.9% urban). This implies the majority of the indigenes live rurally with farming and livestock rearing as their source of food and employment.

About half of the population (41,648) is aged between 15 and 65 Ghana Statistical Service (GSS, 2014). Of these, 31,645 of the population aged between 15 and 65 engage in agriculture as a source of employment the majority of these being males. Below is the method used to determine the farmers' survey sample size.

Formula:

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

Figure 1: Map of Talensi District. Source: www.ghanamap.com

Where n =sample size, N =sample frame (31,645) and α represented the margin of error which is 0.05 with a confidence level of 95%. By substituting 31,645 and 0.05 into the formula: $n=399$.

Out of this 399 farmer sample size 230 respondents were targeted and 225 farmers responded in the survey. With the help of Agriculture Extension Agents (AEAs) 10 communities were randomly selected and 25 farmers from each of these communities were randomly selected to take part in an interview with the aid of semi-structured questionnaires. Furthermore, Focus Group Discussion (FGDs) were also organized separately for 100 key informants comprising officials from the District Assembly, MOFA, EPA, FC and FBOs (Farmer Based Organizations) to ascertain the constraints to adapting to global warming and those strategies which farmers put to use.

The participatory rural appraisal was initially used to access the geographical features and settlements in the study area so as to determine the best approach in reaching respondents (Chambers 1994). Five field officers needed to be trained and supervised in data collection due to the dispersed nature of settlements in the district. The period for data collecting was between February and June 2017. The data collected were analyzed with version 25 of the SPSS software and illustrated as tables to give a clear view of respondents' opinions. A logic-regression model was used to determine the factors influencing adaptation and was also analyzed with SPSS. A Weighted Average Index was also used to analyze farmer's climate-change adaptation strategy, adaptation constraints, and weather extremes (Uddin et al. 2014). Weighted Average Index (WAI) analyses had been used in previous studies in Nepal to evaluate farmers' climate change adaptation strategy and were proven to be efficient and user-friendly (Bryan et al. 2009).

WAI was used in this study to analyze the impacts of climate change on variables such as crops, weather extremes, and adaptation strategies. Climate change adaptation strategies used by farmers such as agroforestry practice, use of drought-resistant crops, use of fertilizer, farmyard manure/mulching, planting season variation, irrigation and use of fertilizer were also ranked on the scale of 0-4 (0-not efficient, 1- less efficient, 2- efficient, 3- most efficient). Weather extremes were also placed on the scale of 0-2 (0- low, 1- moderate, 2- high). A different scale was used in the ranking of variables due to the nature of the questions asked and the responses obtained when the questionnaire was pre-tested before the survey was carried out. The different scale used in ranking was to help obtain a diverse response. WAI of the respondents' variables using the formula below;

$$WAI = \frac{FV0W0 + FV1W1 + FV2W2 + FV3W3 + FV4W4}{FV0 + FV1 + FV3 + FV4} \quad \text{equation 1}$$

$$WAI = \frac{\sum FViWi}{\sum FVi} \quad \text{equation 2}$$

Where W = weight of each respondents variable on the scale, Fv = frequency of variables, i = response on the scale (e.g. $i = 0$ = poor, 1 = good, 2 = very good)

2.2 Model of the Research

2.2.1 Multiple logistic regression model

Logistic (logic) regression analysis is widely used for data analysis and is similar to the linear regression analysis except that its outcome is dichotomous (e.g. Yes/no, low/high or true/false). Logic regression is used for determining the odds of a particular event outcome. It was used in the present study to determine factors having the possibility of influencing a farmer's choice of climate change adaptation. Goldberg et al. (2006) using logical regression to determine the likelihood of breast cancer susceptibility among some groups of women. This implies that the logic regression model is able to predict the likelihood of the occurrence of an event. The outcome in logistic regression analysis is often coded as 0 or 1, where 1 implies that the outcome of a finding is true and 0 indicates that the outcome of the finding is false. If P in the equation is the probability that an outcome is 1, the logic regression model can be expressed as:

$$P = \text{Prob}(Y_i=1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ki})}} = \frac{e^{\beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ki}}}{1 + e^{\beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ki}}} \quad \text{eqn 1}$$

$$\text{Similarly } P_i = \text{Prob}(Y_i=0) = 1 - \text{Prob}(Y_i=1) = \frac{1}{1 + e^{\beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ki}}} \quad \text{eqn 2}$$

Divide equation 1 by 2

$$\frac{\text{Prob}(Y_i=1)}{\text{Prob}(Y_i=0)} = \frac{P_i}{1 - P_i} = e^{(\beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ki})} \quad \text{eqn 3}$$

Where P_i is the probability that Y takes the value 1 and then $(1-P_i)$ is the probability that Y is 0 and e the exponential constant.

P is the expected probability that an outcome has the potential of being true or false. X_{1i} , X_{2i} , X_{3i} up to X_k are independent variables which predict P outcome; β_0 , β_1 , β_2 up to β_k are regression coefficients of the independent variables. To predict the odd outcome of an event with

known characteristic, substitute applicable values into the independent variables and take the log of the expected outcome of the odds express as:

$$\frac{P_i}{1 - P_i} = e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}$$

From the model equation, P_i represents the probability of adaptation to climate change and $(1-P_i)$ represents the probability of non-adaptation.

The questionnaire used to elicit information from respondents and focus groups (FGDs) is indicated in table 1 below. The collected information was analyzed with SPSS, Logic regression model and WAI.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and Discussion

3.1 Determinants of climate change adaptation response

A farmer's approach to adapting to climate change is mostly underpinned by socio-cultural issues, economic policies, and technological challenges. Previous research has indicated that biophysical, economic and social factors contribute immensely in determining farmers response to climate change adaptation (Laube et al. 2012; Miyan 2014). As indicated in table 2 we have assessed various factors influencing a farmer's response to impact of climate change in the study area. The study showed that with a coefficient of 1.025, home to farm distance as

Table 1: Definition of variables used to elicit information in the study area (N=225), FGDs (N=100)

Variables	How variables were coded
*Factors influencing adaptation	Independent variables
Gender	1= male , 2=female
education	1= literate , 2=illiterate
Age	1= 30 yrs and younger, 2= 31-40yrs, 3=41-50yrs, 4=51-60yrs, 5=61 and above
Extension Services	1=yes, 2=yes , 3= not sure
Household size	1=1-5, 2= 6-10, 3=above 10
Access to weather information	1= good, 2= poor access, 3= no access
Farming income	1= good, 2= poor access, 3= no access
Alternative livelihood	1=yes, 2= no , 3= not sure
High temperature and low rainfall	1=increasing, 2=decreasing, 3= moderate, 4= can't tell
Input cost	1= high, 2= low, 3= moderate, 4= don't know
Farm distance	1=Yes, 2=no, 3= not sure
**Nature of weather extremes	
Drought	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
Dry spell	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
High temperature	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
Flood	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
Strong wind	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
Stale air	1= Very Frequent, 2= Frequent, 3= Not frequent, 4= Not sure
***Adaptation practices	
Drought resistant crops	Very good, Good, Somewhat good, Not sure, Not good
Agroforestry	Very good, Good, Somewhat good, Not sure, Not good
Irrigation	Very good, Good, Somewhat good, Not sure, Not good
Inorganic fertilizer	Very good, Good, Somewhat good, Not sure, Not good
Different farming systems	Very good, Good, Somewhat good, Not sure, Not good
Land rotation	Very good, Good, Somewhat good, Not sure, Not good
Crop diversification	Very good, Good, Somewhat good, Not sure, Not good

*Factors influencing adaptation, * weather extremes, **constraints, ***adaptation strategies questionnaire for FGDs (officers from MOFA, EPA, District Assembly, NGOs and FBOs)

the highest tendency of triggering a timely response by the farmer to climate change so as to avoid unforeseen consequences. In the course of the survey, it came to light that farmers tend to be more conscientious if their farms are located near their homes than those further away. The researchers' observations made during the survey showed that farms close to the farmer's settlement receive the needed daily attention because farmers spend much time on those farms. Related studies comparing the same sized farm with the same labor-force but on distant farms compared to nearby farms revealed that nearness of farms to settlement encourages conscientiousness and effective working hours than compared to farms located far from the settlement (Tiwari et al. 2014).

The study showed importance of a farmer's income (coefficient of 0.938) giving a high probability of influencing the farmers ability or incentive to adapt to climate change. Further inquiry revealed that farmers with higher disposable income could easily engage labor, as well as use new technology including use of fertilizers, improved seeds and modern implements to minimize impact of climate change (Nielson et al. 2010). Education had a coefficient of 0.86 and suggested that farmers with education have a higher tendency of understanding the consequences of climate change impact on agriculture and livelihood than farmers who have little if any formal education. This implies that education enhances farmers' knowledge and skills to predict the likelihood of climate variation impact on their farms and to intercede with appropriate countermeasures to prevent crop failure.

Farmers with formal education have more enthusiasm to look out for effective strategies or technologies to militate against unfavorable climatic condition (Dhakal et al. 2016). A back-up livelihood gave a coefficient of 0.814 which was perceived as a factor with high possibility of influencing farmers to adopt countermeasures in curbing climate impact on both land ecology and farming. Discussion with the farmers suggested that other sources of generating income aside farming put farmers in a better position to respond to climatic threats against crop yield. This suggests that any alternative source of income generating activity including beekeeping, livestock rearing, and trading improves a farmer's climate change resilience. Government Extension service (with a coefficient of 0.606) was perceived as a factor capable of influencing farmers adaptation to climate variations to enhance improve yield. Extension officers help build farmers capacity and knowledge of modern technology as well as updating them with weather information to enhance adaptation and reduce their vulnerability (Ford et al. 2011; Uddin et al. 2014). The study revealed that input costs (0.516) also have a high probability of influencing adaptation decisions of farmers. The high cost of inputs such as fertilizers, herbicides, pesticides and tractor services could affect farmers' responses to climate change (Debile 2014). On the other hand, low input costs tend to compel farmers to adapt as effectively and cheaply as possible (Adger et al. 2012). High temperature and low rainfall could influence farmers' willingness to adopt measures to avert uncertainties which could

Table 2: Determinants of climate change adaptation barriers. (N=225)

variables	coefficient	Standard error	P value
constant	1.115	.341	0.001
Age	-0.47	0.62	.453
Education	0.86*	0.93	.003
Extension services	0.606*	.098	0.002
Gender	-.30	0.90	.740
Farming income	0.938*	.088	.000
Household size	0.200	.053	.000
Access to weather information	0.428*	.134	.009
Alternative livelihood	0.814*	.102	.000
Cost of inputs	0.516*	.108	.000
High temperature and low rainfall	0.473*	.106	.000
Farm distance	1.025*	.136	.000

Source: Field survey 2017.

*represent a significant level of 5%.

hamper farm yield. The logit analyses also indicated that access to weather information (0.428) was perceived as a factor with the significant possibility of influencing farmers to take prompt climate change adaptation action. According to researchers, access to weather information enables farmers to plan ahead of the farming season to avoid weather extremes such as flood, high temperature, drought and dry spell (Feola et al. 2015). Discussions with the farmers suggested that regular access to weather information reduces their susceptibility to climate change impact. Age and Gender had a negative coefficient and were thus perceived as factors with no tendency of influencing farmers' adaptability to climate change. This is contrary to research by Dasgupta et al. (2010) which suggested that energetic youth are proactive in adopting labor-intensive measures efficient in sustainable environmental management than older farmers. Gender was not considered an issue owing to the fact that most of the farms are family owned hence husband, wives, and children work on the same family farm. Household size was not perceived as a sensitive factor capable of influencing adaptation because according to the farmers, the topography of the area does not support mechanized farming. Therefore the larger the household, the larger the labor size and vice-versa for a smaller household.

3.2 Weather Extremes

Climate change has worsened weather conditions to the extent of increasing the occurrence of natural disasters. This is supported by information gathered from the farmers and data from Ministry of Food and Agriculture. The study as indicated in table 3 established that High temperature (WAI-1.6) mostly affects crops, livestock, and human lives in the study area. Previous studies reported that Northern Ghana is prone to Cerebral spinal meningitis (CSM) due to poorly ventilated structures coupled with the excessive heat and dry air in the dry season (Armah et al. 2010; Samuel et al. 2014). The dry season, spanning November to May in Northern Ghana exposes the area's inhabitants, especially children, to CSM. The extensive system of livestock rearing in this area where the animals are free-range, expose them to adverse weather conditions subsequently affecting feeding, reproduction, and health. Our own personal observations and interactions with some farmers also showed that high environmental temperature increases water loss from plants and soil through evapotranspiration. Scorching and drying of leaves as a result of high temperature compels farmers to prune the branches and leaves from crops to reduce

evapotranspiration. Drought (WAI-1.5) is one weather extreme with a high tendency to affect crop yield. Among the staple foods notably affected by droughts were maize, millet, guinea corn and groundnuts. Interactions with the farmers suggested that the loose, dry nature of the local soils causes many seedlings to be blown or washed away during heavy rains and strong winds. A dry spell (WAI-1.4) as illustrated in table 3 was also seen as a hindrance to good yield. According to the respondents, a prolonged dry spell which mostly often affects crop maturity and fruit bearing. Discussions with the farmers hinted that dry spell during a fruit-bearing stage or tasseling stage eventually affect yield. Research findings by (Calzadilla et al. 2014) revealed that fertilizer application during a dry spell hinders proper leaching of fertilizer nutrients to the subsoil for good nutrient absorption. This condition eventually increases costs as more solid fertilizer would be needed for a good yield. The research further showed that flood (WAI-1.2) is not common in the study area. This accounted for a low ranking of flood among the common weather extremes in the study area.

3.3 Factors influencing climate change adaptation

Farmers' cooperatives arise when more than one individual effort is needed to achieve aimed objectives (Barham et al. 2009). Most farmers in Africa have long history of carrying out farm activities as cooperatives due to constraints on speed and efficiency due to rudimentary tools and labour intensive agricultural practices (Mabe et al. 2014). Cooperative group formation (WAI- 2.3) was assessed as a factor which highly influenced farmers' adaptation strategies. The farmers were of the opinion that group formation promotes cohesion among farmers and encourages sharing adaptation ideas, skills and farm experience. Similar studies have established that farmer based organization (FBOs) promote reciprocal labour, common interest and shared responsibilities to support farmers during activities such as planting, harvesting, transportation and fertilizer application (Challinor et al. 2007) . Access to a road (WAI-12) was also considered a factor with high possibility of influencing adaptation. The study revealed that easy access to roads enhanced farming in secluded communities through ease of transport of their inputs such as fertilizers and bulky manures to farms. In addition, other studies established that access to roads is of the essence in harvesting, handling and transporting of commodities and highly perishable crops to storage facility to avoid post-harvest losses (Biesbroek et al. 2013).

Table 3: Weather Extremes in the study area.

Variables	Evaluation of responses				Rank
	Low	moderate	high	WAI	
High Temperature	4	94	130	1.6	1
Drought	26	52	147	1.5	2
Dry Spell	26	78	121	1.4	3
flood	50	58	117	1.2	4

Source: field survey 2017

Table 4: Factors influencing climate change adaptation

variables	Evaluation of responses				WAI	Rank
	Not efficient	Less efficient	efficient	Most efficient		
Extension services	11	20	48	146	2.6	1
Access to weather info	17	37	81	90	2.4	2
Group formation	13	12	122	78	2.3	3
Access to road	13	31	72	98	2.2	4
Access to phones	16	14	103	92	2.14	5
Farm insurance	15	36	83	91	2.13	6
Input subsidies	12	29	122	62	2.04	7
Capacity building	21	35	105	64	1.94	8
Access to market	8	47	133	37	1.9	9
Superstitious beliefs	10	145	43	27	1.4	10

Source : field survey 2017

Furthermore, the farmers were of the view that access to roads enabled them to travel far to clear new areas for farming to allow old land fertility to improve during a fallow period. This implies access to road could promote land rotation, a good climate adaptation strategy.

Access to phones (WAI- 2.3) was also assessed as important in influencing farmers to adapt to climate change. Farmers with mobile phones easily share weather, marketing information, notifications of disease outbreaks and other relevant information from the Agricultural Extension Agents (AEAs). Farm insurance (WAI- 2.13) was also realised as a good incentive with a high tendency of allowing farmers to adapt to climate change so as to improve their livelihood. Discussions with the farmers revealed that farmers would feel more secure to when try different adaptation measures if they had the assurance that in the event of any crop failure they are covered by insurance. This implies farm insurance would empower farmers to risk trying different adaptation strategies until they find the most suitable one. Cost of inputs mostly affect cost of farming and subsequently prices of farm commodities (Kahsay et al. 2016). The study revealed that input subsidies (WAI-2. 04) have the possibility of motivating farmers to adapt to climate change. The

farmers were of the view that low-cost inputs would enhance adaptation strategies involving use of farm inputs such as fertilizer, weedicides, insecticides and tractor services. Capacity building (WAI-1.94) was as seen as a good intervention in helping farmers to acquire skill and adequate knowledge in climate change mitigation strategies. The study indicated that most of the farmers had no formal education hence lack modern farming skills and technology. Interactions with the farmers hinted that capacity building would broaden their knowledge and equip them with suitable adaptation skills to face the challenges of climate change. Access to market (WAI-1.91) was perceived by some farmers as relevant in climate change adaptation. The farmers were of course aware that easy access to market can enhance their being able to market fresh vegetables and crops and minimize post-harvest losses. Access to market could also help farmers venture into another trade to create an alternative source of income to avoid being over-dependent on the farm. The study showed that access to market would promote easy access to those farm inputs required for timely planting of crops to avoid drought, dry spell and other uncertainty. Superstitious beliefs (WAI-1.4) were considered the least factor influencing climate change adaptation though most

of the farmers are traditionalist and believe in deities and ancestral spirits. Interactions and personal observations indicated that while most farmers believe climate change is as a result of human activities and population growth, others associate climate variation to wrath of ancestral spirits. The low rank implies few farmers perceive superstitious beliefs as factors influencing farmers' decision to adapt to climate change.

3.4 Climate change adaptation practices

An adaptation strategy involves developing and using different methods to make people and the environment less susceptible to climate variation impact. Impact of climate change on the ecosystem cannot be underestimated as it has been manifested through natural disasters, drought, high temperature, erratic rain and constant changes in humidity (Mertz et al. 2009). The assessment of adaptation practices suitable for improving living standard in the study area suggested numerous adaptation strategies as shown in table 5. Focus group discussion comprising FBOs, government officials (EPA, MOFA, FC) and NGOs indicated that access to an alternative livelihood (WAI-2.6) was seen as the best adaptation strategy suitable for improving livelihoods of the farmers. Discussions with FBOs indicated that alternative livelihood such as beekeeping, dry season gardening, handicraft, and trading has good potential for improving the livelihood of the farmers. The study indicated that mountainous nature of the area serves as good potential for quarry and tourism industry to create jobs. The researchers noticed that the small sections of the mountains currently used for tourism do not attract many tourists due to poor capacity of the private sector and individuals to develop good infrastructure and facilities for tourism. Mulching (WAI-2) was also seen suitable for improving soil moisture and preventing seedlings from heat stress. According to Ochieng et al. (2016) research has shown that mulching improves the soil structure, soil organisms, root penetration, soil aeration, water retention capacity and reduces evapotranspiration. Other studies have also indicated that aside from improving fertility, mulching has lower cost and is therefore a low cost, low risk input. It follows then that in the case of any partial or total crop failure in the wake of weather extremes, poor farmers would not be much indebted (Owusu-Sekyere et al. 2011). Afforestation (WAI-2.31) as indicated in table 5 was perceived as a long-term adaptation strategy with potential for improving micro-climate of the area as well as soil fertility. Discussion with the farmers suggested that trees could serve as windbreaks, reduce erosion and

provide shelter for crops grown in the alleys between trees. Research has shown that afforestation serves as a good potential for carbon sequestration, biomass conservation, soil and endangered species protection (Mustapha et al. 2012). Changes to the traditional planting date (WAI-2.24) has a high chance of reducing the impact of weather extremes such as drought affecting soil moisture, fertility, microorganism activities and crop growth. The focus group discussions further indicated that using improved crop varieties (WAI- 2.23) would promote crop resilience to harsh weather conditions prevailing in the area. Observation of the farms and soils in the study area showed that many years of continuous farming on the same piece of land without consistent re-fertilization have rendered the soil extremely infertile, therefore using improved crop varieties as a mitigation strategy could significantly improve yield compared to the unimproved seeds used over the years. Improved seeds can reduce the risk of crop failure, improve productivity, eradicate hunger, improve drought resistance and minimize pest and disease infestation. Other studies reveal that improved crops increase productivity per unit acre of land to bridge the gap between food security and population growth (Armah et al. 2010; Westra et al. 2013).

Use of fertilizer/ compost (WAI- 2.20) was perceived as a strategy which can significantly improve yield and soil fertility. However, according to the FBOs, top soils rich in added nutrients are easily washed away during heavy rains as a result of study area topography. The high purchase price of Nitrogen fertilizer coupled with subsequent emissions of N_2O to the environment do not augur well for using inorganic fertilizer as an adaptation practice (Oyekale et al. 2012). Furthermore, heavy use of chemicals such as pesticides and inorganic fertilizers destroy the ecosystem and threaten human health (Brown et al. 2007; Etwire et al. 2013). Nevertheless, other research indicated that difficulties in gathering scattered droppings as a result of the extensive system of livestock rearing in Africa coupled with challenges of transporting bulky animal droppings to distant farms make use of organic fertilizer an unreliable adaptation strategy for large hectares of land (Sutcliffe et al. 2016). Other research findings have established that use of crop residues on the farm as compost could help improve soil fertility at a lower cost than animal droppings and nitrogen fertilizer (Ford et al. 2011).

Crop diversification (WAI-1.94) was perceived to be a good strategy to improve farmers' income and livelihood. The study indicated that introduction of new crops other than the staple crops commonly cultivated in the area could help farmers to obtain a good yield.

Crop diversification reduces build up of weeds, and pests and disease infestation that would otherwise occur in a monoculture. Diversification also enhances utilization of nutrients in different layers of the soil (Bommarco et al. 2013). Accordingly, crop diversification helps leguminous crops to reduce erosion, soil water evaporation, improve biodiversity conservation and soil temperature. Agroforestry (WAI- 1.92) ranked 9th was seen as a strategy with potential for improving soil fertility, improving microclimate and preventing direct sunlight impact on crops. In addition, agroforestry provides woodlot, fresh fruits and foliage for livestock in the dry season. Land rotation (WAI-1.90) as a climate adaptation strategy was assessed as a viable practice that could allow infertile lands to fallow for some years to regain fertility. On the contrary, clearing virgin and conserved areas for agriculture to meet growing demand for food negatively affects the environment and create repercussions for humanity (Debile 2013). Further deliberation in the course of the discussions showed that rate of population growth in the district would create land tenure issues in the future, hence land rotation was not encouraged as a good adaptation practice. Assessment of livestock rearing (WAI-1.8) as an adaptation strategy showed good prospects in transforming lives of poor farmers whose crop yields are severely challenged as a result of poor soil fertility and the high cost of farm inputs. The study showed that availability of pasture and foliage for grazing could help in livestock production if farmers diversify into the livestock sector. Empirical studies have indicated that government policies to strengthen and develop capacity of livestock farmers, including incentives and livestock adaptation research would create a favorable platform for using livestock as an adaptation strategy (Krätli 2008)

3.5 Farmers actual Climate adaptation practices in the Area

Adaptation practices should be pragmatic and capable of improving farmers' resilience and reducing vulnerability to climate variation (Miyan 2015). The study outputs shown in figure 6 indicate those adaptation practices commonly used by the farmers in addressing the impact of climate change as well as improving yield. Among the adaptation practices used by farmers; altered planting date (19%) is mostly used by the farmers in the area as the irregular rainfall pattern often creates drought. In the course of the field survey, it was noticed that due to poor access to weather information farmers mostly rely on their farm experience in predicting when the rains are likely to come and prepare their land and inputs accordingly before the rain starts. The research also showed that farmers mostly prefer improved crop varieties (17%) which are resistant to drought, diseases and pests, even though most of the improved seeds are expensive and not easily accessible. The survey indicated that most of the farmers living in abject poverty buy few improved seeds and mix with their own stored seeds to reduce cost as well as avoid complete crop failure. Mixed cropping (15%) was also commonly seen as an adaptation practice in the study area. The farmers were of the view that mixed cropping reduces weed invasion and drought impact. Information gathered from the farmers indicated that using leguminous crops together with cereals such as maize, millet, guinea corn and sorghum improves soil nutrient and moisture content. Other studies have indicated that unlike mono-cropping, which does not support efficient utilization of soil nutrient due to the same depth of root, mixed cropping enhances utilization of soil nutrients located in different layers of

Table 5: Assessment of perceived best climate change adaptation practices

variables	Evaluation of Responses					Rank
	Not efficient	Less efficient	efficient	More efficient	WAI	
Alternative livelihood	1	6	46	69	2.6	1
mulching	5	3	42	72	2.5	2
afforestation	2	1	77	42	2.31	3
Change in planting date	2	13	61	46	2.24	4
Improved short season varieties	5	10	59	48	2.23	5
Use of fertilizer/compost	5	13	56	48	2.20	6
Crop diversification	4	22	73	23	1.94	7
agroforestry	5	1	15	101	1.92	8
Land rotation	7	27	64	24	1.90	9
Livestock rearing	12	14	74	22	1.8	10

Source: field survey 2017

the soil profile (Bommarco et al. 2013). In addition, mixed cropping reduces the risk of pest and disease spread due to the inherent resistance within a mixed crop compared to a monoculture. The study revealed that 13% of the respondents engaged in economic activities such as weaving, petty trading, local beer brewing (pito) and hunting in the dry season to earn additional income so as to meet family needs. The study also indicated that some of the rural dwellers migrate down south during the dry season to engage in temporal jobs such as trading and other labor-intensive jobs for additional income.

Accordingly, land rotation (11%) was used by farmers who have no money to regularly purchase fertilizers and other necessary inputs to improve their land fertility. The respondents showed that most farmers abandoned old infertile lands and travelled miles away from their homes to clear virgin lands in order to adapt to climate change. However some of the farmers indicated that lack of access to roads and or transport makes farming further away from home tedious. Most of the farmers perceived land rotation as a suitable adaptation practice because they do not incur much cost to improve yield. The research also indicated that some of the farmers perceive using fertilizer (10%) and livestock rearing (6%) as good adaptation practices that can improve their living condition. Farmers were of the opinion that vast grassland areas coupled with crop residue feed supplements were potentially good for livestock rearing though sometimes the dry nature of pastures and crop residues affected livestock intake. The research showed that irrigation (9%) was also one of

the good practices gaining attention in the area. Most of the farmers use watering cans to irrigate their vegetable gardens planted near dam sites to the crop then supplied their family with fresh vegetables whilst they could sell the surplus for income. Observation and interactions with the farmers indicated that farmers who engage in this style of irrigation produce crops throughout the year and hence obtain additional income and food to supplement yield during the off farming season.

4 Conclusion and Recommendations

The study indicated that farmers with some level of formal education have a stronger capacity and resilience to climate change vulnerability than uneducated farmers. Encouraging the youth engaged in agriculture to seek formal education could serve them well in terms of future prospect and unpredicted climate change threats. Extension services are useful and help make farmers proactive to climate change adaptation.. This can be achieved if the current disparity in numbers of available AEA and farmers is addressed to improve the farmer-AEA ratio. Among weather extremes assessed, drought and high temperature were the commonest. Farmers are vulnerable because of poor access to weather information. Variation in planting season adopted by farmers to mitigate weather extremes affects cropping season and prices of most needed foodstuffs on the market. The

Figure 2: adaptation practices in the study area. Source: field survey 2017

adverse effect of weather extremes could be minimized if farmers' access to weather information is improved.

Formation of cooperative groups creates the opportunity for sharing labor, skills, technology and other intelligence in relation to climate change and to enhance preparedness for adaptation. Adaptation strategies such as timely planting and other labor-intensive farm practices could be enhanced if cooperatives are encouraged. Poor road network coupled with lack of transportation in rural areas affects regular farm visits and time spent per day on the farm. Therefore access to a good road network and means of transport would boost regular farm visits and daily work output to tackle adaptation strategies more rigorously than at present. As farmers in the study are classified as poor farmers due to their income level and living standards, incentives in the form of farm insurance, input subsidies, and capacity building would enhance farmers' security and willingness to adopt mitigation measures that would increase their self-reliance and reduce vulnerability to climate change. Using mobile phones as means of communication is one of the most convenient and fastest ways of information dissemination. Provision of a good telecommunication network in rural areas would enhance rapid sharing of farm and weather information, also outbreak of diseases and new adaptation technology. Therefore the use of phones would reduce communication barriers among rural farmer to enhance resilience to climate change.

Lack of alternative sources of livelihood increases rural farmers' susceptibility to climate change effects. The study indicated that drought, heat and low rainfall affect yield and food security in the study area. Alternative livelihood such as beekeeping, handicraft, irrigation for dry season gardening would reduce reliance on rain-fed agriculture for food security and poverty alleviation. An educational campaign on the use of adaptation strategies including crop diversification, improve seeds, agroforestry, and changed planting season could save farmers from total crop failure. Climate change campaigns without subsidizing new input costs and loans access may not put farmers in the position to acquire needed inputs for adaptation. Availability of grasses and fodder in the study area good potential for farmers to easily combine livestock and crop production to improve livelihood. In the event of seasonal crops failure due to extreme weather conditions, farmers could rely on livestock for income and food.

The researchers' detected possible limitation of certain adaptation practices used by the farmers hence recommended that further research to test the actual viability of the adaptation practices used would be relevant

so as to incorporate them into national and international agriculture policies and farming systems.

Conflict of interest: Authors declare no conflict of interest.

References

- Acquah H.D., Farmers' perception and adaptation to climate change: a willingness to pay analysis, *J. Sust. Dev. Africa*, 2011, 13, 150-161
- Adger W.N., Barnett J., Brown K., Marshall N., O'brien K., Cultural dimensions of climate change impacts and adaptation, *Nat. Clim. Change*, 2012, 3, 112-117
- Antwi-Agyei P., Fraser E.D.G., Dougill A.J., Stringer L.C., Simelton E., Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data, *Appl. Geogr.*, 2012, 32, 324-334
- Armah F.A., Odoi J.O., Yengoh G.T., Obiri S., Yawson D.O., Afrifa E.K.A., Food security and climate change in drought-sensitive savanna zones of Ghana, *Mitig. Adapt. Strat. Gl.*, 2010, 16, 291-306
- Barham J., Chitemi C., Collective action initiatives to improve marketing performance: Lessons from farmer groups in Tanzania, *Food Policy*, 2009, 34, 53-59
- Biesbroek G.R., Klostermann J.E., Termeer C.J., Kabat P., On the nature of barriers to climate change adaptation, *Reg. Environ. Change.*, 2013, 13, 1119-1129
- Bommarco R., Kleijn D., Potts S.G., Ecological intensification: harnessing ecosystem services for food security, *Trends Ecol. Evol.*, 2013, 28, 230-238
- Boyd E., Eornforth R.J., Lamb P.J., Tarhule A., Brouder A., Building resilience to face a recurring environmental crisis in African Sahel, *Nat. Clim. Change*, 2013, 3, 631-637
- Bryan E., Deressa T.T., Gbetibouo G.A., Ringler C., Adaptation to climate change in Ethiopia and South Africa: options and constraints, *Environ. Sci. Policy*, 2009, 12, 413-426
- Calzadilla A., Zhu T., Rehdanz K., Tol R.S.J., Ringler C., Climate change and agriculture: Impacts and adaptation options in South Africa, *Water Resour. Econ.*, 2014, 5, 24-48
- Challinor A., Wheeler T., Garforth C., Craufurd P., Kas-sam A., Assessing the vulnerability of food crop systems in Africa to climate change, *Clim. Change*, 2007, 83, 381-399
- Chambers R., The origins and practice of participatory rural appraisal, *World Dev.*, 1994, 22, 953-969
- Dasgupta A., Baschieri A., Vulnerability to climate change in rural Ghana: mainstreaming climate change in poverty reduction strategies, *J. Int. Dev.*, 2010, 22, 803-820
- Derbile E.K., Reducing Vulnerability of Rain-fed Agriculture to Drought through Indigenous Knowledge Systems in North-eastern Ghana, *Int. J. Clim. Chang. Strateg. Manag.*, 2013, 5, 71-94
- Dhakal S., Sedhain G.K., Climate Change Impact and Adaptation Practices in Agriculture: A Case Study of Rautahat District, Nepal, *Climate*, 2016, 4, 63
- Etwire P.M., Al-hassan R.M., Kuwornu J.K.M., Osei-Owusu Y., Application of Livelihood Vulnerability Index in Assessing

- Vulnerability and Climate Change in Northern Ghana, *J. Environ. Earth Sci.*, 2013, 3, 157-170
- Fagariba C.J., Song S., Serge K.G.S., Baoro., Climate Change Adaptation Strategies and Constraints in Northern Ghana: Evidence of Farmers in Sissala West District, *Sustainability*, 2018, 10, 1484
- Feola G., Lerner A.M., Jain M., Montefrio M.J.F., Nicholas K.A., Researching farmer behaviour in climate change adaptation and sustainable agriculture: Lessons learned from five case studies, *J. Rural Stud.*, 2015, 39, 74-84
- Ford J.D., Berrang-Ford L., Paterson J., A systematic review of observed climate change adaptation in developed nations, *Clim. Change*, 2011, 106, 327-336
- Fosu-Mensah B.Y., Vlek P.L.G., MacCarthy D.S., Farmers' perceptions and adaptation to climate change: a case study of Sekyere dumase district in Ghana, *Environ. Develop. Sustainability*, 2012, 14, 495-505
- Goldberg J.I., Borgen P.I., Breast cancer susceptibility testing: Past, present and future, *Expert Rev. Anticancer Ther.*, 2006, 6, 1205-1214
- IPCC, Fourth Assessment Report, Intergovernmental Panel on Climate Change Secretariat, Geneva, 2007
- Kahsay G.A., Hansen L.G., The effect of climate change and adaptation policy on agricultural production in Eastern Africa, *Ecol. Econ.*, 2016, 121, 54-64
- Kithia J., Climate change risk responses in East African cities: need, barriers and opportunities, *Curr. Opin. Env. Sust.*, 2011, 3, 176-180
- Krätli S., Cattle Breeding, Complexity and Mobility in a Structurally Unpredictable Environment: The Wodaabe Herders of Niger, *Nomadic Peoples*, 2008, 12, 11-41
- Kusakari Y., Asubonteng K.O., Jasaw G.S., Dayour F., Dzivenu T., Lolig V., et al., Farmer-perceived effects of climate change on livelihoods in Wa West District, Upper West region of Ghana, *J. Disast. Res.*, 2014, 9, 516-528
- Laube W., Schraven B., Awo M., Smallholder adaptation to climate change: dynamics and limits in northern Ghana, *Clim. Change*, 2012, 111, 753-774
- Lobell D.B., Bänziger M., Magorokosho C., Vivek B., Nonlinear heat effects on African maize as evidenced by historical yield trials, *Nat. Clim. Change*, 2011, 1, 42-45
- Mabe F.N., Gifty S., Samuel D., Determinants of choice of climate change adaptation strategies in northern Ghana, *Res. Appl. Econ.*, 2014, 6, 75-94
- McNeeley S.M., Examining barriers and opportunities for sustainable adaptation to climate change in Interior Alaska, *Clim. Change*, 2012, 111, 835-857
- Miyan M.A., Droughts in Asian least developed countries: Vulnerability and sustainability, *Weather Clim. Extrem.*, 2015, 7, 8-23
- Mubaya C.P., Njuki J., Liwenga E., Mutsvangwa E.P., Mugabe F.T., Perceived Impacts of Climate-Related Parameters on Smallholder Farmers in Zambia and Zimbabwe, *J. Sust. Dev. Africa*, 2010, 12, 170-186
- Mustapha S.B., Sanda A.H., Shehu H., Farmers' Perception of Climate Change in Central Agricultural Zone of Borno State, Nigeria, *J. Environ. Earth Sci.*, 2012, 2, 21-28
- Nielsen J.O., Reenberg A., Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso, *Global Environ. Change*, 2010, 20, 142-152
- Nyantakyi-Frimpong H., Bezner-Kerr R., The relative importance of climate change in the context of multiple stressors in semi-arid Ghana, *Global Environ. Change*, 2015, 32, 40-56
- Ochieng J., Kirimi L., Mathenge M., Effects of climate variability and change on agricultural production: The case of small-scale farmers in Kenya, *Journal of Life Science*, 2016, 77, 71-78
- Owusu-Sekyere J.D., Alhassan M., Nyarko B.K., Assessment of Climate Shift and Crop Yields in the Cape Coast Area in the Central Region of Ghana, *ARPN J. Agric. Biol. Sci.*, 2011, 6, 49-54
- Oyekale A.S., Oladele O.I., Determinants of climate change adaptation among cocoa farmers in southwest Nigeria, *J. Eng. Appl. Sci.*, 2012, 2, 154-168
- Peterson C., 2013. Fast-growing groundnuts keep Ghana's farmers afloat amid climate shifts. Available from: <http://www.trust.org/item/20130709095148-pwiz0/?source=hpblogs>. [Accessed 16th August 2016].
- Shrestha A.B., Bajracharya S.R., Sharma A.R., Duo C., Kulkarni A., Observed trends and changes in daily temperature and precipitation extremes over the Koshi river basin 1975-2010, *Int. J. Climatol.*, 2017, 37, 1066-1083
- Sissoko K., Van Keulen H., Verhagen J., Tekken V., Battaglini A., Agriculture, livelihoods and climate change in the West African Sahel, *Reg. Environ. Change*, 2011, 11, 119-125
- Samuel N.A.C., Vivian A.N., Climate Change and Cerebrospinal Meningitis in the Ghanaian Meningitis Belt, *Int. J. Environ. Res. Public Health*, 2013, 11, 6923-6939
- Sutcliffe C., Dougill A.J., Quinn C.H., Evidence and perceptions of rainfall change in Malawi: Do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa?, *Reg. Environ. Change*, 2016, 16, 1215-1224
- Thomas D.S.G., Twyman C., Osbahr H., Hewitson B., Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa, *Clim. Change*, 2007, 83, 301-322
- Tiwari K.T., Rayamajhi S., Pokharel R.K., Balla M.K., Determinants of the climate change adaptation in rural farming in Nepal Himalaya, *Int. J. Multidiscip. Curr. Res.*, 2014, 2, 2321-3124
- Uddin M.N., Bokelmann W., Entsminger J.S., Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: a farm level study in Bangladesh, *Climate*, 2014, 2, 223-241
- UN, The Millennium Development Goals Report, United Nations, New York, 2007
- UNFCCC, Vulnerability and adaptation to climate change in small island developing states – Background paper for the expert meeting on adaptation for small island developing States, UNFCCC Secretariat, Bonn, Germany, 2007a
- Westra S., Alexander L.V., Zwiers F.W., Global increasing trends in annual maximum daily precipitation, *J. Clim.*, 2013, 26, 3904-3918
- Yengoh G.T., Armah F.A., Onumah E.E., Odoi J.O., Trends in agriculturally-relevant rainfall characteristics for small-scale agriculture in northern Ghana, *J. Agric. Sci.*, 2010, 2, 3-16