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Factors Influencing Farmers' Climate Change Adaptation in Northern Ghana: Evidence from Subsistence Farmers in Sissala West, Ghana

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ABSTRACT

Most African countries are vulnerable to climate change as a result of poverty, weather extremes, and insufficient governmental agricultural support. Using the area of Sissala West District, factors influencing farmers' adaptation to climate change and strategies used to avert climate change impact were determined. A total of 330 small-scale farmers were sampled and their views were determined Using logits regression model, weighted average index, and frequency table. Weighted average index was used to rank opinions of 150 key informants in focus group discussions. Using logits regression model, the study indicated irregular rainfall, high temperature, weather information, and high evaporation as the factors compelling farmers to adapt to climate change. Weighted Average Index used to measure weather extremes revealed that drought and temperature had the highest level of occurrence. Furthermore, climate change adaptation strategies assessed in the study showed that agroforestry practices, drought-resistant crops, and mulching were the most preferred methods. The study concluded that farmers' ability to adapt to climate change can be improved if Environmental Protection Agency and Ministry of Food and Agriculture intensify climate adaptation campaigns, increase access to weather information, and training farmers on adaptable strategies including, but not limited to, alternative sources of livelihood.

Key words: *Adaptation, Agriculture, Perceived Effects, Strategies*

INTRODUCTION

Countries are experiencing climate change as a result of environmental land degrading activities such as unregulated farming, wood logging, hunting, mining, and infrastructure development in an attempt to meet human needs (*Miyan 2015*). As population increases, human livelihood activities continuously trigger climate change (*Boyd et al. 2013*). Research has shown that Africa is vulnerable to climate change due to poverty, inadequate technology, economic challenges, weather extremes and poor governmental agriculture policies (*Lobell et al. 2011*). Other studies showed that financial, educational, sociocultural, institutional, and technological barriers in Africa increase farmers' vulnerability to climate change (*Antwi-Agyei et al. 2012; Boyd et al. 2013;Kithiia et al. 2011*). In addition, these barriers influence the ability of African countries to deal with malnutrition and conflicts that arise, both internally and externally.

Weather extremes coupled with years of continuous farming on the same plot of land has rendered the soil infertile, in turn worsening food security crises associated with climate change effect in Africa. In achieving food security and economic development, studies have shown that the impact of climate change is detrimental to Sub-Saharan Africa (SSA). This is because the agriculture sector serves as the major source of employment and economic backbone (*Kahsay et al. 2007; Sissoko et al. 2011*). This implies, weather extreme and infertile soil affecting yield lead to poor economic growth.

The geographical location of West Africa has increased its vulnerability to climate change for the past three to four decades and this has affected food security in the region (*Biesbroek 2013*). Ghana, being one of the African countries with agriculture as its economic backbone, needs to tackle climate change constraints holistically by bringing on board all stakeholders who invariably contribute to agriculture promotion. There is established empirical evidence that the Ghana agriculture sector is dwindling as a result of poor sensitization of farmers and inadequate government support to tackle adaptation constraints (*Owusu-Sekyere etal. 2011*).

Similar research finding hinted that climate change impact experienced in Ghana highly affects farming communities in savanna areas of Northern Ghana (*Kusakari et al. 2014*). Agriculture in Ghana is predominantly small scale with most farms being less than two hectares due to high cost of inputs and inadequate government support. A study indicated that subsistence farmers are highly susceptible to climate change as a result of poor income level and lack of alternative source of employment in Ghana (*Fosu-Mensah et al. 2012*).

Northern Ghana is noted for producing staple grains such as maize, millet, guinea corn, and rice as a result of good climatic conditions for such crops. However, in recent times, unfavorable climatic conditions have exposed farmers to severe droughts, dry spells, low rainfall, high temperatures, and diseases. This compelled most farmers to adapt by either migrating to the south to look for nonexistent jobs during the dry season or changing planting period from early April to late June to avoid drought, dry spell or any unforeseen threat. Changing planting period as an adaptation strategy has affected productivity and maturity of certain long duration crops (*Armah et al. 2010*), but other findings indicated that changing planting period has rather favored farmers using improved and short duration crops over the years (*Etwire et al. 2013*). Addtional studies determined that, excessive droughts in Northern Ghana had contributed to unseasonably high temperatures, soil infertility, and poor water retention capacity of the soil (*Dasgupta et al. 2010*). Some farmers in Ghana have also resorted to using crop rotation, land rotation, improve seed and irrigation as adaptation strategy but this has not yielded good result (*Kusakari et al. 2014*).

Using fertilizer, shifting cultivation, drought resistant crops, livestock, hunting, and trading as means of combacting impacts of climate change in Nothern Nigeria, Mali, Burkina Faso and Sudan has not yielded satisfactory results (*Boyd et al. 2013*). Further evident of knowledge indicated that FAO and other research institutions have also proposed interventions such as crop diversification, agroforestry, use of improve seeds and livestock rearing as a means of improving climate adaptation strategies but these measures have not adequately addressed poor conditions of farmers in Africa (*Mabe et al. 2014*). There are many constraints contributing to farmers' inability to effectively adapt prudent strategies to reduce the impact of climate change on agriculture in savanna areas of most Africa countries including Ghana. A better understanding of how these constraints influence farmers' choices of adaptation strategies would enable researchers to strategically recommend scientific measures that could enhance farmers' adaptation strategies. Farmers' choices for adapting to climate change depend on many considerations. However the effectiveness of farmers' adaptation strategies mainly depends on biophysical and socio-economic factors such as farming experience, farm labor, weather extremes, income, household size, extension services, access to weather information, input cost, and age.

This research determined the factors influencing farmers' ability to adapt to climate change. Further, the study aimed to assess adaptation strategies suitable for livelihood and microclimate improvement. The study again assessed most occurring weather extremes affecting agriculture and livelihood. Also, it evaluated the effects of climate change on livelihood and agricultural practices.

MATERIALS AND METHOD

Study Area

The Sissala West District lies within the Guinea Savannah belt of Ghana with the district capital situated at Gwollu. It can be found in the north eastern corner of the Upper West Region between longitude 2°300 W and 2°00 W and latitude 10°300 N and 11°00 N. The total land area of Sissala West District is 411,289 km^2 and is about 25% of the total landmass of the Upper West Region (**Figure 1**). The annual rainfall is between 800 mm to 1,000 mm and the mean annual temperature is about 28° to 37°C. The annual rainfall peak is between April and July, with few showers from August to October. This follows a general pattern identified with the three Northern Regions of Ghana. The rainy season is followed by harmattan - a prolonged dry season characterized by cold and hazy weather from early November to March. The relative humidity in the rainy season is 70 to 90% but as low as 20 % in the dry season. Variations in climatic conditions of the area sometimes cause changes in the seasonal conditions.

The vegetation consists of perennial grasses with scattered fire resistant trees such as locust (*Parkia biglobosa*), Shea (*Vitellaria paradoxa*), Kapok (*Ceiba petandra*) and baobab (*Adansonia digitata*). The perennial grass such as Andropogon gayanus serve as pasture for livestocks reared in the area. Human activities, notably annual routine bush burning, inappropriate farming practices and indiscriminate felling of trees for fuel wood and charcoal as well as poor animal husbandry practices have led to the loss of the vegetative cover in the district.

The forest reserves at Gbelle, Tiwii, Kuni and Gwollu

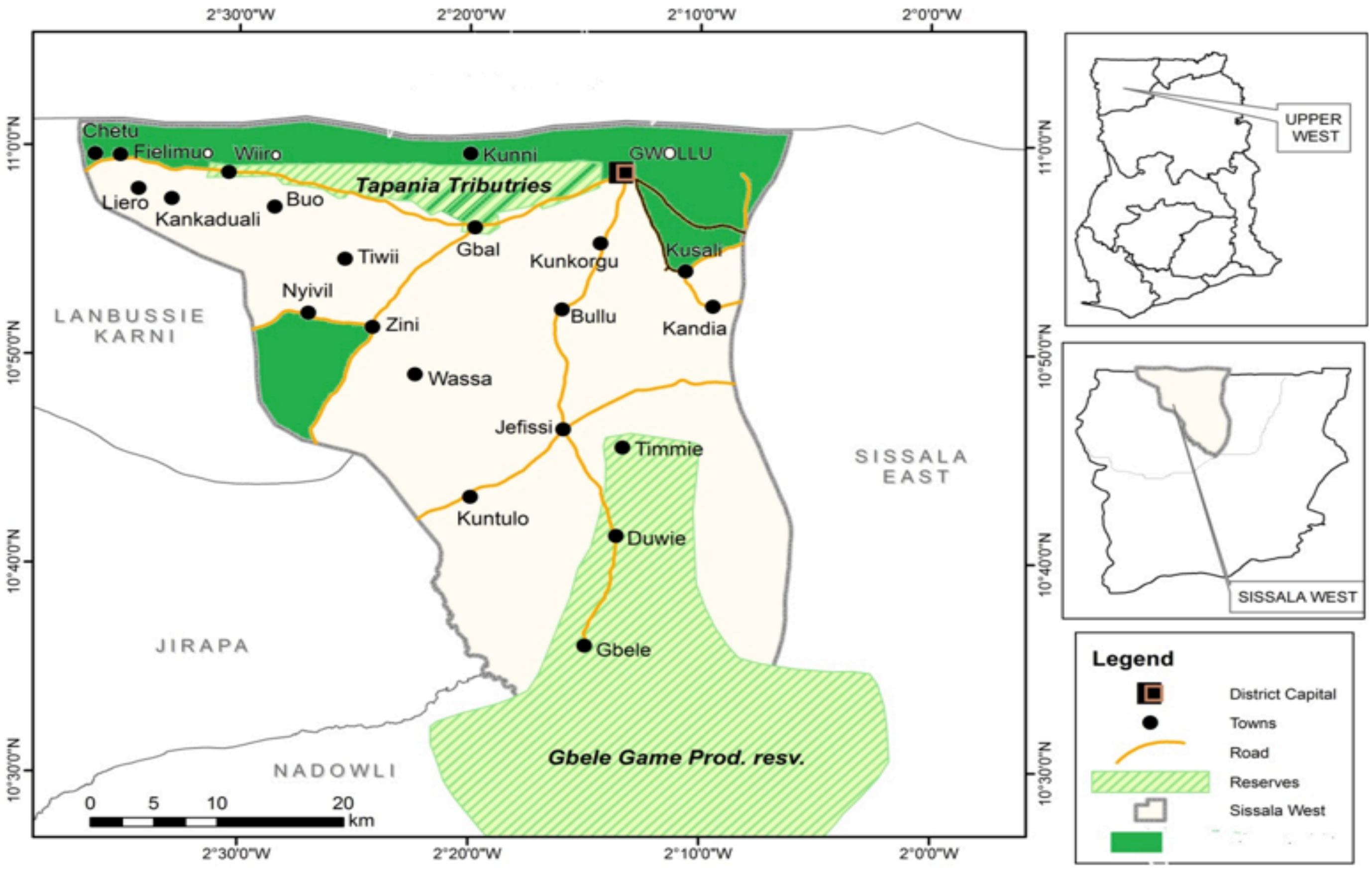

Figure 1. Map of Sissala West District (Source: Sissala West District Assembly).

are constantly under pressure for firewood, charcoal and shelter. Most of the houses are poor ventilated mud houses with thatched roofs. Efforts to address deforestation have encouraged the Forestry Commission to embark on wood lot plantation using teak, neem and cassia. Agriculture is the main occupation of the majority of the indigenes in the district. Vast arable land has promoted the cultivation of cereals and legumes in all parts of the district. Aside farming, charcoal burning, hunting, and wood logging are sources of alternate livelihood.

Farmers' 2016 updated census data, obtained from the District Agriculture Development Unit (DADU) under the Sissala West District Assembly, showed that 39,134 people between the ages of 15 and 65 years engage in agriculture as a source of employment with the majority being males. Following is the method used to determine the sample size for the survey which was carried out for farmers:

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

Where n= sample size, N= population size (39,134) and α represented the margin of error which is 0.05 with a confidence level of 95%. By substituting 39,134 and 0.05 into the formula: n= 395.

From the 395 sample size, 350 farmers were targeted for sampling. However, due to financial constraints and inadequate field assistants to help in administering the questionnaires, only 330 farmers were able to participate in the survey. The dispersed nature of settlement and inaccessible road network linking the communities and farms compelled the researchers to engage Agriculture Extension Agents (AEAs) to randomly select 13 farming communities (Kusali, Gwollu, Nyimati, Bullu, Tiwi, Wassa, Fielmuo, Zini, Jeffisi, Gbal, Wiro, Kandia, Duwie). The researchers used AEAs' portable geological positioning system (GPS) device for easy location of farms and settlements. The researchers and the field assistants randomly selected 30 farmers from each of these communities during the survey with the aid of semi-structured questionnaires. Furthermore, Focus Group Discussions (FGDs) were also organized separately for 150 key informants comprised of 10 District Assembly officials, 20 Ministry of Food and Agriculture (MOFA) pesonnel, 10 Environmental Protection Agency (EPA) personnel, 10 Forestry Commission (FC) staff members, and 10 FBOs groups(Farmer Based Organizations; 10 members from each FBO group) to ascertain the adaptation strategies farmers use. During discussion in the District Assembly, the 150 participants' hall, were subdivided randomly into 10 smaller groups for discussion and presentation of views. The FGDs were used to solicit diverse views on issues surrounding adaptation constraints and strategies. To be familiar with selected communities and the appropriate time to reach farmers, the researchers used rural appraisal familiarize themselves with some sections of selected communities before conducting the main survey. Evidence shows that using participatory rural appraisal (PRA) before main survey is conducted enhances data collection (*Chambers 1994*). Five field officers were trained and supervised to aid in data collection due to the dispersed nature of settlements in the district. The questionnaire was pretested in 10th January-January15th 2016 and the necessary corrections in the questionnaire were made before conducting the main survey for a period of 4 months (27th February – 28th June 2016).

Analyses of Data

The field survey data collected was analyzed with version 23 of the SPSS software. The results were illustrated results as tables to give a clear view of respondents' opinions. The logic regression model was also used to determine the factors influencing adaptation. The study further used Weighted Average Index (WAI) to determine farmers' climate change adaptation strategies, adaptation constraints, and weather extremes. The WAI analyses used in previous studies in Nepal to evaluate farmers' climate change adaptation strategies were efficient in the assessment (*Uddin et al. 2014*). The WAI was used to analyze the impacts of climate change on variables such as crop, weather extremes, constraints, and adaptation strategies. The Likert scale was also used to rank farmers' opinions on climate change constraints using variables such as high rate of deforestation, unpredictable weather, inadequate government support, poor adaptation strategy, poor weather information, inadequate credit facilities, and land tenure issues on the scale of 0-3 (0-not sure, 1-low, 2-moderate, 3-high). Farmers' climate change adaptation strategies 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 at all interested, 1- not very interested, 2- undecided, 3- somewhat interested, 4-very interested). 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 which were attained when the questionnaire was pre-tested before the survey was carried out. The different scale used in ranking was to help obtain diverse responses. WAI of the respondents' variables was computed using the following formula:

$$WAI= \frac{F0W0+F2W2+F3W3+F4W4}{F0+F1+F3+F4}$$

$$WAI= \frac{\sum FiWi}{\sum Fi}$$

Where W= weight of each assessed respondents variable on the scale, F= variables frequency, i= response on the scale (e.g. i= 0=very poor, 1= poor, 2=good, 3=very good).

Model of the Research

Multiple Logistic Regression Models. Logistic (logic) regression analysis which was widely used in the data analysis process is similar to that of linear regression analysis except that the outcome is dichotomous (e.g., low/high or true/false). It was used to determine whether there is the possibility of an event occurring or not (**Table 1**). The logic regression model was successfully used to determine the likelihood of breast cancer sustainability among target groups of people in the United State of America (*Goldberg et al. 2006*).

The outcome in logic regression analysis is often coded as 0 or 1, where 1 implies that the outcome of findings is true and 0 indicates the outcome of findings to be false. If P in the equation is the probability that an outcome is 1, the logic regression model can be expressed as:

$$P= \frac{exp(b0+b1X1+b2X2+b3X3.......+bpXp)}{1+exp(b0+b1X1+b2X2+b3X3.......+bpXp)} \quad (1)$$

P is the expected probability that an outcome has the potential of being true or false. X1, X2, X3 up to Xp are independent variables which predict P outcome; b0, b1, b2 up to bp are regression coefficients of the independent variables. To predict unexpected outcomes of an event with known characteristics, substitute applicable values into the independent variables and take the log of the expected outcome is expressed as:

$$ln\left[\frac{p}{1-p}\right] \quad (2)$$

$$ln\left[\frac{p}{(1-p)}\right]= b_0+b_1X_1+b_2X_2+b_3X_3+.......+bpXp \quad (3)$$

From the model equation, P represents the probability of farmers being influenced by certain factors to adapt to climate change and (1-P) represents the probability not to adapt to climate change.

A questionnaire was used to elicit information from respondents and FGDs (**Table 1**). The collected information was analyzed with SPSS, logic regression model and WAI.

RESULTS

Demographic characteristics of respondents

Majority of respondents were between the ages of 31-40 years representing 31.8% of the total respondents (**Table 2**). The youngest group, 30 years old and younger, represented 28.5% range of all the respondents. The remaining 19.1% of respondents fell within the age the range of 41-50 years. About 206 of the respondents were male while 124 were female as shown (**Table 2**). Male respondents were more than female respondents due to unwillingness of females to answer questions when their husbands or males relatives were around due to cultural expections. The survey showed that 150 respondents representing 45.5% had no formal education. This implies that the illiteracy rate is high in the district. Moreover, 93 respondents (28.2 %) had basic education at the primary level. Only 13 respondents (3.9%) had received tertiary education. This implies many of the dwellers in the study area do not complete higher levels of formal education.

Factors influencing Farmers' Climate Change Adaptation Decision

The study indicated that erratic rainfall (coffecient-6.337*) was perceived as a factor with a high tendency of influencing climate change adaptation (**Table 3**). This implies that farmers consider the nature of rainfall patterns before making adaptation decisions. High rates of deforestation (6.058*) was also seen as a factor with a high possibility of influencing adaptation decisions. With high deforestation that expose farmlands to harsh weather conditions, farmers were compelled to put measures in place to reduce vulnerability.

High evaporation (5.337*) also have a tendency of compelling farmers to make prompt decisions to improve their climate change resilience. The study showed that in the event of high evaporation, farmers would be proactive to prevent loss of water from plants, soil and sources of water. Access to weather information (4.328*) would encourage farmers to adapt to climate change to improve yield. Easy access to weather information enhances preparedness for climate change. The study showed evidence that education level (4.233*) could influence farmers to make quick decisions and find measures to address climate change

Table 1. Definition of variables used to elicit information in the study area (N=330), FGDs (N=150).

Variables	How variables were coded
**Factors influening adaptation*	Independent variables
Age	1= 30 yrs and younger, 2= 31-40yrs, 3= 41-50yrs, 4= 51-60yrs, 5= 61 and above
Gender	1= male , 2=female
education	1= non formal, 2= primary, 3= junior high, 4=s ec/voc/tech, 5= tertiary
Farm labour	1= family labour, 2= hired labour 3= communal labour
Household size	1=1-5, 2= 6-10, 3= above 10
Access to weather information	1= good, 2= poor access, 3= no access
Access to credit facilities	1= good, 2= poor access, 3= no access
High rate of deforestation	1=yes, 2= no , 3= not sure
High temperature	1=increasing, 2= decreasing, 3= moderate, 4= can't tell
High rate of evaporation	1= high, 2= low, 3= moderate, 4= don't know
*Nature of weather extremes	
Drought	1= high, 2= low, 3= moderate, 4= don't know
Dry spell	1= high, 2= low, 3= moderate, 4= don't know
High temperature	1= high, 2= low, 3= moderate, 4= don't know
Flood	1= high, 2= low, 3= moderate, 4= don't know
*Effects of climate change	List of effects by respondents
**Adaptation strategies	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Drought resistant crops	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Agroforestry	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Irrigation	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Inorganic fertilizer	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Different farming systems	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
Use of Virgin lands for farming	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested
MulchingComposting	Not at all interested, somewhat uninterested, undecided, Somewhat interested, interested

Table 2. Demographic characteristics of respondents.

Characteristics of respondents	Frequency	Percentage
GENDER		
male	206	62.4
female	124	37.6
TOTAL	330	100
AGE		
30 years and below	94	28.5
31 years to 40	105	31.8
41 years to 50	63	19.1
51 years to 60	36	10.9
61 years and above	32	9.7
TOTAL	330	100
EDUCATION		
Non formal Education	150	45.5
Primary school	93	28.2
Junior high school	48	14.5
Sec/Voc/Tech	26	7.9
Tertiary	13	3.9
TOTAL	330	100

Source : Field survey 2016

Table 3. Logic regression model results of factors influencing farmers' climate change adaptation. (N=330).

Variable	Coefficient	Standard error	P. value
Constant	7.187	1.537	0.001
Education level	4.233*	1.256	0.033
Farm labour	0.498	2.129	0.000
Household size	3.453*	1.129	0.002
Erratic rainfall	6.337*	1.186	0.032
Access to weather information	4.328*	2.291	0.021
Access to credit facilities	-3.410*	1.276	0.038
Farm Size	0.939	1.346	0.002
Access to extension service	4.011*	1.349	0.015
High rate of deforestation	6.058*	2.222	0.001
Average distance covered by farmer to farm	0.258	1.148	0.082
High temperature	3.259*	1.070	0.005
High rate of evaporation	5.377*	1.165	0.023

*indicates significance (α) level at 95%

challenges. Farmers with formal education adapt to climate change better than those without formal education. The survey further showed that access to extension services (4.011*) also enabled farmers to adopt strategies that enhance their climate change resilience. Access to extension services is perceived as an opportunity for the timely flow of information from extension officers to farmers and vice versa. High temperatures (3.259*) were considered a factor that influences farmers' adaptation actions. In the event that temperatures are too high, posing threat to crops, livestock, and farmers' health, farmers would adapt measures to avoid any uncertainty. On the other hand, interactions with farmers hinted that, when temperatures are not detrimental to crops and livestock, farmers would not be proactive to adapt any measures. The research indicated that access to credit facilities (-3.410*) has no tendency of influencing farmers' climate change adaptation decisions. No correlation between climate change adaptation decision and credit facilities.

Weather extremes in the study area

Drought is perceived as the most frequently occurring weather extreme that prevents farmers from securing good yields. Farmers related that frequent droughts in the study area have compelled them to look for short duration crop varieties to avoid crop failure (**Table 4**). High temperature ranked second in order of weather extremes often affecting crop growth, yield, and post harvest storage. High temperatures are due to high intensity sunlight and inadequate trees to create cooler micro-climates in the study area. Dry spells ranked third that is a result of irregular rainfall patterns in the study area. According to the farmers, dry spells mostly affected fertilizer application and loosening of the soil for good aeration and micro-organism activities. The study further showed that floods ranked last and it is not considered as a serious weather phenomenon in the area since it does not affect farming. Topography of the area coupled with poor rainfall does not often creates floods, though heavy rainfall at times does flood some farming areas.

Farmers Perceived Effects of Climate Change

Twenty-four percent (N=79) of farmers were of the opinion that climate change affecting yield increased food insecurity, poverty, and hunger (**Table 5**). Further, 18.1% (N=60) of farmers usually have serious challenges with water supply hence preventing them from engaging in dry season gardening as an alternative livelihood to supplement their food and income. Also, access to potable drinking water for livestock and humans is a major

Table 4. Nature of weather extremes in study area (N=330).

Variables	Weather occurrence responses evaluation			WAI	Rank
	High	Moderate	Low		
Drought	148	90	92	2.16	1
High temperature	124	123	83	2.12	2
Dry spell	83	114	133	1.85	3
Flood	84	28	218	1.59	4

*indicates significance (α) level at 95% (Source: 2016 field survey) challenge during the dry season. The survey indicated that 16.4% (N=54) of farmers perceived the high cost of farming as one of the serious effects of climate change. The farmers stated that climate change has created high demand for farm inputs including fertilizer, improve seed, and tractor services. Information from the survey showed that 14.5% (N=48) of farmers were of the opinion that unfavorable climatic conditions in farming communities increase the risk of unemployment. The research further showed that among the effects of climate change recorded during the field survey, 12.4% (N=41) of farmers suggested that forest degradation could worsen effect of climate change on farmers livelihood. The analyses showed that 8.8% of (N=29) farmers were of the view that climate change could lead to a high cost of living in communities where farming is the only source of livelihood. The high cost of farm inputs to improve soil fertility and yield could eventually lead to high cost of food production hence affecting food security. Climate change poses threat to food security and health of farmers who rely on agriculture for their livelihood. The study showed that 5.8% (N= 19) of farmers were of the view that poor health would undermine farm labor and eventually trickle down to create poor yields and food insecurity.

Farmers climate change adaptation strategies

Focus Group Discussions (FGDs) were also organized separately for 150 key informants comprising 10 District Assembly officials, 20 Ministry of Food and Agriculture (MOFA) staff members, 10 Environmental Protection (EPA) personnel, 10 Forestry Commission (FC) staff members and 10 FBOs groups(Farmer Based Organizations; 10 members from each FBO group) to ascertain the adaptation strategies farmers use. The discussions encouraged all participants to share ideas and suggest solutions which could help improve farmers' climate change resilience. The FGD participants suggested agroforestry practices such as alley cropping, inter-planting and woodlot plantation (WAI=2.98) as the best adaptation method to improve microclimates, and boost soil fertility, as well as reduce the high intensity of direct sunlight on the crops and soil nutrients. Using good drought resistant crops and seeds (2.94= WAI) was ranked second in order of relevance to climate change adaptations by the participants (**Table 6**). Farmers and other opinion leaders suggested that improved crops could withstand droughts, high temperatures, and dry spells. Farm manure/mulching (WAI=2.79), which is third in ranking, was seen as a good adaptation strategy to help boost soil fertility since most of the farmers have abundant livestock and crop residues. Planting season variation (WAI=2.76) was also perceived as a good measure to tackle climate change challenges. FBOs and key informants were of the opinion that instead of planting at the regular farming season, farmers should prepare farmland and make all other necessary input ready so as to sow without delay as soon as the rain starts.

Farming systems (WAI=2.74) such as crop rotation, mixed cropping, and land rotation were also seen as good adaptation measures which could help improve yield (**Table 6**). Using Irrigation methods (WAI=2.64) as an adaptation strategy was ranked 6th in order of relevance to climate change adaptation realised during the FGDs. This was seen as a viable method to improve crop production in places with poor rain, high occurrence of droughts, or dry spells. The FGDs also indicated that inorganic fertilizer (WAI=2.5) was ranked 7th in order of importance as an adaptation strategy. Use of inorganic fertilizer was seen as expensive, but efficient with a rapid result. Use of virgin land for farming (WAI= 2.49) was also seen as a good adaptation strategy since new farmland is more fertile than old farms. However, the concerns raised indicated that encouraging farmers to clear new areas in order to increase yield would create massive deforestation. For this reason, it was not considered as good adaptation strategy. Alternative livelihood (WAI= 2.1) was ranked as the last strategy in the FGDs organized. This low ranking conforms to the

Table 5. Farmers perceived effect of climate change.

Variables	Frequency	Percentage	Actual effects evaluation
Poor yield	79	24	Hunger, poverty and food security
Frequent water shortage	60	18.1	Poor source of drinking water, inadequate irrigation activities in dry season, and poor livestock watering
High cost of farming	54	16.4	High cost of input and high credit facilities interest rate
Unemployment	48	14.5	Poor living standard, poverty, conflict, and theft
Forest degradation	41	12.4	Bare land, soil erosion, high soil temperature, and high moisture evaporation
High cost of living	29	8.8	Low-income savings and poor living standards
Poor health	19	5.8	Low crop production

Source : Field survey 2016

Table 6. FGDs (N=150) climate change adaptation strategies in order of importance using WAI.

Evaluation of responses variables	not at all interested	Somewhat uninterested	undecided	somewhat interested	very interested	WAI	Rank
Agroforestry practice	12	27	30	35	46	2.98	1
Drought-resistant crops	13	20	26	48	43	2.94	2
Use of manure/mulching	8	19	33	53	37	2.79	3
Planting Season variation	15	23	33	47	32	2.76	4
Different farming systems	14	19	42	47	28	2.74	5
Irrigation method	14	25	37	42	32	2.64	6
Use of inorganic fertilizer	11	30	43	37	29	2.5	7
Use of Virgin Lands	15	19	48	43	25	2.49	8
Alternative livelihood	12	25	37	55	21	2.1	9

Source: key informants, FBOs, Opinion leaders' discussion (2016)

response by farmers and opinion leaders disagreeing with using charcoal production, hunting, and wood logging by the indigenes as a means of an alternative livelihood.

DISCUSSION

The gender of respondents was taken into consideration to ascertain how this contributes to environmental degradation and climate change resilience. Since gender influences socio economic activities carried out which adversely impact the environment, it is crucial to give both sex equal chances to respond to the interview schedules. Research findings have shown that due to the tedious nature of manual farming, most men prepare the land while the women provide support in sowing, harvesting and marketing of farm produce (*Mubaya et al. 2010*). This implies that the impact of climate change will affect both men and women. Analyses of age groups indicated that the majority of active working individuals falls within the age range who are considered to have adequate energy to work (**Table 2**). This implies that since farming is their main source of food, income and employment, invariably without any alternative livelihood, climate change could affect their food security and livelihood. A large labour force affects availability of hired or free labour to implement labour demanding strategies to curb climate change impacts on farming. The study showed that the majority of indigenes had no formal education. This is due to the location of the district and poor living conditions which do not attract teachers to teach in the regions' schools. Also, due to family labour demand on farms for crop production, most parents allow only one or two children to acquire basic education, while using the rest of their children for family labour on farms and in other economic activities that bring income to the family. Education would enable members of farming communities to adapt to conditions and make better decisions likely to benefit to all. Sustainable agriculture dictates that farming communities should be trained or educated to adopt efficient climate change mitigation strategies, aligning both customary and statutory laws together so as to enhance collaboration between individuals, interest groups, local authorities and government agencies (*Sissoko et al. 2011*).

Farmers are proactive in making sensitive decisions regarding changes in rainfall and weather extremes (**Table 3**). Therefore rainfall pattern with the highest coefficient has the highest tendency of influencing farmers' decisions on climate change adaptation strategies. Similar studies showed that farmers' experiencing severe drought and high temperature have the tendency of easily adopting technology at any given cost to improve soil moisture and temperature for good yield (*Nielson et al. 2010*). The poor rainfall pattern in the region, causing droughts and high temperatures, compels some farmers to hire tractor services and extra labor for ploughing, sowing, fertilizer application and harvesting. Generally most farmers would take prompt response to climate change adaptation in the event that high temperatures increase soil moisture evaporation. This implies that high evaporation rates and other unfavourable climatic conditions are likely to influence farmers' preparedness for adapting to climate change. Personal observation and interactions indicated that high temperature increased evaporation of water bodies especially those exposed directly to impact of sunlight. Access to weather information enables farmers to plan ahead and adopt measures to curb climate variability impact (*Mubaya et al. 2010*). Other findings showed that access to weather information increase farmers preparedness in avoiding heat stress, drought as well as pest and weed invasion (*Miyan 2015*). The study revealed that regular weather information has the tendency of influencing farmers' preparedness for unforeseen uncertainty better than the event of inaccessible weather information. This implies regular access to weather information is essential for farmers' climate variability consciousness. Interactions and the study analyses also showed that education level has probability of influencing adaptation to climate change. Farmers with some level of education during the survey demonstrated that educated or highly educated farmers mostly understand and easily apply new technology or skill acquired than uneducated ones. Education and income should not be a barrier to farmers' climate change adaptation, hence, climate change adaptation strategies used by farmers should be less costly and easily applicable to encourage easy adaptation Antwi-(*Agyei et al. 2011*). However, it is interesting to note that, educated farmers also have the ability to explore different avenues to curb climate change due to their broad scope of knowledge than uneducated ones (*Laube et al. 2012*). In addition, latest scientific adaptation strategy involving calibration, reading, and precision tend to favor educated farmers. Agriculture Extension Agents (AEAs) play an essential role in agricultural promotion. They help in training and disseminating new and improve agricultural practices to farmers. The study indicated that the possibility of farmers' adapting to climate change increases with access to agriculture extension services. On the other hand, poor access to agriculture extension officers could negatively affect farmers' climate variation adaptation when confronted with challenges demanding immediate attention (*Adger et al. 2012*). According to the research analyses as indicated in table 3, household size as also has the possibility of influencing climate change adaptation. The researchers' interactions and observations with different household size during the survey further established that large households are likely to adapt to climate change better than small household due to the availability of labor for more demanding adaptation strategies than a small household. A related study indicated that large household mostly relies on family labor to adapt to climate change so as to enhance family food security (*Tiwari et al. 2014*). An intensity of temperature could influence farmers' decision on climate change adaptation strategy. Evidence of studies have established that farmers may not necessarily adapt to climate change when temperatures do not pose much threat to crops, nevertheless farmers are likely to adapt to climate change when temperatures are unbearable and pose threat to livestock and crop yield (*Westra et al. 2013*).The research analyses indicated that thetendency of farmers adapting to climate change increases with high temperature. Access to credit facilities had a negative correlation on climate change adaptation. Personal observation and interaction with the farmers suggested that difficulties in accessing credit coupled with high-interest rate make credit facilities unattractive. Information gathered during the survey pointed out that easy access to credit facilities could facilitate farmers' adaptation to climate change as well as yield improvement. Similar information gathered showed that farmers with easy access to credit facilities have high preferences for adapting to climate change than those without access to credit because some adaptation strategies increase the cost of production (*Feola et al. 2015*).

The nature of weather extremes in the study area was obtained directly from farmers during the survey and verified from the Regional Metrological Office to erase any doubt from the information obtained from the farmers (**Table 4**). The study showed that the weather information gathered from the farmers where in consistent with those from the Metrological Office. The Likert scale used to evaluate farmers (respondents) opinions indicated that, among all the weather conditions threatening farming, drought was seen as the most serious weather extremes. Frequent drought hardens the topsoil preventing the use of rudimentary tools like hoe and cutlass. Farmers who seek tractor services pay a high amount when the soil is dry and hard as a result of the drought. High temperature was also found to be one of the weather extremes affecting crops and livestock production in the study area. Personal observation and discussions with the farmers showed that extensive livestock rearing system practiced in the study area exposes livestock to direct impact of high temperature. This affects feeding, reproduction, disease prevention and health of livestock. Dry spell affects productivity especially when crops are fruiting. Personal observation showed that maize, guinea corn, and sorghum, the main cereals grown in the study area forms small cobs when dry spell sets in at the tasselling stage. Flood which has been one of the major impacts of climate change was ranked last perhaps this is due to low annual rainfall in the study area. Flood not common in the study area is as a result of low rainfall and high evapotranspiration.

Climate change has numerous direct and indirect effects on the economy, environment, and lives of people. This implies that climate change consequences are inevitable hence measures should be put in place to address its impact on the environment and humanity. The survey conducted established that farmers were of the opinion that climate change affecting yield increase food security challenges, poverty, and hunger. Research related to food security and family size showed that large farm families with poor yield could be underfed in the situation where there is no alternative source of food to supplement farm yield (*Armah et al. 2010; Challinor et al. 2007*). Interactions with the farmers indicated that farmers with poor harvest often allow their old farms to lie fallow and travel miles away from home to clear new fertile lands to improve yield. Low rainfall couple with high-temperature increase frequent dry up of water bodies such as wells, dams, and streams. The study established that farmers have challenges with water supply hence preventing them from using dry season gardening as alternative livelihood to supplement their food and income. Also, access to potable drinking water for livestock and human consumption is mostly a big challenge during the dry season. The farmers perceived high cost of farming as one of the serious effects of climate change. The farmers stated that climate change has created high demand for farm inputs including fertilizers, improve seeds and tractor services. It was also realized that high input demand for yield improvement has led to high cost of inputs hence increasing the cost of farming. The study revealed that unemployment is one of the impacts of climate change farming communities are likely to face in the event that early warning systems and plausible scenarios of climate change are ignored Though few indigenes engage in activities such as hunting, charcoal burning and petty trading as an alternative livelihood for income supplement, farming is the main source of employment in the study area. Farmers were of the opinion that unfavorable climatic conditions in farming communities increase the risk of unemployment. Research findings on a correlation between climate change and income showed that the impact of climate change on soil fertility increase risk of poverty and hunger in developing countries especially in Sudan and Sahel regions of Africa (*Derbile et al. 2013*). Related studies have also indicated that externalities associated with climate change and keen competitions for land in peri-urban areas for agriculture could create land tenure issues (*Calzadilla et al. 2014*). The farmers were of the view that climate change could lead to high cost of living in communities where farming is their only source of livelihood. The high cost of farm input to improve soil fertility and yield could eventually lead to high cost of food production hence affecting food security. Climate change poses threat to food security and health of farmers who rely on agriculture for their livelihood. The farmers were of the view that poor health would undermine farm labor and eventually trickle down to poor yield and food insecurity. Frequent heat waves coupled with poorly ventilated structures in rural areas of Northern Ghana leads to a frequent outbreak of Cerebrospinal Meningitis (CSM) and skin diseases (*Acquah 2011*). The tendency of human vulnerability to diseases is high when exposed to bad weather conditions.

The adaptation strategies analyzed were the cross-cutting issues which most of the participants listed as most preferred strategies to address climate change challenges. Farmers suggesting agroforestry practices as the suitable climate change resilience strategy was earlier realized during the survey that some farmers were already intercropping teak, cashew, and mangoes with cereals and legumes. Studies have suggested that Alley and Taungya farming both forms of agroforestry improve soil fertility, increase yield, and retain soil moisture as well as reducing evapotranspiration (*Ochieng et al. 2016*). Furthermore, apart from improving vegetation cover and increasing carbon stock, cash crops used in agroforestry could be harvested in the future for additional income. Use of improved seeds was as considered one of the best adaptation strategy during the FGDs because aside the ability to withstand draught, high temperature and dry spell, improved seeds have short growing period and could also withstand diseases, pest and weeds. Cereal crops largely grown in the study area can be planted twice within the season if good short duration seeds are obtained. Farmer Based Organisations (FBOs) which had already resorted to using improved seeds attested that there had been a significant yield improvement. Farmyard manure was considered good adaptation method during the discussions due to it availability and low cost. Participants of the FGDs stated that some farmers were already using farm by- product for mulching and composting on the farms especially vegetable gardens on small scale. As most of the farmers lack the ability to afford high prices of fertilizer, adapting to mulching and composting would save cost as well as improve soil fertility. Research findings indicated that farmers using farmyard manure and crop residues as compost increase yield, boost soil fertility, and save cost (*Mustapha et al, 2012*). According to participants, issues of drought and dry spell could be reduced if there is variation in planting season. This mitigation was suggested as a result of irregular rainfall pattern in the study area. Planting season variation could help farmers adequately prepare for the period the raining season is suspected to last in other to avoid crop failure. Using different farming system approach as adaptation strategy enables farmers to try different farming systems suitable for particular crops growth and climatic conditions prevailing in a particular area. The FGDs established that crop rotation was considered as one of the best systems helping farmers to grow different crop varieties at different seasons when weather conditions are irregular due to climate change. In addition, the discussion revealed that mix cropping was noted as a good method for improving soil fertility when leguminous crops are intercropped with other non-cover crops to improve the soil fertility and moisture. Land rotation was also suggested by some of the respondents as one of the good farming systems but was not considered suitable due to population growth and land tenure issues in the study area. Land rotation in recent times is unconducive for climate change adaptation as land is becoming scarce resource due to population growth (*Sutcliffe et al. 2016*).However, the land rotation would help in a situation where farmland could lie fallow for some years to regain fertility.

The study analyses and discussion revealed that farmers were of the view that dugout, dams, and wells constructions near farms or homes for irrigation could help in fresh vegetable production to supplement main farming season yield. The researchers' observations showed that developing irrigation facilities in the communities could contribute tremendously in poverty and hunger alleviation in communities with extreme climatic condition. Input subsides enables vulnerable farmers mostly from poor developing countries to access farm inputs such as fertilizer, weedicides, insecticides and tractor services to improve their resilience against climate change (*Tiwari et al, 2014*). The opinions from the discussions revealed that, if government subsidizes fertilizers, poor farmers can easily access improve seeds and fertilizers to help increase yield. Though the fertilizer would not improve soil structure, the nutrients in the fertilizer will help boost yield even if theclimatic conditions are not favorable. Poor soil fertility as a result of many years of cultivating crops on the same piece of land coupled with unfavourable climatic conditions in the study area, convinced the participants during the discussions that, alternative sources of livelihood including bee keeping, animal husbandry, fishing and handicrafts could improve farmers living conditions. Research findings have indicated that alternative source of livelihoods such as beekeeping, weaving, livestock rearing and dry season gardening reduce over-reliance on the main farming season for food and income in certain farming communities in Ghana (*Nyantakyi-Frimpong et al. 2015*). However, it was interesting to note that the participants were of the view that poor road network, low-income coupled with the lack of large market centers in the communities do not augur well for using trading as an alternative livelihood in the study area.

CONCLUSIONS AND RECOMMENDATIONS

The research findings detected numerous factors hindering farmers' quest to improve soil fertility and climatic conditions. Impacts of poor rainfall and high temperatures causing frequent drought, dry spell and dry-ups of water bodies affecting crop production could be addressed if access to weather information is improved. Weather information should be available, accessible and usable to enhance farmers' mitigation preparedness in curbing climate change impact. This can be achieved if the link between MOFA and the Metrological Services Department is strengthened for easy dissemination of weather information. High farm input cost as a result of importation of most agricultural input coupled with poor government commitment to the agricultural sector restrains farmers from acquiring needed input for adaptation. As most farmers are characterized as low-income small-scale farmers, high input cost would prevent effective strategies that could improve soil fertility and yield. Intensification of government support for the agricultural sector would enhance easy acquisition of needed input for adaptation and yield improvement. Land tenure issues have been realized as an underpinning factor preventing farmers from committing resources to good adaptation practices. Farmers' concerns of losing farmland to rightful owners could be addressed through enactment of land reform policies and land tenancy agreement to enhance adopting efficient adaptation strategy.

Farmers' welfare maximization is the ultimate aim of adapting to climate change. Poor soil fertility in the study area and inability of farmers to afford farm input such as fertilizers, weedicides, and tractor services increases farmers susceptibility to climate change impact. Therefore agricultural practices including improved seeds, changes in planting season, drought-resistant crops, short duration crops, composting, mulching could serve as a good intervention for adaptation. As the government is a major stakeholder in the agricultural sector, climate change adaptation strategies could be improved significantly if the Forestry Commission, EPA and MOFA are resourced to train farmers on easily adaptable strategies including agroforestry to improve vegetation and microclimate. In addition, intensifying campaign on livestock rearing, beekeeping, weaving, and irrigation as an alternative livelihood should be encouraged to reduce reliance on rain-fed agriculture. Farming communities are becoming skeptical about efficiency of current climate change adaptation strategy, therefore, further research for more efficient and less expensive adaptation strategies to improve farmers' resilience to climate change would be of essence.

REFERENCES

Acquah, H.D. (2011). Farmers´ perception and adaptation to climate change: a willingness to pay analysis. *Journal of Sustainable Development in Africa* 13: 150-161.

Adger, W.N., Barnett, J., Brown, K., Marshall, N. and O'brien, K., 2012. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, 3(2), 112-117.

Doi: 10.1038/nclimate1666.

Antwi-Agyei, P., Fraser, E.D.G., Dougill, A.J., Stringer, L.C. and Simelton, E., 2012.Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography*, 32,324-334. doi: org/10.1016/j.apgeog.2011.06.010.

Armah, F.A., Odoio, J.O., Yengoh, G.T., Obiri, S., Yawson, D.O. and Afrifa, E.K.A. (2010). Food security and climate change in drought-sensitive savanna zones of Ghana. *Mitigation and Adaptation Strategies for Global Change*, 16(3), 291-306.

Biesbroek, G.R., Klostermann, J.E., Termeer, C.J. and Kabat, P., 2013.On the nature of barriers to climate change adaptation. *Regional Environmental Change*, 1-11. Doi: 10.1007/s10113-013-0421-y.

Boyd, E., Eornforth, R.J., Lamb, P.J., Tarhule, A., and Brouder, A., 2013. Building resilience to face recurring environmental crisis in African Sahel. *Nature Climate Change*, 3, 631–637. doi:10.1038/nclimate1856

Calzadilla, A., Zhu, T., Rehdanz, K., Tol, R.S.J. and 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., and Kassam, A. (2007).Assessing the vulnerability of food crop sys-tems in Africa to climate change. *Climatic Change,* 83(3) 381-399. doi:10.1007/s10584-007-9249-0

Chambers, R., 1994. The origins and practice of participatory rural appraisal. *World Development*, 22(7), 953-969. Doi: org/10.1016/0305-750X (94)90141-4.

Dasgupta, A. and Baschieri, A. 2010. Vulnerability to climate change in rural Ghana: mainstreaming climate change in poverty reduction strategies. Journal of International Development, 22(6), 803-820. Doi:10.1002/jid.1666.

Derbile, E.K. 2013. Reducing Vulnerability of Rain-fedAgriculture to Drought through Indigenous Knowledge Systems in North-eastern Ghana. *International Journal of Climate Change Strategic Management.* 5, 71–94.

Dhakal, S. and Sedhain, G.K.., 2016. Climate Change Impact and Adaptation Practices in Agriculture: A Case Study of Rautahat District, Nepal. Climate, 4, 63.

Etwire, P. M., Al-hassan, R. M., Kuwornu, J. K. M. and Osei-Owusu, Y., 2013. Application of Livelihood Vulnerability Index in Assessing Vulnerability and Climate Change in Northern Ghana. *Journal of Environment and Earth Science*, 3(2), 157-170

Feola, G., Lerner, A.M., Jain, M., Montefrio, M.J.F. and Nicholas, K.A. Researching farmer behaviour in climate change adaptation and sustainable agriculture: Lessons learned from five case studies. *Journal of Rural Studies*.2015, 39, 74–84

Ford, J.D., Berrang-Ford, L. and Paterson, J. 2011.A systematic review of observed climate change adaptation in developed nations. *Climatic Change*, 106(2), 327-336. Doi: 10.1007/s10584-011-0045-5.

Fosu-Mensah, B.Y., Vlek, P.L.G. and MacCarthy, D.S., 2012. Farmers' perceptions and adaptation to climate change: a case study of Sekyeredumase district in Ghana. Environment, *Development and Sustainability* 14: 495-505.

Goldberg JI, Borgen PI. Breast cancer susceptibility testing: Past, present and future. Expert Review of Anticancer Therapy. 2006; 6(8): 1205-1214.

Kahsay, G.A. and Hansen. 2016. L.G.The effect of climate change and adaptation policy on agricultural production in Eastern Africa. *Ecol. Econ*. 121, 54–64.

Kithiia, J. 2011. Climate change risk responses in East African cities: need, barriers and opportunities. *CurrentOpinion in Environmental Sustainability,* 3(3), 176-180. Doi:org/10.1016/j.cosust.2010.12.002

Kusakari, Y., Asubonteng, K.O.; Jasaw, G.S.; Dayour, F.; Dzivenu, T.; Lolig, V.; Donkoh, S.A.; Obeng, F.K.; Gandaa, B. and Kranjac-Berisavljevic, G. 2014. Farmer-perceived effects of climate change on livelihoods in Wa West District, Upper West region of Ghana. *Journal of Disaster Research*. 9: 516-528.

Laube, W., Schraven, B., and Awo, M. 2012. Smallholder adaptation to climate change: dynamics and limits in northern Ghana. *Climatic Change*, 111(3), 753-774. Doi: 10.1007/s10584-011-0199-1.

Lobell, D.B., Bänziger, M., Magorokosho, C. and Vivek, B., 2011. Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Climate Change*, 1(1), 42-45. Doi: 10.1038/nclimate1043.

Mabe, F.N., Gifty, S. and Samuel, D. 2014. Determinants of choice of climate change adaptation strategies in northern Ghana. *Research in Applied Economics* 6: 75-94.

Miyan, M.A. 2015. Droughts in Asian least developed countries: Vulnerability and sustainability. *Weather Climate Extremes*. 7,8

Mubaya, C.P., Njuki, J., Liwenga, E., Mutsvangwa, E.P. and Mugabe, F.T., 2010. Perceived Impacts of ClimateRelated Parameters on Smallholder Farmers in Zambia and Zimbabwe. *Journal of Sustainable Development in Africa*: 12(5): 170-186

Mustapha, S.B., Sanda, A.H. and Shehu, H. 2012. Farmers' Perception of Climate Change in Central Agricultural Zone of Borno State, Nigeria. *Journal of Environmental Earth Science* 2, 21–28.

Nielsen, J.O. and Reenberg, A. 2010. Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. *Global Environmental Change*, 20(1), 142-152. Doi: org/10.1016/j. gloenvcha.2009.10.002.

Nyantakyi-Frimpong, H., Bezner-Kerr, R.The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. *Global Environmentql Chang*e 2015, 32, 40–56.

Ochieng, J., Kirimi, L. and Mathenge, M. 2016. Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. *Journal of Life Science*. 77, 71–78.

Owusu-Sekyere, J.D., Alhassan, M. and Nyarko, B. K., 2011. Assessment of Climate Shift and Crop Yields in the Cape Coast Area in the Central Region of Ghana. *ARPN Journal of Agricultural and Biological Science* 6(2): 49-54.

Oyekale, A.S. and Oladele, O.I. 2012. Determinants of climate change adaptation among cocoa farmers in southwest Nigeria. *ARPN Journal of Science and Technology* 2: 154-168.

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), 119-125. Doi: 10.1007/s10113-010-0164-y.

Sutcliffe, C., Dougill, A.J. and Quinn, C.H. 2016. Evidence and perceptions of rainfall change in Malawi: Do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa? *Regional Environmental Change*, 16: 1215. doi:10.1007/s10113-015-0842-x

Oyekale, A.S. and Oladele, O.I. 2012. Determinants of climate change adaptation among cocoa farmers in southwest Nigeria. *ARPN Journal of Science and Technology* 2: 154-168.

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), 119-125. Doi: 10.1007/s10113-010-0164-y.

Sutcliffe, C., Dougill, A.J. and Quinn, C.H. 2016. Evidenceand perceptions of rainfall change in Malawi: Do maize cultivar choices enhance climate change adaptation in sub-Saharan Africa? *Regional Environmental Change*, 16: 1215. doi:10.1007/s10113-015-0842-x

Tiwari, K.T., Rayamajhi, S., Pokharel, R.K. and Balla, M.K. 2014. Determinants of the climate change adaptation in rural farming in Nepal Himalaya. *International Journal of Multidisciplinary and Current Research* 2: 2321-3124.

Uddin, M.N., Bokelmann, W. and Entsminger, J.S. 2014. Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: a farm level study in Bangladesh. *Climate* 2: 223-241.

Westra, S.; Alexander, L.V. and Zwiers, F.W. 2013. Global increasing trends in annual maximum daily precipitation. *J. Clim.* , 26, 3904–3918.