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Climate Change Adaptation Strategies and Constraints in Northern Ghana: Evidence of Farmers in Sissala West District

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Abstract: Research findings indicate that most African countries are vulnerable to climate change as a result of challenges such as poverty, weather extremes, and insufficient governmental agricultural support. For this reason, the researchers used the Sissala West District as a case study to determine factors influencing farmers' adaptation to climate change and strategies used to avert climate change impact. A total of 330 small-scale farmers were sampled for survey and 150 key informants were used in focus group discussions. Utilizing the logistic regression model, the study indicated irregular rainfall, high temperature, weather information, and high evaporation as the factors that highly influenced farmers' ability to adapt to climate change. A 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 the Environmental Protection Agency and the Ministry of Food and Agriculture intensify climate adaptation campaigns, increase access to weather information, and train farmers on adaptable strategies including, but not limited to, alternative sources of livelihood.

Keywords: adaptation; agriculture; challenges; effects; weather extremes

1. Introduction

Research has indicated that countries are experiencing climate change as a result of environmental degrading activities such as farming, wood logging, hunting, mining, and infrastructure development in an attempt to meet human needs [1]. Evidence of increasing carbon emissions, drought, poor rainfall, and high temperatures, including frequent natural disaster occurrence, indicates that climate change is increasing at alarming rate. Further research has revealed that current weather extremes already affect millions of people worldwide, putting food and water security at risk and threatening agriculture supply chains and many coastal cities [2]. Studies have established that natural disasters as a result of climate change disproportionally affect lower-income countries and that the economic losses of these countries mostly exceed 10% of their gross domestic product (GDP) [3]. The World Bank indicated that by 2050 the world would need to feed a population of about 11billion whilst tackling emission challenges, increasing carbon sink, and improving climate-resilient food security [4]. Furthermore, the world needs to provide affordable energy access to about 1.5 billion people worldwide living in remote places without electricity, while reducing emissions associated with energy generation to a minimum level and ensuring a transition from the use of fossil fuels [1–4]. As the population increases, human livelihood activities continuously trigger climate change. Studies have shown that Africa is vulnerable to climate change due to poverty, inadequate technology, economic challenges, weather extremes, and poor governmental agriculture policies [5]. Other studies have shown that financial, educational, sociocultural, institutional, and technological barriers in Africa increase farmers' vulnerability to climate change [3–5]. In addition, these barriers influence the ability of African countries to deal with malnutrition and conflicts, both internally and externally, that arise.

Weather extremes coupled with years of continuous farming on the same plot of land has rendered the soil infertile, worsening food security crises associated with climate change effect in Africa. Studies have shown that climate change is now perceived as a security challenge to Sub-Saharan Africa (SSA) as result of poor resilience [6]. This implies that weather extremes coupled with infertile soil and poor agriculture technology affecting productivity increase the vulnerability of farmers and households. As climate change adaptation research has extensively been conducted in regions such as Canada, Europe, Australia, parts of Asia, and the United States, Africa is grappling with good research on adaptation barriers hindering the implementation of adaptation strategies [4–6]. Climatic projections using existing data have indicated that prolonged and more intense droughts are likely to cause SSA to become drier by 2040 [1–3]. Other studies have also indicated that the determination of appropriate climate variation adaptation strategies in SSA is difficult due to different biophysical challenges related to geographical location [7]. Therefore, the prolonged drought, temperature, food security, and diseases that are repercussions of climate change should be tackled using perceived and pragmatic adaptations approach. Although the perception of climate change may not necessarily be consistent with certainty, it could be a useful part of a solution.

Studies have predicted that the current rate of environmental degradation and climate change in Africa will contribute to a faster rise in temperature in the 21st century and that this will affect food security due to the poor resilience of small-scale farmers, who are predominant in the agriculture sector [4–8].

Further findings have proven that West Africa experienced a significant increase in temperature between 0.5 °C and 0.9 °C from 1990 to 2010, and predicted that the magnitude is expected to increase by 2050 [9]. A similar study has revealed that excessive droughts in Northern Ghana have contributed to unseasonably high temperatures, soil infertility, and poor soil water retention capacity [10]. Northern Ghana, which used to produce approximately 40% of grains and legumes nationally in the past two decades, now produces less than 25% [11]. The use of fertilizer by farmers as a means of alleviating the adverse impacts of climate change in the region has not yielded satisfactory results. The Ministry of Food and Agriculture (MOFA) and related research institutions have proposed interventions such as crop diversification, agroforestry, drought-resistant crops, and livestock rearing as a means of combating the impact of climate change, but these measures have not adequately addressed poor conditions in the region [3].

Attempts by international organizations, nongovernmental organisations (NGOs), and governments to address the impact of climate change in SSA have encouraged some farmers to devise strategies to conserve soil moisture, reduce soil temperature, and improve soil fertility. As farmers employ their own means to reduce the adverse impact of climate change on livelihood, adaptation awareness has already been introduced to Africa. Adaptation is perceived as a process whereby vulnerable farmers and households adopt strategies to mitigate the adverse impact of climate variation on ecosystems and livelihoods [12]. Stakeholders and international organization efforts to tackle climate change have considered adaptation strategies as formidable policies to address extreme poverty, hunger, food insecurity, and other impacts associated with climate variability [13]. Similarly, feasible existing adaptation strategies could be aligned with new adaptation strategies that have the tendency to improve the environment within a short period for the benefit of farmers [1–6]. Therefore, adaptation constraints and strategies need to be backed by empirical data from farmers to enhance the clear distinction between the realities and perceptions of climate change. This implies that farmers' wellbeing could be improved if farmers' adaptation experiences form an integral part of climate change policy.

This study aims to assess adaptation strategies suitable for livelihood and microclimate improvement. It investigates constraints impeding farmers' efforts to cope with the adverse impacts of climate change. It also attempts to evaluate the effects of climate change on livelihood and agricultural practices. Lastly, the research again looks at the factors that influence farmers' ability to adapt to climate change in the Upper West Region of Ghana.

2. Materials and Methods

2.1. Study Area

The Sissala West District is found in the Upper West Region of Ghana, with its district capital situated at Gwollu as shown in Figure 1. It has a total land area of 411,289 km^2, which is about 25% of the total landmass of the Upper West Region. It can be found in the northeastern corner of the Upper West Region between longitude 23°00′ W and 2°00′ W and latitude 103°00′ N and 11°00′ N. According to the Regional Metrological Office, the annual rainfall is between 800 mm and 1000 mm and the mean annual temperature is in the range of 28° to 37°. The district, as well as the region, experiences a unimodal rainfall pattern annually between April and July, with few showers from August to October. The main natural resources of the district include vast arable land, guinea savannah vegetation for livestock rearing, and a very high population of economic drought-resistant trees such as dawadawa, shea, neem, baobab, and a few mahogany trees. A large portion of the natural ecology has been modified by human activities in the quest for human livelihood.

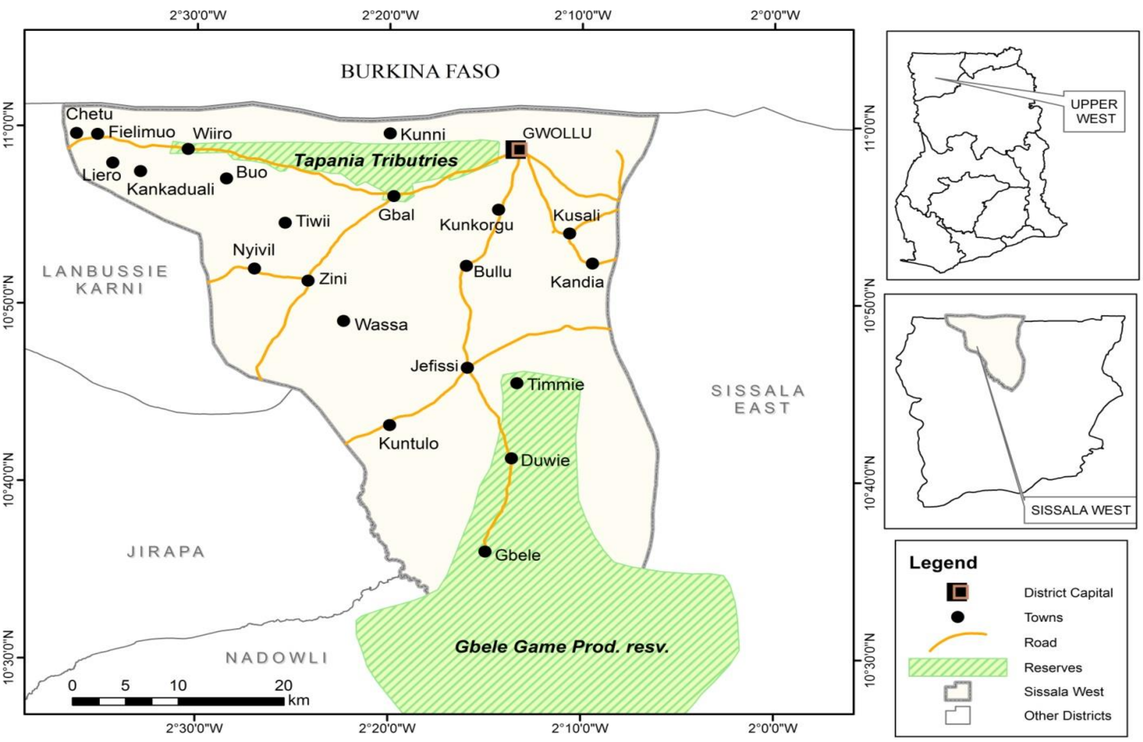

Figure 1. Map of Sissala West. Source: Sissala West District Assembly.

Agriculture is the main occupation for the majority of the indigenes in the district practice. The vast arable land has promoted the cultivation of cereals and legumes in all parts of the district. Apart from farming, charcoal burning, hunting, and wood logging are their alternative sources of livelihood.

2.2. Sample Size

The 2016 farmers updated census data, which were obtained from the District Agriculture Development Unit (DADU), showed that 39,134 of the population aged between 15 and 65 years engage in agriculture as a source of employment, with the majority being males. A total of 399 farmers were targeted for sampling but only 330 farmers actually participated in the survey. With the help of Agric Extension Agents (AEAs), 10 communities were selected and 30 farmers from each of these communities were randomly selected to take part in the survey with the aid of semi-structured questionnaires. 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 constraints and adaptation strategies farmers' use. The focus group discussions (FGDs) were used to solicit diverse views on issues surrounding adaptation constraints and strategies.

The participatory rural appraisal used in previous study as a community entry method [14] was initially used to assess the geographical features and settlements in the study area so as to determine the best approach in reaching respondents. Five field officers were trained and supervised to aid in data collection due to the dispersed nature of the settlements in the district. The period for collecting the data lasted four months, between February and June 2016.

2.3. Analyses of Data

The field survey data collected were analyzed with version 23 of the statistical package for social sciences (SPSS) software and illustrated as tables to give a clear view of respondents' opinions. A logic regression model which was used to determine the factors influencing adaptation was also analyzed with SPSS. Weighted Average Index (WAI) was also used to analyze farmer's climate change adaptation strategy, adaptation constraints, and weather extremes. A study involving the use of Weight Average Index (WAI) in Nepal to evaluate farmers' climate change adaptation strategy was efficient in the assessment [15]. Therefore, using WAI to analyze the impacts of climate change on variables such as crop weather extremes, constraints, and adaptation strategies were perceived to be efficient. 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 a 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, and irrigation were also ranked on a scale of 0–4 (0—not at all interested, 1—not very interested, 2—undecided, 3—somewhat interested, 4—very interested). Weather extremes were placed on a 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 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. The WAI of the respondents' variables was computed using the formula below:

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

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

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

2.4. Model of the Research

Multiple Logistic Regression Models

Logistic (logic) regression analysis is a widely used data analysis method that is similar to linear regression analysis except that the outcome is dichotomous (e.g., yes/no, low/high, or true/false). Logic regression is used to determine the odds of an outcome of an event. It was used here to determine factors having the possibility of influencing farmers' climate change adaptation. Other studies have established that logical regression is able to determine the likelihood of breast cancer sustainability among some groups of women in the United States [16]. 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:

$$\text{Logit}\ [P(outcome)] = \left[\frac{P(outcome)}{1 - P(outcome)}\right] = \{\text{b}_0 + \text{b}_1\text{X}_1 + \text{b}_2\text{X}_2 + \text{b}_3\text{X}_3 \ldots + \text{b}_\text{p}\text{X}_\text{p}\} \quad (1)$$

The probability of obtaining the outcome of the model is by exponentiating both sides of the equation as:

$$\left[\frac{P(outcome)}{1 - P(outcome)}\right] = \exp\{\text{b}_0 + \text{b}_1\text{X}_1 + \text{b}_2\text{X}_2 + \text{b}_3\text{X}_3 \ldots + \text{b}_\text{p}\text{X}_\text{p}\} \quad (2)$$

P is the expected probability that an outcome has the potential of being true or false. X_1, X_2, X_3, up to Xp are independent variables that predict the outcome of P; b_0, b_1, b_2, up to b_p are regression coefficients of the independent variables. To predict the odd outcome of an event with a known characteristic, substitute the applicable values into the independent variables and take the log of the expected outcome of the odds; this is expressed as:

$$\text{Ln}\left[\frac{Px}{(1 - P)}\right] = \text{b}_0 + \text{b}_1\text{X}_1 + \text{b}_2\text{X}_2 + \text{b}_3\text{X}_3 + \ldots\ldots + \text{b}_\text{p}\text{X}_\text{p} \quad (3)$$

From the model equation, P_x represents the probability of farmers being influenced by certain factors to adapt to climate change and $(1 - P)$ represents the probability of not adapting to climate change. Below is the questionnaire used to elicit information from respondents and focus group discussions (FGDs). The collected information was analyzed with SPSS, logic regression model, and WAI. Sample questionnaire used in the data collection is illustrated in Table 1.

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

Variables	How Variables Were Coded
* ***Factors influencing adaptation***	1 = adapted, 2 = not adapted (dummy variable)
Gender	1 = male, 2 = female
Education	1 = literate, 2 = illiterate
Farm labor	1 = family labor, 2 = hired labour
Household size	1 = 1–5, 2 = 6–10, 3 = above 10
Access to weather information	1 = yes, 2 = no access
Access to credit facilities	1 = yes, 2 = no access
Deforestation	1 = increasing, 2 = decreasing
Temperature pattern	1 = increasing, 2 = decreasing
Evaporation	1 = increasing, 2 = decreasing

Table 1. *Cont.*

Variables	How Variables Were Coded
* *Nature of weather extremes*	
Drought	1 = high, 2 = low, 3 = moderate, 4 = do not know
Dry spell	1 = high, 2 = low, 3 = moderate, 4 = do not know
High temperature	1 = high, 2 = low, 3= moderate, 4 = do not know
Flood	1 = high, 2= low, 3 = moderate, 4 = do not know
Reasons of adaptation	Improve soil fertility, reduce drought, reduce high temperature, promote yield
* *Effects of climate change*	List of effects by respondents
** *Constraints of adaptations*	
Poor weather information	1 = high, 2 = moderate, 3 = low
High cost of input	1 = high, 2 = moderate, 3 = low
Inadequate extension officers	1 = high, 2 = moderate, 3 = low
Inadequate credit facilities	1 = high, 2 = moderate, 3= low
High rate of deforestation	1 = high, 2 = moderate, 3 = low
Inadequate government support	1 = high, 2 = moderate, 3 = low
Unpredictable weather	1 = high, 2 = moderate, 3 = low
Poor adaptation strategy	1 = high, 2 = moderate, 3 = low
High rate of deforestation	1 = high, 2 = moderate, 3 = low
** *Adaptation strategies*	
Planting season variation	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Drought resistant crops	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Agroforestry	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Irrigation	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Inorganic fertilizer	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Different farming systems	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Use of virgin lands for farming	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested
Mulching/composting	1 = not at all interested, 2 = somewhat interested, 3 = undecided, 4 = interested, 5 = very interested

* Factors influencing adaptation, * weather extremes, * climate change effects—questionnaires for farmers. ** constraints, ** adaptation strategies questionnaire for focus group discussions (FGDs) comprising Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA), District Assembly, nongovernmental organisations (NGOs), and Farmer Base Organisation (FBO).

3. Results and Discussion

3.1. Factors Influencing Farmers' Climate Change Adaptation Decisions

Table 2 represents the analysis of the logistic regression model, which was used to determine variables influencing farmers' climate change adaptation. Variables such as farmer experience, membership of FBO(s), and adaptation method were considered redundant as a result of multicollinearity between the variables; hence, those were removed from the analyses.

Farmers in Ghana generally practice rain-fed agriculture, but irrigation is also used to produce fresh vegetables on a small scale. The unimodal rainfall pattern average between 800 mm and 1000 mm in northern Ghana renders farmers highly vulnerable to climate change as result of the underutilization of insufficient irrigation facilities to supplement rainwater [17]. Other studies have shown that the bimodal rainfall pattern average between 1200 mm and 1500 mm in Southern Ghana renders farmers less susceptible to poverty and climate change than farmers in Northern Ghana experiencing weather extremes and a low rainfall average between 900 mm and 1100 mm [18]. Savanna zones characterized by unimodal rainfall create a short cropping season and long drought period, threatening food security in situations where no irrigation facilities are used to supplement rainfall [19]. Related studies have indicated that the income of rural farmers who rely on irrigated agriculture is 80% higher than those who practice rain-fed agriculture because irrigated farmers produce fresh crops throughout the year [20]. The study indicated that areas located in the guinea savanna zone face challenges of weather extremes; therefore, the rainfall pattern with the highest coefficient has the high tendency to influence farmers' decision on climate change adaptation strategies. Further studies have shown that farmers in high drought and high temperature area have a tendency to easily adopt technology at any giving cost to improve soil moisture and temperature for good yield [21]. The poor rainfall pattern in the region causing drought and high temperatures compels some farmers to engage tractor services and extra labor for ploughing, sowing, fertilizer application, and harvesting to avoid climate change-associated challenges.

Table 2. Logistic regression model results of factors influencing climate change adaptation ($N = 330$).

Variable	Coefficient	Standard Error	*p*-Value
Constant	7.187	1.537	0.001
Education level	4.233 *	1.256	0.003
Farm labor	0.498	2.129	0.002
Household size	3.453 *	1.129	0.001
Erratic rainfall	6.337 *	1.186	0.001
Access to weather information	4.328 *	2.291	0.001
Access to credit facilities	−3.410 *	1.276	0.008
Farm size	0.939	1.346	0.004
Access to extension service	4.011 *	1.349	0.005
A high rate of deforestation	6.058 *	2.222	0.000
Distance average covered by a farmer	0.258	1.148	0.082
High temperature	3.259 *	1.070	0.000
A high rate of evaporation	5.377 *	1.165	0.003

Source: Field survey 2016. * represents a significance level of 5%.

Forest and trees are vital for carbon sinks and sequestration. Therefore, deforestation contributes to climate change and constitutes a threat to ecosystem improvement. About 850 million hectares of forest in the world that could support biodiversity and improve ecosystem as well as contribute to climate change adaptation and mitigation have been degraded through human activities and natural disasters [16].

Studies have also asserted that deforestation is a key factor compelling farmers' to intensify climate change adaptation capability in order to curb biophysical challenges and save economic trees in the environment [18]. Other studies have established that fallow land for biomass production in Zimbabwe significantly improved maize production continuously for five years compared to post fallow land, which used nitrogen fertilizer for maize production on the same piece of land [9]. This suggests that trees improve soil fertility and support cropping for a longer period of time than inorganic fertilizer. Charcoal production and wood logging serving as alternative sources of livelihood have led to the loss of many different species of trees (shea, dawadawa, neem, mahogany, etc.) with economic and medicinal value in the study area. This study showed that the likelihood of farmers adapting to climate change increases with high deforestation threat in order to conserve trees of direct economic benefit.

Generally, most farmers would promptly respond to climate change adaptation in the event that high temperatures increase soil moisture evaporation. This implies that high evaporation rate is likely to influence farmers' preparedness for adapting to climate change. Personal observation and interactions indicated that high temperature increases the evaporation of water bodies, especially those exposed to the direct impact of sunlight. It was interesting to also note that most of the water bodies had no trees at their banks to form a watershed, thus contributing to the frequent loss of water through the evaporation process.

Access to weather information enables farmers to plan ahead and adopt measures to curb climate variability impact [22]. Further studies have suggested that access to weather information increases farmer preparedness for heat stress, drought, and pest and weed invasion [14]. This study revealed that regular weather information assessed with a high coefficient has a high likelihood of influencing farmers, in comparison to those with irregular or no access to weather information. This implies that regular access to weather information has the tendency to increase farmers' climate variability consciousness.

The analyses also showed that education has a strong positive correlation with adaptation to climate change. It is believed that educated farmers mostly understand and easily apply new technologies or skills acquired on their farms, as compared to uneducated ones. Studies have suggested that climate change adaptation strategies chosen by farmers should be those easily applied without stress to encourage easy adaptation [4–21]. 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 [23]. Though uneducated farmers can also apply new adaptation technology on their farms, those involving calibration, reading, and precision would be more easily utilized by 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. This 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 [24]. The farmer to agriculture extension officer ratio in Ghana is on average 1 extension agent: 3000 farmers, making it difficult for extension officers to visit farmers on regularly [9]. Generally, agriculture extension officers in Ghana work under deplorable conditions due to inadequate government funding. As a result, most were hesitant to urgently help farmers when the need arose.

According to the research, household size also has the possibility of influencing climate change adaptation. This study showed that large households are more likely to adapt to climate change than small households due to the greater availability of labor for more demanding adaptation strategies. A related study indicated that communities with scarce or high labor cost rely on family labor to adapt to climate change in order to ensure continuous good yield [2–25]. Nevertheless, a small household could also adapt to climate change, but due to the scarcity or high cost of labor in the area, they are not able to expand their farms as large household may be able to do.

An intensity of temperature could influence farmers' decision on climate change adaptation strategy. Previous 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 [26]. The research analyses indicated that the tendency of farmers to adapt to climate change increases with high temperature. The inference drawn from the study is that farmers usually look out for measures to curb the impact of high temperature on crop yield and soil moisture. Meanwhile, when temperatures do not pose much threat to crop production, farmers reluctantly adopt mitigation strategies [26].

Access to credit facilities had a negative correlation with climate change adaptation. Personal observation and interaction with the farmers suggested that difficulties in accessing credit coupled with high interest rates make credit facilities unattractive. This has compelled most farmers to rely on their own meager income to purchase farm input. 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. Further studies have shown that farmers with easy access to credit facilities have high preferences for adapting to climate change compared to those without access to credit [27], as some adaptation strategies affect the cost of production.

3.2. Weather Extremes in the Study Area

The nature of weather extremes in the study area, shown in Table 3, was obtained directly from farmers during the survey, but was verified by the Regional Metrological Office. The Likert scale used to evaluate farmers' (respondents') opinions indicated that, among all of the weather conditions threatening to farms, drought was seen as the most serious weather extreme. Frequent drought hardens the topsoil, preventing the use of rudimentary tools such a hoes and cutlasses. Farmers who seek tractor services pay a high amount when the soil is dry and hard as a result of the drought.

Table 3. Nature of weather extremes in the 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

Source: Field survey 2016.

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 revealed that extensive livestock rearing system practiced in the study area exposes livestock to the direct impacts of high temperatures. This affects feeding, reproduction, disease prevention, and the health of livestock. According to the farmers, dry pastures and heat stress as a result of high temperatures during dry seasons result in poor feeding, poor growth, and the death of their livestock. Furthermore, other studies have also indicated that high temperatures affect the growth, harvesting, and storage of highly perishable crops including vegetables such as tomatoes, pepper, onion, and eggplant, thus also increasing farmers' vulnerability to climate variations [28].

Dry spell with a WAI of 1.85 was ranked third in order of impact on agriculture. 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, form small cobs when dry spell sets in at the tasseling stage. Flood, which has been one of the major impacts of climate change worldwide, was ranked last with a WAI of 1.59. This is perhaps due to the low annual rainfall in the study area. Flooding is not common in the study area is as a result of the low rainfall and high evapotranspiration.

3.3. Farmers' Perceptions of Climate Change Adaptation

Willingness to adapt to climate change could boost farmers' proactiveness in finding suitable solutions to address climate change issues. Creating microclimates to enhance livelihood activities would be of essence to communities with climate change challenges [29,30]. Perceptions of adaptation to climate change were assessed through a formal interview with the aid of a semi-structured questionnaire. Data analyses illustrated in Table 4 showed that 30% (*N* = 99) of farmers were of the opinion that the main reason why most farmers adapt to climate change is to achieve food security. Therefore, government subsidizing farm input and providing farmers with insurance would enhance farmers' adaptation strategy to boost soil fertility as well as promote good yield.

The study also indicated that reducing dry spell effect represents 23.6% (*N* = 78) of farmers' perception of climate change adaptation. Farmers have resorted to using improved seed, crop diversification, and early maturing crop varieties to avert the impact of the dry spell on farming. Furthermore, the study showed that 23% (*N* = 76) of farmers adapted to climate change in order to reduce drought on their farm. Research has shown that as farmers in Africa practice rain-fed agriculture; thus, irregular rainfall mostly compels farmers to change planting season to reduce or avoid the effects of drought and dry spell on crops [31,32]. Further interactions revealed that some farmers have attempted using afforestation, agroforestry, and mulching to improve the soil moisture content. As Northern Ghana is noted for poor rainfalls and high temperature, early planting and drought-resistant crops could help farmers obtain good yield as well as reduce the impact of bad climatic conditions [6].

Table 4. Perceived reasons for adaptation to climate change. Source: Field survey 2016.

Variables	Frequency	Percentage	Adaptation Practices Evaluation
Agriculture input subsidies	99	30	Creating good microclimate
Reducing dry spell effect	78	23.6	Early maturing crops and timely planting
Reduce drought	76	23.0	Agroforestry and mulching
Improve soil fertility	72	21.8	Mulching, farmyard manure, zero tillage, and agroforestry
Reduce high-temperature effect	5	1.5	Tree planting and reducing deforestation
Total	330	100	

Soil fertility improvement was also considered by 21.8% (*N* = 72) of farmers as a good reason for adapting to climate change. Farm practices including mulching, composting, zero tillage, use of leguminous crops, and agroforestry serve as good interventions for soil nutrient improvement [33]. Interactions with farmers revealed that preferences are mostly given to low-cost cultural practices for yield-boosting and climate variation adaptation. High temperatures were perceived as a serious threat contributing to environmental degradation. The study indicated that 1.5% of farmers (*N* = 5) adapt to climate change due to high temperatures affecting crop growth, yield, storage, and soil moisture; this is similar to studies by Reference [29] indicating that heat stress and evapotranspiration affect crop yield and yield quality (e.g., biochemical composition and biomass accumulation) of farms located mostly in the savanna zone. The presence of high temperatures in the study area contributes to the frequent dry-ups of dams, dugouts, and other water bodies serving as sources of drinking water for both livestock and households. Information gathered during the study suggested that the indigenes consider high temperature as an unavoidable condition due to the guinea savanna location of the area.

3.4. Farmers' Assessment of Perceived Effects of Climate Change

Climate change has numerous direct and indirect effects on the economy, environment, and lives of people. These effects may be long or short-term. 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 as illustrated in Table 5 indicates that 24% (*N* = 79) of farmers were of the opinion that climate change affecting yield increases 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 the farm yield [34]. Interactions with the farmers indicated that farmers with a poor harvest often allow their old farms to lie fallow and travel miles away from home to clear new fertile lands to improve the yield. This implies that farmers who have no alternative means to adapt to climate would be tempted to degrade the environment in order to acquire fertile land for good yield. Nevertheless, land scarcity coupled with land tenure issues as a result of population growth makes it difficult for farmers to use land rotation to improve their situation.

Low rainfall couple with high temperatures increase the frequency of the dry-up of water bodies such as wells, dams, and streams; this in consistent with Reference [29], which suggested that irregular precipitation and warm temperature affect the strengthening predictive capacity and forecasting baseline actions aiming at water conservation for agriculture purposes. The study showed that 18.2%

(N = 60) of farmers usually have serious challenges with water supply, hence preventing them from engaging in dry season gardens as an alternative livelihood to supplement their food and income. Also, access to potable drinking water for livestock and human is often a big challenge during the dry season.

Table 5. Farmers' perceived effect of climate change.

Variables	Frequency	Percentage	Actual Effects Evaluation
Poor yield	79	24	Hunger and food insecurity
Frequent water shortage	60	18.2	Poor source of drinking water, inadequate irrigation activities in dry season, poor livestock watering
High cost of farming	54	16.4	High cost of input, high credit facilities interest rate
Unemployment	48	14.5	Poor living standards, poverty, conflict, theft
Forest degradation	41	12.4	Bare land, soil erosion, high soil temperature, high moisture evaporation
High cost of living	29	8.8	Low-income savings, poor living standard
Poor health	19	5.8	Low crop production
Total	330	100	

Source: Field survey 2016.

The survey indicated that 16.4% (N = 54) of farmers perceived the high cost of farming to be one of the serious effects of climate change. The farmers stated that climate change has created high demand for farm inputs including fertilizers, improved seeds, and tractor services. It was also realized that a high input demand for yield improvement has led to the high cost of inputs, apparently increasing the cost of farming.

This study revealed that unemployment is one of the impacts of climate change that farming communities are likely to face in the event that early warning systems and probable scenarios of climate change are ignored. Although a 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. 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. Research findings on the correlation between climate change and employment showed that the impact of climate change on soil fertility increases risk of poverty and hunger in developing countries, especially in Sudan and Sahel regions of Africa [35,36]. Related studies have also indicated that externalities associated with climate change including keen competitions in peri-urban areas for food production could create land tenure issues [37].

The study showed that 8.8% (N = 29) of farmers were of the view that climate change could lead to a high cost of living in communities with farming as their only source of livelihood. The high cost of farm inputs to improve soil fertility and yield could eventually lead to a high cost of food production, hence affecting food security.

The research further showed that among the effects of climate change realized during the field survey, 12.4% (N = 41) and 8.8% (N = 29) of farmers respectively perceive forest degradation and the high cost of living as serious adverse effects of climate change on farmers livelihood. The farmers were of the view that continuous reliance on the forest for basic necessities including herbs, food, and shelter affects biodiversity conservation.

Climate change poses a threat to food security and the 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 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 [38]. The tendency of human vulnerability to diseases is high when exposed to bad weather conditions.

3.5. 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 FBO groups (Farmer-Based Organizations; 10 members from each FBO group) to ascertain the best and easy adaptation strategies suitable for improving climatic conditions in the district to aid in boosting agriculture and improving livelihood. The various opinions gathered during the discussions were computed and ranked as shown in Table 6. The adaptation strategies analyzed were the cross-cutting issues which the majority of participants listed as the most preferred strategies to address climate change challenges.

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

Variables	Not at All Interested	Not Very Interested	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: focus group discussions (FGDs) 2016.

The FGDs' responses perceived agroforestry practices (WAI = 2.98) as the best adaptation method to improve microclimate, boost soil fertility, and reduce the high intensity of direct sunlight on the crops and soil nutrients. In the course of the study, it was realized that some farmers were already intercropping teak, cashew, and mangoes with cereals and legumes. Related findings by Reference [34] indicated that alley and taungya farming—both forms of agroforestry—improve soil fertility, increase yield, and retain soil moisture in addition to reducing evapotranspiration. Furthermore, apart from improving vegetation cover and increasing carbon stock, cash crops used in agroforestry could be harvested in the future for additional income. Using improved seed (2.94 WAI) was ranked second in order of relevance to climate change adaptations by the participants. Farmers and other opinion leaders suggested that improved crops could withstand drought, high temperature, and dry spell. Farmer-Based Organizations (FBOs) who had already resorted to using improved seeds attested that there had been a significant yield improvement.

Farm manure/mulching (WAI = 2.79), which was third in ranking, was seen as a good adaptation strategy to help boost soil fertility since most of the farmers have lots of livestock and crop residues. In the course of the discussion, it was realized that few farmers rely on their farm byproducts for mulching and composting. 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 [29].

Planting season variation (WAI = 2.76) was seen also 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 could prepare farmland and make all other necessary input ready so as to sow without delay as soon as the rain starts. 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 the irregular rainfall pattern in the study area.

Different farming systems (WAI = 2.74) such as crop rotation, mix cropping, and land rotation were also seen as good adaptation measures. Crop rotation was seen as a farming system that can help farmers to grow different crop varieties when weather conditions are irregular due to climate change. In addition, mix cropping was seen 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 farming systems but was not considered suitable because of high land demand for a different purpose. Land rotation in recent times is unconducive for climate change adaptation as land is becoming a scarce resource due to population growth [30]. However, land rotation would help in a situation where farmland could lie fallow for some years to regain fertility.

Using irrigation methods (WAI = 2.64) as an adaptation strategy was ranked sixth in order of relevance to climate change adaptation. This was seen as a viable method that can help improve crop production in places with poor rain, high drought, or dry spell. Farmers were of the view that dugouts, dams, and wells near their farms or homes for irrigation could help in vegetable gardening, thereby supplementing farm yield. Personal observation showed that irrigation improvement could contribute tremendously to reduce hunger in places with a poor climatic condition.

The FGDs also indicated that inorganic fertilizer (WAI = 2.5) was ranked seventh in order of importance to adaptation strategy. This was seen as expensive but efficient with a rapid result. The opinions from the discussions revealed that, if the government subsidizes fertilizers, poor farmers can easily access fertilizers to help increase yield. Though the fertilizer would not improve soil structure, the nutrients in the fertilizer will help boost yield even if the climatic conditions were not favorable.

The use of virgin land for farming (WAI = 2.49) was also seen as a good adaptation strategy since new farmland would be more fertile than the old farms. However, the concerns raised indicated that encouraging farmers to clear new areas in order to increase yield would create massive deforestation. As a result, it was not considered one of the best adaptation strategies.

Alternative livelihood (WAI = 2.1) was ranked as the last option in the FGDs. This low ranking conforms to the response by farmers and opinion leaders disagreeing with using charcoal production, hunting, and wood logging as a means of an alternative livelihood. Evidence of research established that alternative sources of livelihoods such as beekeeping, weaving, livestock rearing, and dry season gardening reduced over-reliance on the main farming season for food and income [39]. The participants were of the view that low-income levels coupled with the lack of large market centers do not augur well for using trading as an alternative livelihood. However, the opinions of the FGDs suggested that encouraging farmers to give serious attention to dry season gardening, livestock rearing, beekeeping, and weaving will help reduce dependence on farms for survival.

3.6. Constraints Impeding Climate Change Adaptation

The Likert scale was used to assess numerous challenges impeding farmers' climate change adaptation strategy. The study as shown in Table 7 established that among the main constraints considered as impediments to adaptation, unpredictable weather conditions were perceived as a serious constraint affecting farmers' efforts to curb climate change impact on the environment as well as farmland. Predictable weather would provide statistical data on past and present changes in the weather trends so as to anticipate effects and prepare suitable responses to face extreme occurrences [29–33]. While the study showed that unpredictable weather (WAI = 1.91) was perceived as an obstacle to farmers' abilities to plan ahead or use suitable adaptation strategies to curb climatic changes in the study area, related research indicated that unpredictable weather and poor agriculture support in East Africa compelled farmers to devise different strategies to cope with climatic conditions [40,41]. This implies that in an attempt to reduce the adverse impact of unfavorable climatic conditions, farmers utilize different adaptation strategies until they settle on those most suitable to improve their livelihood.

Inadequate government support (WAI = 1.83) was ranked second in the order of adaptation constraints by farmers in the study area. Farmers were of the view that poor government support for the agriculture sector increases farmers' vulnerability to climate change impact. The study indicated that the high cost of inputs including tractors services, improved seeds, and farm labor hinders farmers' efforts to mitigate challenges associated with climate change. Furthermore, the discussions indicated that poor anticipation by government agencies including the Metrological Services Department and MOFA on how climate will affect farmers live now and in future, leading to inability to make provisions for uncertainty, is a result of poor government funding of the agriculture sector.

Access to weather information is very vital in helping farmers to plan ahead against any unexpected outcome on their farms as well in reducing shock effects [42]. Inadequate weather information, ranked third, was also perceived as a serious concern due to the ineffective flow of weather information between the Metrological Services Department (MSD) and MOFA before reaching the farmers. Related studies indicated that ideally, effective correspondence between MOFA and MSD would enhance well-integrated data for monitoring weather conditions and providing appropriate predictions for risk assessment [9]. Land tenure issues, which ranked fourth, were also considered a serious constraint because most of the farmlands belong to families, communities, or the government, hence preventing farmers from committing resources into farmland management. Information gathered indicated that, for fear of losing farmland due to land ownership issues in the study area, farmers mostly do not risk improving the fertility of the land.

The analyses of the FGDs showed that the high cost of inputs as a result of the importation of most agricultural inputs including fertilizer, weedicides, and insecticides affects smallholder farmers' purchasing power. As climate change adaptation entails a direct or indirect cost, opinions gathered during the discussion revealed that most farmers in the study area perceive high input cost as a setback to adaptation. Research findings revealed that high input cost prevents poor smallholder farmers from accessing the needed farm inputs for climate change adaptation [43].This is similar to a study by Reference [44], which asserted that as a result of poor climatic conditions in Northern Ghana, farmers have resorted to using improved groundnut seeds as an adaptation strategy; however, the high cost of the purported improved seed compelled most farmers to use unimproved seeds from local the market.

Inadequate extension officers coupled with a lack of logistics hinders proper extension services. Similarly, the abysmal performance of extension officers in Ghana is a result of the poor farmer-extension officer ratio (1:3000), which is higher than that proposed by the World Bank (1:1500) [9]. This invariably undermines the dissemination of information to farmers and the organization of farm demonstrations to improve adaptation skill. Intercontinental studies of agricultural extension officers training and resourcing have indicated that extension officers in Africa are poorly trained and under-resourced [45]. This study indicated that in most cases, farmers in remote areas without access to extension officers keep trying different adaptation methods based on experience until a suitable one is reached.

The study showed that uneducated farmers have a low tendency to adapt to technologically inclined strategies in order to tackle the adverse effects of climate change. On the other hand, deliberations during the FGDs hinted that there is a higher tendency of educated farmers to adapt to climate change strategies involving skill or technology compared to uneducated farmers. As most farmers in the study area are uneducated, they prefer simple adaptation technologies to avoid any uncertainty. Studies conducted in Burkina Faso using planting distance and fertilizer application to assess ease of adapting to climate change proved that educated farmers adapted more easily to the strategy than uneducated farmers [46].

The FGDs indicated that poor soil fertility as a result of continuous farming on the same piece of land for decades is highly affected by climate change. The research also indicated that poor soil fertility was considered a constraint because infertile soil cannot support an adaptation strategy such as agroforestry, which takes a long period to improve soil fertility. Farmers' continuous reliance on the same piece of land for farming prevents any strategy that allows the land to lie fallow for some period [35]. According to the responses from the group discussions, some farmers have resorted to acquiring a loan to purchase fertilizer to boost their yield instead of using compost and agroforestry practices, which take some time before improving the soil fertility.

Table 7. Constraints impeding climate change adaptation and evaluation of responses.

Variables	High	Moderate	Low	Not Sure	WAI	Rank
Unpredictable weather	54	35	20	41	1.91	1st
Inadequate gov't. support	53	39	22	36	1.83	2nd
Poor weather information	46	29	48	27	1.73	3rd
Land tenure issues	52	34	39	25	1.72	4th
High cost of input	51	37	41	21	1.64	5th
Inadequate extension officers	49	47	29	25	1.63	6th
Lack of formal education	53	49	25	23	1.61	7th
Poorsoil fertility	51	57	23	19	1.51	8th

Source: key informants, FBOs, opinion leader discussions (2016).

4. Conclusions

This study showed that climate change is considered a serious environmental challenge affecting the food security and livelihood of farmers in Northern Ghana. 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 minimized 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 the easy dissemination of weather information.

High farm input cost as a result of the importation of most agricultural inputs coupled with a poor government commitment to the agricultural sector restrains farmers from acquiring the 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 the easy acquisition of needed input for adaptation and yield improvement.

Land tenure issues were identified 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 the 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 the inability of farmers to afford farm input such as fertilizers, weedicides, and tractor services increases farmers' susceptibility to climate change impact. Therefore, cultural practices including improved seeds, changes in planting season, drought-resistant crops, short duration crops, composting, and mulching could serve as good interventions for climate change resilience.

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, further campaigns to encourage livestock rearing, beekeeping, weaving, and irrigation as alternative livelihoods should be undertaken to reduce reliance on rain-fed agriculture. Farming communities are becoming skeptical about the efficiency of current climate change adaptation strategies; therefore, further research for more efficient and less expensive adaptation strategies to improve farmers' resilience to climate change is of the essence.

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