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Smallholder Farmers Perception of Climate Change and Adaptation Strategies of Rural Livelihoods in the Berekum Municipality, Ghana

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Abstract

It is noted that climate change would have severe environmental, monetary, and social impacts in Ghana particularly among the rural farmers whose livelihoods depend on natural resources and rain-fed agriculture. This study assessed farmers' perception of climatic factors and the adaptation strategies that influence their farming livelihood. The study employed a survey using a semi-structured questionnaire involving 93 farmers from three communities fringing Taint II forest reserve in the Berekum Municipality. From economic perspective majority of the respondents were full-time farmers. It was also observed that both traditional and scientific methods were used by the farmers to predict weather changes. The majority of the respondents have noticed changes in temperature patterns for the past ten years, which was attributed to: Deforestation, God's punishment, Bush burning, High sun intensity and Erratic rainfall. The study further revealed some adaptation strategies employed by the farmers such as: Creating fire belts to prevent fire outbreak in the drying seasons, creating water channels on their farmland to prevent erosion, planting crops that can withstand excessive rain and drought and mixed cropping to overcome livelihood challenges resulting from climatic factors. Nevertheless, most of the respondents have no adaptation strategies, as indicated by the phrase 'doing nothing'. The study, therefore, calls for intensive education among farmers on adaptation strategies in this forest-savannah transition zone to overcome climatic factors affecting their livelihoods. Also, the identified autonomous adaptation strategies should be assessed and promoted among farmers since the majority do 'nothing' during extreme changes in temperature and rainfall. These should be championed by the Forestry Commission Environmental Protection Agency and Ministry of Food and Agriculture and the Municipal.

Keywords: Smallholder farmer; Rural livelihoods; Adaptation strategies; Climate change; Ghana

Introduction

Generally agriculture landscape provides economic, socio-cultural, and ecosystem services to the wellbeing of the populace. According to approximately 2.5 billion people directly depend on an agricultural production system [1]. Livelihood consists of capabilities, assets, and activities required for a living, and it is sustainable when it can be adjusted with and recover from shocks [2,3]. Livelihood is, therefore, sustainable when it focuses on the mobilization of assets, capabilities, capital to enhance wellbeing and protect the environment [4,5]. It is noted that households often depend on a diverse portfolio of livelihoods in their struggle for survival to improve standards of living [6]. The sustainability of a livelihood system is a function of two features: Sensitivity and resilience. A livelihood is sensitive when it is negatively affected by external shocks such as drought, also the resilience of livelihood is the period required for a system to adapt and recover from the shocks [7]. Rural households obtain a livelihood from agriculture, rural labor market, and self-employment in the rural non-farm economy to towns, cities, and other countries [8]. About 60-70% of the population of Sub-Saharan Africa lives in e areas where the people are vulnerable to poverty and deprivation. Since households in rural areas depend directly or indirectly on agriculture and given the immense contribution of this sector to the overall economy it should be an integral element of development and growth. Growth resulting from Agriculture has played a vital role in reducing poverty and enhancing the economies of many Asian and Latin American countries; nevertheless, these effects have not been fully realized in Africa noted that the livelihoods of rural households differ across regions and countries where the majority of rural households depend on one type of activity others have diversified their livelihood base to reduce climatic and non-climatic risks [9-11]. Agriculture activities often face several risks leading to economic hardship to rural households thus making them vulnerable and needy explains livelihood assets as the resources of production accessible to a specific individual, household or group that can be used in their livelihood activities [12-16].

However, agriculture is sensitive to climate variations, which imply productivity [17]. Climate change is one of the topical issues of our time. It is now more confident than ever, based on many lines of evidence, that humans, through their many activities, are changing the earth's climate. According to there are two leading causes of this effect [18]. That is, climate variability attributable to natural causes such as modulations of the solar cycles, volcanic eruptions, forest fires, meteorites, etc. and climate change attributable to ongoing human activities. However, there are several anthropogenic and land use activities, such as the combustion of fossil fuel, deforestation, construction, mining, transportation, and agricultural activities [19]. The natural and anthropogenic activities have increased the concentration of Green House Gases (GHG's) in the atmosphere, a primary driver of climate change and the extensive warming of the earth's surface [20].

Africa is vulnerable to climate change due to factors such as widespread poverty, land tenure litigation, and overdependence on rain-fed agriculture [21,22,8]. Climate change effects as a result of natural and anthropogenic factors manifested by floods, droughts, erratic rainfall patterns, and extreme events have had an ultimate effect on the Gross Domestic Product (GDP) and the livelihood of rural communities depending on rain-fed agriculture reported that the changes in rainfall and temperature in drought-prone areas are likely to increase the population of pests and diseases in both humans and crops, hence resulting in low yields of output and reduction in income levels [23,24]. It is reported that about 70% of Ghana's population derives their livelihood from agricultural activities the forest, and other non-farm activities [19]. The forest-savanna transition zone is considered as the primary area of food production in Ghana asserted that agriculture activities are mostly affected by irregular rainfall patterns and prolonged drought periods which also influence soil moisture content [25,26]. Inadequate rainfall will lead to poor seed germination and seedling emergence, which will retard crop yields. However, the reduction in agricultural productivity is also linked to non-climatic factors, such as soil infertility, an infestation of pests and diseases, and inadequate extension services reported of two most critical climatic elements which facilitate the occurrence and localization of pest and disease vectors when temperature is high under conditions of optimum water supply.

Ghana Statistical Service (2010) gives a summary of livelihood activities in the Berekum Municipality. Agriculture is the primary economic activity of which 57 % of the population engages in for their livelihood [27]. The farming activities in the Municipality are crop farming, tree planting, livestock rearing, and fish farming. Within the urban localities, the majority of the households are into crop farming activities, and livestock (Ibid). Agricultural systems depend on reliable water sources, and in most developing countries, agriculture production is rain-fed. However, with the current warming effect, there is an alteration in rainfall patterns with huge uncertainties [28]. This adversely had led to a reduction in yield and productivity of arable crops and livestock since their performance depends much on environmental conditions. Increases in temperature and a decline in rainfall will result in ecological stresses that could weaken the functioning of ecological systems, mostly in terms of plant development and growth [29]. Climate change Adaptation encompasses alleviating the effects of climate change by regulating policies, processes and strategies. Climate change adaptation is classified as either independent (autonomous) or planned (policy-driven). An autonomous adaptation is a farmer-driven action at the micro-level to overcome climatic and non-climatic challenges. The planned adaptation is macro-level, often facilitated by the government or the development partners and private sector to efficiently regulate threats or actualities of climate change reported that provision of low-interest credits enables Ghanaian based smallholder farmers to invest in essential inputs (e.g improved seeds, fertilizers and agrochemicals) and machinery that alleviate their susceptibility to climate change [30-32]. Several management practices will enable smallholder farmers to acclimatize to climate variability and change. It includes changing planting dates, crop selection, exploiting the spatial variation of landscape-situating fields in fertile areas and proximity to water sources, conservation agriculture practices [33-35]. An example of adaptation practice is agroforestry, which maximizes amounts of fodder for livestock, leads to shading of livestock and crops from extreme temperatures, maintain the soil fertility, reduces erosion and also increases crop productivity asserted that the output of extension services in Ghana is weak and must be strengthened by providing sufficient support to their fundamental activities [36,37].

Additionally supporting the local inputs procurement and distribution facilities establishment *via* tactical public-private partnerships will increase the availability of essential inputs in rural areas [38]. However, in major Sub-Saharan countries like Ghana, insufficient funding, and inadequate capacity of institutions often make these expensive policies impossible [39]. According to "different socio-economic groups of households (the well-off, intermediate and poor) have differently pursued multiple adaptation strategies (e.g., growing of drought-tolerant crops, wetlands cultivation, and diversification to non-farm activities) depending on their livelihood assets". The Berekum Municipal is an agrarian community where farmers depend on rain-fed agriculture. Nevertheless, there has been a reduction in agricultural productivity due to changes in the climatic factors and non-climatic factors. The paper aims to explore how smallholder farmers in the Berekum Municipality perceive climate change how rainfall and temperature changes affect their livelihoods and means of overcoming these challenges in their agrarian livelihood.

In the next section, we touch on the methodology employed for this study. The results and discussion relating to the relevant literature section look at smallholder farmers traditional and scientific knowledge of predicting and access weather information. We also present and discuss farmers perception of climatic factors (i.e., rainfall and temperature) on their livelihoods and measures accessible to farmers in adapting to climate change. The concluding section synthesizes the findings and makes suggestions for policy recommendations.

Materials and Methods

The study area

The study was undertaken in three communities fringing Tain II forest reserve in the Berekum Municipality of the Bono Region of Ghana, namely Kutre No.1, Oforikrom and Namasua. The Municipality is located in the North-western corner of the Bono Region. It lies between latitude 7'15 South and 8'00 North and longitude 2'25 East and 2'50 West. The municipal covers a total land area of about 863.3qkm. It is surrounded to the North-east and North-west by Tain District and Jaman South District, respectively. Southwest by Dormaa East District and to the South-east is Sunyani (Figure 1) Berekum lies in the semi-equatorial climatic condition.
Abundant sunshine and rainfall yield warm and humid weather. The Municipality rainfall is the double maxima type with a mean annual rainfall ranging between 1,275 mm-1,544. The first rainy season occurs from May to June followed by a second rainfall season between September and October.

The Municipal has the moist-semi deciduous forest type vegetation covering about 80% of the entire middle stretch of land, with isolated patches of wooded savannah in the northernmost and eastern corner of the District. The District falls under the forest-savannah transition zone. Underlying the Municipality is a metamorphic rock. Soils in the Municipal fall into the ochrosols group which is generally fertile and therefore supports the cultivation of cocoyam, plantain, cocoa, maize and cassava. The topographical attributes of Berekum municipality is flat land with variations in height. An undulating landform can be found in the south interspersed with a few isolated low hills to the north and northeast (Figure 1).

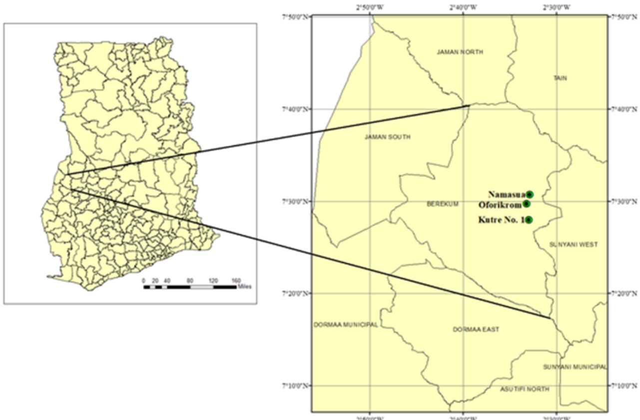

Figure 1: District map of Ghana showing Berekum Municipality source: Authors construct. **Note:** Towns, Districts.

Research design, data collection, and analysis

The study employed a cross-sectional design, which enables a researcher to capture a snapshot of the views of the study respondents within the period of data collection. Purposive sampling was the first step to select three communities in the Berekum Municipality, due to their proximity to the Tain II forest reserve. A simple random sampling technique was used to select a sample of 93 respondents from the households of the three selected communities. Samples of 5%, 10% and 100% were chosen from the total number of households per community, as shown in Table 1.

Table 1: Selected communities, total population, households' population and sample size for each community.

Communities	Total population per community	Total number of households per community	A sample size of respondents
Kutre No.1	4335	952	48
Namasua	1245	342	34
Oforikrom	Unknown	11	11
Source: Ghana Statistical Service (2010).			

The data from the semi-structured questionnaires were analyzed using Statistical Package for Social Science (SPSS) version 20 to obtain descriptive statistics such as percentages of responses and presented in the form of charts and tables. In Oforikrom, the majority of the respondents were not able to understand the local language (TWI) that made the administration of the questionnaire very difficult. However, few people managed to translate TWI to their local dialect, which made the exercise quite cumbersome.

Secondary data from NASA and Inter-annual rainfall variability assessment

We complemented the perceptions of the study respondents on rainfall and temperature changes for the past ten years to a 33 years data of Berekum Municipality obtained from the NASA Langley Research Center (LARC) POWER Project funded through the NASA Earth Science/Applied Science Program. Lamb index was used to assess the inter-annual and decadal variability in the overall rainfall from 1982-20215 [40]. This index determines whether the rainfall in a given study area at a specific period is experiencing normal, in excess or deficit rainfall. The index Ip is given as;

$$I_p = \frac{P_i - P_m}{\sigma}$$

Where

Ip = Lamb index,

P_i = the value of the yearly rainfall of the year i

P_m = the mean total rainfall over the study period and

σ = the standard deviation of the overall data.

When Ip is greater than 0.5, the year or period is classified as experiencing excess rainfall, when Ip is between -0.5 and 0.5, the year or period is classified as experiencing normal rainfall. However, when IP is less than -0.5, the year or period is classified as experiencing deficit rainfall in the study area in question.

Results and Discussion

Socio-economic characteristics of respondents

A total of 93 respondents of an average age of 44 years responded to the survey. The minimum age among the respondents was 15 years, and the maximum age was 88 years. There were 52 females (56%) and 41 (44%) males who engaged in the study. When respondents were asked to indicate their status as House Hold Heads (HHH), 36 males were found to be HHH, and 27 females were HHH. With regards to respondents' educational levels, 30% had no formal education, 17% had gone through primary education, and 46% had attained their education level at the Junior High School (JHS) level, five percent at the secondary level, and two percent at the tertiary level. Seventy-five per cent of the respondents were full-time farmers, 16% of the respondents were part-time farmers and 9%unemployed. Other livelihoods engaged in by the part-time farmers were the informal sector (petty trading), civil servants, and artisans.

The livelihoods of the three selected communities were purely agrarian, of which the majority of respondents (both males and females) were into full-time and part-time farming noted that the livelihoods of rural households vary across regions and countries [10]. Given this livelihood patterns, the majority of rural people were involved in rain-fed agriculture and support that food crop farming constitutes the principal livelihood for rural households [41]. The reported that food crop production accounting for about 70% of agricultural output comes from the Brong-Ahafo Region [42]. Since respondents are smallholder farmers, if farming is affected by climatic factors such as irregular rainfall and extreme temperature coupled with other non-climatic factors, then the household food security and income levels of the study communities will be affected. This finding is similar to who indicated that rural inhabitants are mostly involved in rain-fed agriculture of which climate change is a significant risk factor affecting their livelihood and household food security [26].

Farmers knowledge of predicting the weather, reliability, and implication on livelihoods

The majority of the smallholder farmers (87%) reported that they still use traditional means in the form of signs to predict the changes in weather. However, 13% of the respondents, on the other hand, said they do not use the traditional methods in predicting the weather in the farming activities. For 87% of the respondents who use the signs, majority (38%) said rainfall could be predicted using the sun's direction, shape, and intensity, 32% indicated the presence of the monsoon winds and 30% mentioned the cloud gathering as a sign to predict the whether it will rain or not as shown in (Figure 2).

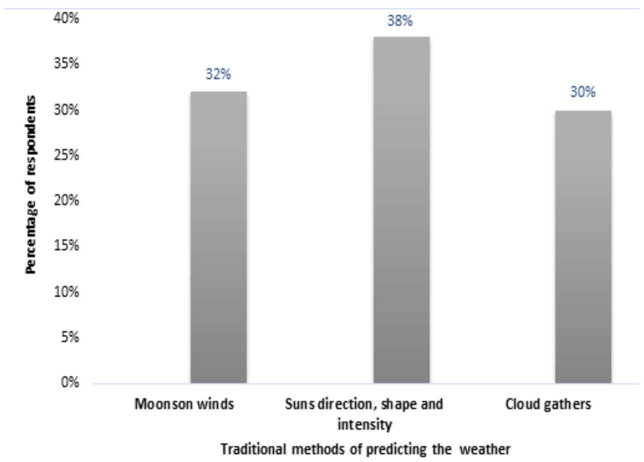

Figure 2: The traditional methods of predicting the weather.

When the respondents were asked of the reliability of these signs or traditional methods mentioned 66% of the respondents said the traditional methods of predicting the weather are still reliable whiles 34% of the respondents said the traditional methods are not reliable. Two critical reasons provided by those who said the traditional methods are unreliable are deforestation indicated by 66% and erratic rainfall by 34% of the respondents.

Figure 3 shows the implication of the unreliability of weather changes on respondents' livelihood. Among the study communities, 37% of the respondents said it brings about low yields because farmers become uncertain about when planting can be done. For 24% of the respondents, it brings about hunger, 20% also said there is less rainfall compared to previous years, and 19% said it brings about difficulties in farming as shown in (Figure 3).

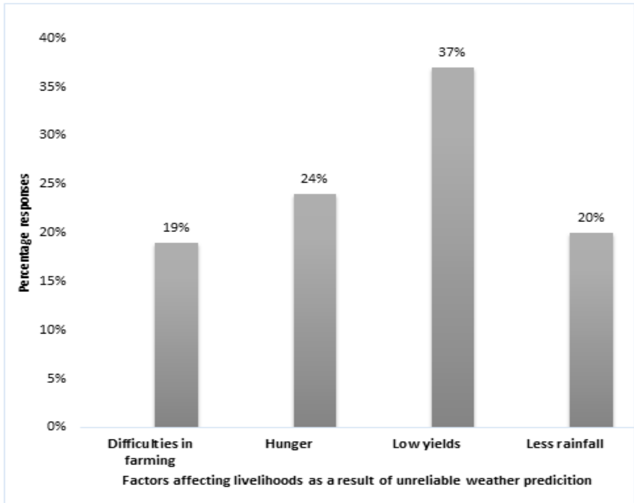

Figure 3: Implication of unreliable weather prediction on farmers' farming livelihood.

The farmers reported two avenues used to listen to scientific knowledge of changes in the weather. For the majority of the respondents (83%), listening to the weather forecast through the radio is what informs them about the weather changes, whiles 17% also mentioned the television. Studies from reported that farmers use a variety of traditional methods to predict the weather among them include prevailing wind direction from the west towards the East, cloud patterns, behavioural patterns of some animal and birds as well as phonological changes associated with some plant species [43]. Irrespective of these traditional methods used in predicting the weather, farmers said these methods are often unreliable as a result of deforestation and erratic rainfall. Its implications on farmers' livelihood were low yields, hunger, less rainfall, and difficulties in farming. However, farmers also receive scientific information on the weather through radio and television also confirm these traditional and scientific methods identified in the study communities that farmers used traditional and scientific methods in predicting the weather which includes movement of the wind and the direction of winds, the type, and nature of cloud that precedes rain and scientific methods like radio and television [44].

Farmers perception of climatic factors (Temperature and rainfall) on their livelihoods

Ninty-nine per cent of the respondents attested to the fact that they have noticed temperature differences for the past ten years, which has adverse effects on their livelihoods. For 54% of the respondents said they had observed high temperature for the past ten years, 25% indicated extreme temperature, low temperature (19%) and moderate temperature (2%). The majority of the farmers (31%) attributed the changes in temperature to deforestation, 24% said erratic rainfall, and 10% perceived it as God's punishment as shown in Table 2.

Table 2: Reasons for the changes in temperature pattern for the past 10 years.

Reasons for the in changes temperature patterns for the past ten years	Frequency (N=93)	Percentages (%)
Deforestation	29	31
Erratic rainfall	22	24
High intensity of the sun	17	18
Bushing burning	16	17
God's punishment	9	10
Total	93	100

According to the respondents, regular rainfall provides favourable conditions for their farming activities. For 48% of the respondents, their income level increases 39% of the respondents also reported an increase in crop yields, while 13% said it makes farm work less complicated. On the contrary, according to the respondents, prolong dry season has adverse effects on their farming activities. For 42% of respondents, it retards crop growth, and 6% indicated a loss of soil moisture contents (Figure 4).

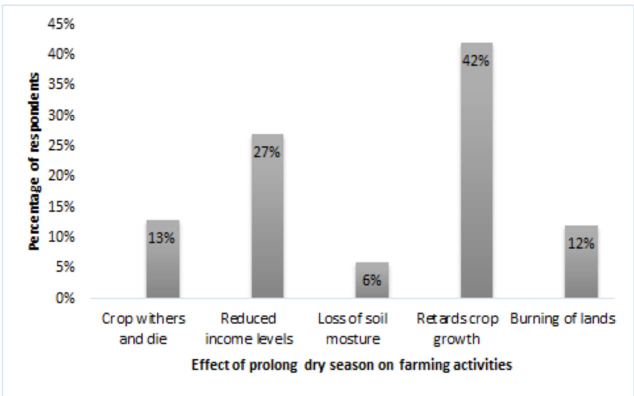

Figure 4: Effects of the dry season on farming activities.

The study indicates that the majority of farmers in the selected communities' perceived changes in the weather pattern. The critical parameters of weather used in this study were temperature and rainfall. The majority of the respondents attested to the fact that the temperature has changed for the past ten years asserted that local communities are aware of the changes in climate because of the variability in rainfall patterns and increasing temperature [45,46,26]. The study revealed that the changes in temperature were attributed to God's punishment, erratic rainfall, deforestation, high intensity of the sun, and bush burning. A 33 years data obtained from the NASA Langley Research Center (LARC) POWER Project funded through the NASA Earth Science/Applied Science Program for the Berekum Municipality indicated an inverse relationship between rainfall and temperature. As temperature increases, rainfall drops. Figure 5 shows a decreasing trend in rainfall with a significant increase in temperature.

Additionally, the Lamb index clearly defines the changing trend in inter-annual and decadal rainfall in the Berekum municipality(Figure 6). The study area experienced deficit rainfall from 1998 through to 2008 as rainfall dropped below -0.5, as revealed by the Lamb index (Figure 6). This is used From a scientific perspective, with the a exemption of God's punishment, the other factors mentioned by the respondents are in line with Lamb Index. Nevertheless, the farmers' perception of a decline in rainfall and higher temperature attributed to God's punishment cannot be ignored. The finding from the study is in line with that the prevalence of drought incidence occurs as a result of peoples disobedient and immoral deeds towards God that has resulted in punishment (Figures 5 and 6) [47].

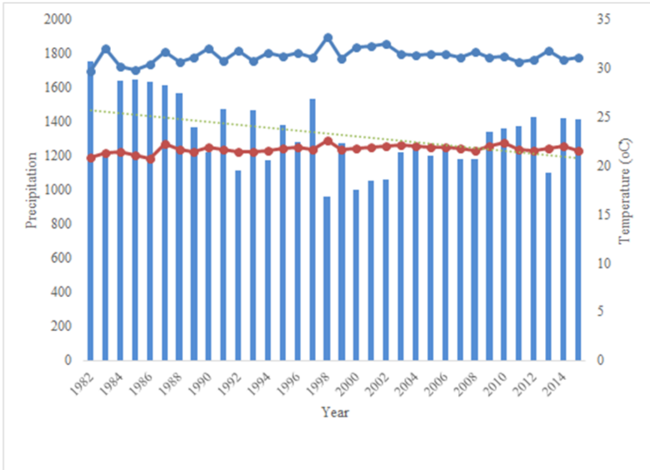

Figure 5: Total annual rainfall and temperature for Berekum Municipality (1982-2015). **Note:** Precip, Tmax, Linear(Precip).

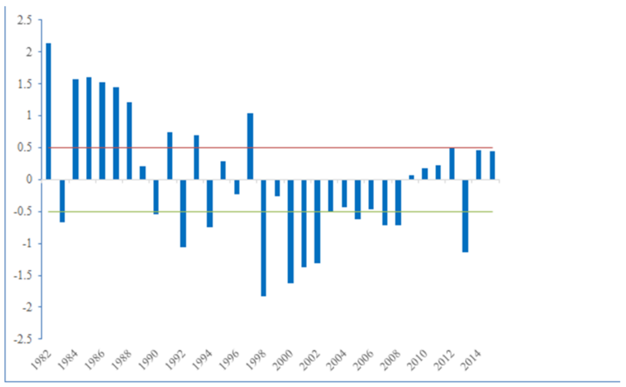

Figure 6: Inter-annual variability of rainfall rates using the Lamb index, Berekum Municipality, 1982-2015. **Note:** Lamb Index, Excess, Deficit.

From the study findings, it clearly shows that rainfall had a positive effect on farmers farming activities; among them include an increase in income levels, an increase in crop yields, and less strenuous work. This result is s in line with that in a good season of evenly distributed rainfall pattern, crops grow well, which increases crop yields and income levels [48]. On the contrary, the effects of the prolonged dry season on farming activities result in retarding of growth of crops, burning of farmlands, crop-withering and dying, loss of soil moisture leading to a reduction of income asserted that prolong drought periods influence loss of soil moisture and decline crop yields [26]. Similarly, reported that insufficient rainfall leads to poor seed germination and seedling emergence, which will retard crop yields [19].

Farmers perception of adaptation mechanism in the study communities

In responding to the changes in the climatic conditions, the smallholder farmers had some adaptation mechanisms based on the seasonal changes, as shown in Table 3. Concerning little or no rainfall the majority of the respondents in the study communities said during that period they do nothing and the least mechanisms adapted are preparing the soil for the next planting season and the application of pesticide by respondents from Namasua and Kutre No.1 communities. Also, in the period of excessive rainfall, the majority of the smallholder farmers in the study communities reported doing 'Nothing'. However, in Namasua, farmers attested that they plant crops whilst in Kutre No. 1 the smallholder farmers affirmed that they create channels to prevent erosion on their farms and in Oforikrom, farmers do plant crops that can withstand excessive rain. In periods of extreme temperature, the smallholder farmers across the study communities 'do nothing' whilst the least mechanisms adapted by the smallholder farmers include weeding, harvesting, and drying of food crops (Table 3).

Table 3: Adaptation mechanisms in the three selected communities.

Seasonal changes	**Adaptation Mechanism**		
	Namasua	**Kutre No.1**	**Oforikrom**
Littleno rainfall	Nothing (62%)	Nothing (73%)	Nothing (100%)
	Irrigation (18%)	Irrigation (21%)	
	Create fire belts (15%)	Application of pesticide (6%)	
	Pray to God (3%)		
	Prepare the soil for the next planting season (3%)		
Excessive rainfall	Nothing (59%)	Nothing (48%)	Nothing (64%)
	Create channels to prevent erosion (26%)	Create channels to prevent erosion (21%)	Plant crops that can withstand excessive rain (beans, garden eggs, okra, plantain) (27%)
	Plant more crops: 15%	Plant more crops (6%)	Weeding (9%)
		Cultivating crops that can withstand the rains (cassava and plantain) (15%)	
		Application of chemicals and fertilizer (6%)	
		The land is a steep slope, so there is no erosion (4%)	
Extremely hot temperature	Nothing (82%)	Nothing (63%)	Nothing (100%)
	Create fire belts (12%)	Irrigation (25%)	
	Plants cashew because it creates shade for the rest of the crops (3%)	Application of chemicals (8%)	
	Weeding (3%)	Harvesting and drying (4%)	

The adaptation strategies used by the farmers fall within the autonomous adaptation compared to planned adaptation [30]. With little rainfall, the following strategies were adopted: i) farmers created fire belts to prevent fire outbreak; ii) some farmers also prepare their farmland for the next planting season, iii) application of pesticide to control pest infestation. Farmers attested to the fact that during the dry season, pest invades their farmland, so they employ both locally made and synthetic chemicals on their farmland; iv) some farmers do irrigate their farmland and v) farmers pray to God for rains. In periods of excessive rainfall, farmers create channels on their farmland to prevent erosion. Some farmers also plant crops that can withstand excessive rain such as beans, okra, plantain, cocoyam, cassava and garden eggs. Some farmers also weed their farmland to prevent crop-weed competition. With extremely hot periods, farmers irrigate their farmland, apply pesticides, and adopt mixed cropping, where they grow food crops with tree crops like cashew. It was also noted that the cashew plant provides shade to the food crops from direct contact with the sun, which prevents soil water retention and their leaves decompose and fix nutrients into the soil indicated that farm-level adaptation or production level adaptation includes the modification of crop varieties that can withstand both long drought periods and excessive rainfall [49]. Also reported that farmers adapt to climate change by planting tree crops for shade, use chemicals, fertilizers, irrigate and plant different crop varieties [46]. Most of the respondents across the three communities reported of 'doing nothing' during climatic stress. The finding supports the assertion that farmers in the transition zone reported of 'do nothing' except to be at the 'mercy' of the weather attributing to the low capacity of most farmers to deal with climatic and non-climatic challenges confronting them (IBID).

Conclusions

The study sought to assess farmers' perception of climate change and adaptation strategies of their farming livelihood. The study revealed that farmers in the study areas were actively involved in rain-fed agriculture. Farming is a significant livelihood venture among the majority of respondents in the three communities either as full-time or part-time farmers. Respondents did use traditional methods to predict the weather, which includes clouds gathering, monsoon winds, and the sun's direction, shape, and intensity. Respondents attested to the fact that the traditional methods were not often reliable as a result of deforestation and erratic rainfall. Since the traditional methods were not reliable, respondents also rely on information from the radio and television to predict the weather changes. Also, respondents perceived changes in temperature for the past ten years was confirmed by the 33 years data in the Municipality. These changes were attributed to deforestation, God's punishment, erratic rainfall pattern, bush burning and high intensity of the sun. Irregular or erratic rainfall or long drought period were found to result in crops withering and dying, thus retard crop growth, loss of soil moisture, burning of farmlands and reduction in income levels. However, during the rainy season, there are high crop yields, less stressful work, and increase the income level.

In predicting and getting weather information, both scientific and traditional methods were employed. The adaptation strategies employed in this study falls within the autonomous adaptation; thus farmers' level of adaptation included the i) application of pesticide and fertilizer, ii) irrigation, iii) planting of crops that can withstand excessive rain and extended drought periods iv) creating fire belts v) creating channels and vi) harvesting and drying of crops. The study, therefore, concludes that a blend of planned adaptation with autonomous is needed to enhance the adaptive capacity of rain-fed agriculture, which is one of the critical pillars of food sources in Ghana. The following are suggested policy recommendations:

- The Environmental Protection Agency, in collaboration with the Department of Agriculture should endeavor to organize periodic climate change programs in local communities to educate farmers on effective adaptation mechanisms.
- The Metrological Service Agency, in collaboration with Agriculture Extension Officers, should update farmers on the rainfall and temperature patterns to help farmers to know the exact periods of planting their food crops.
- The Ministry of Food and Agriculture should construct the appropriate irrigation mechanisms in periods of dry seasons and storage facilities to store foodstuffs in the bumper seasons.
- Agriculture extension officers should educate farmers on effective agriculture practices that will help minimize low productivity, especially during the prolonged dry season.
- In the forest-savannah transition zone, where rainfall and temperature will continue to decline, both autonomous and planned adaptation should be taken into consideration to obtain better adaptive strategies.

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Conflict of Interest

The authors declare that they have no competing interests

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