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Climate change adaptation strategies of smallholder farmers in the Mamprugu-moaduri district of Ghana

Mumuni Yahaya[1,2*], Peter Damoah-Afari[3], Caleb Mensah[1], Naomi Kumi[1], Nana Agyemang Prempeh[1], and Prisca Ama Anima[3]

Abstract
This study assesses climate change effects and adaptation strategies of small holder farmers in the Mamprugu-Moaduri District of Ghana. A multistage sampling procedure was employed to select 150 farmers for the study. The results revealed that, farm risk level, ability to adapt, farmers' income, age, farming experience, climate change awareness, and extension visits were factors that significantly influenced the adaptation strategies by smallholder farmers (in order of importance). Based on the findings, the Ghana Meteorological Agency is expected to play a very significant role in providing relevant and timely information on early warning to farmers, especially before and during the of the rainy season. This will help farmers to effectively adapt to the consequences of climate change.

Keywords
climate change; climate change awareness; adaptation strategies; small holder farmers; early warning

[1]Department of Atmospheric and Climate Science, University of Energy and Natural Resources (UENR), Sunyani, Ghana
[2]Ghana National Service Scheme, Northern Regional Office, Tamale
[3]Department of Geographic Science, University of Energy and Natural Resources (UENR), Sunyani, Ghana
***Corresponding author**: mumuniyahaya2016@gmail.com
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Contents

1. Introduction

Changes in weather pattern are seen as a global concern, as they brutally affect the livelihoods of communities and food systems in developing countries. Climate change related shocks have harmful effects on agricultural production, worsening the farm incomes of households as well as their food security (Addaney, 2020; Assan et al., 2018). Climate change has resulted in decadal changes in atmospheric and oceanic conditions leading to changes in economic and biophysical actions (Lenton et al., 2019: World Bank, 2008: IPCC, 2021; Adams et al., 2018). In most parts of Sub-Saharan Africa (SSA), these climatic changes are further worsened by poor soils that result in poor production systems and a lack of appropriate plans regarding the use of inputs (fertilizers) and access to financial credits. Furthermore, the situation is worsened with limited research institutions addressing climate change-related issues (Abutaleb et al., 2018; Thornton et al., 2010), uncertainty of climate change and predictable impacts on how this uncertainty can be solved for the benefit of the society (Wilby et al., 2009).

Agriculture is very essential in Africa, since the African agricultural sector provides livelihood (for about 80% of the labor population) and food for its people. Environmental alteration and climate inconsistency in sub-Saharan Africa's agriculture sector has developed weakness, and thus the need to adapt to predictable and definite deviations in the weather (Assan et al., 2018). It is worrying that the continent is defenseless to climate change and climate inconsistency due to the fact that, majority of the of the population are underprivileged and dependent on agricultural production, which is extremely sensitive to rainfall unpredictability and temperature changes (The World Bank Group, 2010). Nevertheless, climate variation isn't new, it remains a strong influence on the agricultural sector in Sub-Saharan Africa where majority of smallholder agriculture are most susceptible to negative effects of climate change. Achieving sustainable development has become a major challenge due to adverse effect of climate change. (Juana et al., 2013; Veronesi 2013; Pereira, 2017; Serdeczny et al., 2016). Serdeczny (2015) noted that with the current trend of climate change, West Africa is projected to experience severe impacts on food production, decline in oceanic productivity, severe risks for food security and negative repercussions for human health and employment. The Food and Agriculture Organization (FAO) (2007) noted that the political and social factors that are important determinants of food security in Africa will be placed under significant stress because of climate change. This will further increase the incidence of food insecurity and rural poverty that could affect the livelihoods of many households (Codjoe and Owusu, 2011). This is further compounded by the fact that households in Ghana are often confronted with multiple stressors that act inter-dependently to adversely affect livelihood outcomes (Antwi-Agyei et al., 2016).

In the Ghanaian context, a mean annual temperature rise of 1.0ºC since 1960 has been reported (McSweeney et al., 2008). The future projection for temperature shows an increase of 0.6ºC, 2.0ºC, and 3.9ºC by 2020, 2050, and 2080, respectively (Economic Commission for Africa, 2011). Agriculture plays a momentous role in sustaining the livelihood of the majority of Sub-Saharan Africa's (SSA) population, and this is typified in Ghana (Ziba, 2015). Some years ago, agriculture in Ghana, accounted for more than a third of the national Gross Domestic Product (GDP) but this share keeps declining due to climate change. Despite these challenges, agriculture still accounts for approximately 22.7% of Ghana's GDP and employs about 54% of its workforce (GSS, 2014). There is growing body of literature on climate change and adaptation in rural Ghana (Addaney et al., 2021; Cobbinah et al., 2022). Despite the expanding knowledge on climate change in rural Ghana, there is an apparent lack of bottom-up knowledge co-production at the community and farm-level, where tactical information can be used to predict the variations in weather parameters to help farmers to effectively respond to climate change (Omerkhil et al., 2020). The northern regions of Ghana, including the Mamprugu-Moaduri District, is characterized by damaging anthropogenic land-use practices such as overgrazing by livestock, cutting down of trees, bush burning and wood charring. These activities increase the susceptibility of the environment to climate change as evidenced by inconsistent patterns of rainfall, the threats of desertification, soil erosion and droughts, and poor soil fertility (Stanturf et al., 2011).

There is therefore the need for more inclusive and local-level knowledge, co-produced in rural communities on the projected impacts and risks of climate change on agricultural systems (IPCC 2021). This study, thus, explores the role of smallholder farming methods in facilitating the adaptation to climate change impacts in the agricultural sector in the Mamprugu Moaduri District. It assesses the impacts of climate change, experienced by smallholder farmers and explores the adaptation strategies adopted by these farmers in the study area. The outcome of this study will help provide relevant information to farmers and the general public on the dangers associated with climate change and its mitigation processes. The results of this study also provide information to the government on implementation of policies that will be beneficial to farmers in mitigating the adverse effects of climate change in their communities.

2. Materials and Method

2.1 Study setting

The study was conducted in the Mamprugu Moaduri District in the North East Region of Ghana. It is specifically located within longitudes 0° 35'W and 1° 45'W and Latitude 9° 55'N and 10° 35'N. This district shares boundaries with North Gonja District to the West, Kunbungu District to the South, Sisala East in the Upper West Region, Builsa South in the Upper East Region and West Mamprusi District in the Northern Region (Figure 1). The district was chosen for this study due to its vulnerability to extreme climatic events such as perennial floods and periods of dry spells. The population of Mamprugu-Moagduri District is 46,894, representing 1.9 percent of the region's total population (GSS, 2014). Males constitute nearly 50 percent and females represent just a little above 50 percent. In terms of rural-urban distribution, the district has all its inhabitants living in rural localities. This implies that the district is completely a rural one. Of the employed population, about 94.0 percent are engaged as skilled agricultural, forestry and fishery, 2.8 percent in craft and related trade, and 1.7 percent are engaged in services and sales.

The district lies within the savannah climatic belt with a single maxima rainfall season (unimodal rainfall regime). The mean seasonal rainfall ranges from 1000mm to 1400mm and occurs between May and October with July to September as the peak period. As a result of heavy rains during the peak period, there are always floods and after which there is a prolonged dry season from November to April. There are all year-round high temperatures with the hottest month being March with an average monthly temperature between 25.5ºC and 35ºC. During the rainy season, there is high humidity and sunshine with heavy thunderstorms. The dry season is characterized by dry harmattan winds from November to February and high sunshine from March to May. The district's geology is made up of Middle Voltain rocks normally suitable for rural water supply. It is largely covered by a flat and undulating terrain. The most significant river in the district is the White Volta and its tributaries include Sissili and the Kulpawn rivers. Along the valleys of these rivers are large arable lands, good for the cultivation of rice and other cereals. The soils are mostly alluvial soils, rich in nutrients especially along the valleys, and are suitable for rice production, with considerable soil erosion due to bad farming practices and the rampant bush burning. The district's natural vegetation is a Guinea Savannah Woodland, composed of short trees of varying sizes and density, growing over a dispersed cover of perennial grasses and shrubs.

2.2 2.2 Research Design and Approach

The study employed a multistage sampling procedure. In the initial phase, purposive sampling was employed in selecting Five (5) Communities in the study area, namely Yagaba, Loagri, Zanwara, Prima and, and Tantala. These communities were selected based on information gathered from some key stakeholders in the district (examples, National Disaster Management Oranization (NADMO), Ministry of Food and Agriculture (MoFA), Water Resource Commission (WRC) in the district, and from my personal interactions with some members of these communities. The study employed the Yamane (1967) formula in determining the sample size as follows:

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

Where n=sample size, N= Population size (240), e=margin of error which 0.05 at 95% confidence interval.

Therefore;

$$n = \frac{240}{1 + 240(0.05)^2} \tag{2}$$

Simple random sampling was then employed in selecting the respondents for the study. A sample size of one-hundred and fifty (150) smallholder farmers' households were considered from the five communities with 30 smallholder farming households selected from each of the communities as shown in Table 1. With the use of questionnaires, primary data was collected from the smallholder farmers. Questionnaires were designed to solicit the views of the farmers on the prevailing farming methods, impacts and effects of climate change on their farming activities, and their adaptation strategies used.

Descriptive statistics were used to analyze farmers' socioeconomic characteristics, farming methods as well as effects of climate change experienced by smallholder farmers in the Mamprusi-Moaduri District. Results from this analysis are presented in tables, charts, and graphs in the next section.

Table 1. Sampling Distribution

Communities	No of Respondents	Percentage (%) respondents
Yagaba	30	20
Loagri	30	20
Zanwara	30	20
Primaand	30	20
Tantala	30	20
Total	**150**	**100**

Source: Author's computation, 2021

3. Results and Discussion

3.1 Socio-demographic data of respondents

As indicated in in Table 2, about 104 of the respondents (69.3%) were males while 46 (30.7%) were females. This means that males in the district mostly engaged in crop farming activities than their female counterparts.

Table 2. Respondents Socio-demographic Characteristics

Variable	No. of Respondents	Percent
Sex		
Male	104	69.3
Female	46	30.7
Total	**150**	**100**
Marital Status of Respondents		
Single	18	12
Engaged	11	7.3
Married	96	64
Divorced	9	6
Widow/Widower	16	10.7
Total	**150**	**100**
Literacy Level of respondents		
No Education	84	56
Arabic	3	2
JHS	15	10
Primary	27	18
SHS	9	6
Tertiary	12	8
Total	**150**	**100**
Source of Production Income		
Bank Loan	2	1.33
Family	65	43.33
Farming	42	28
Friends	2	1.33
Personal Savings	29	19.33
Wages and Salary	10	6.67
Total	**150**	**100**

Source: Author's computation, 2021

This finding is in agreement with Abdulai et al. (2013) that the proportion of males engaged in agriculture are higher than their female counterparts. This shows that that marital status has an influence on household productivity and outcomes. That is, marital partners contribute to each other's welfare by helping to provide access to productive resources which enhance livelihoods. From Table 2, 64% of the respondents were married while 12% and 10% were single and widows/widowers, respectively. As indicated in Table 2, about 56% of the total respondents had no formal education, while 2%, 10%, 18%, 6% and 8% had education up to Arabic, JHS, Primary, SHS and Tertiary, respectively. This indicates that majority of the

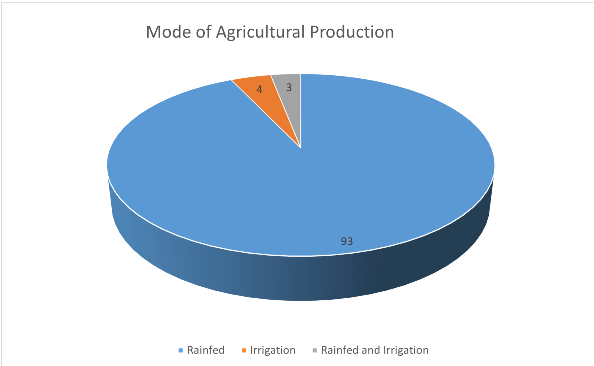

Figure 1. Mode of Agricultural Production. Source: Author's computation, 2021

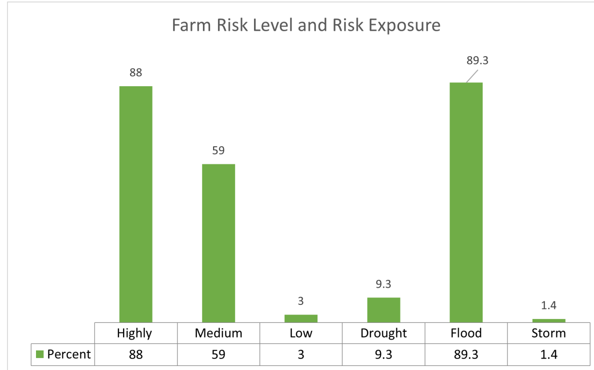

Figure 2. Risk level and risk exposure of farms. Source: Author's computation, 2021

farmers in the study area had no formal education. The income distribution of the respondents showed the various sources in which farmers get their production income from. It is revealed that, about 43.3% of the respondents generate their production income from family support (Table 2). Also, 28.0%, 19.3%, and 6.7% respectively represent respondents who generate their incomes from, farming, personal savings and wages/salary, with 1.3% respondents depending on friends and bank/loan for their production capital.

3.2 Mode of Production Systems

The prevalent agricultural practices identified among the respondents in the study area were rain-fed, irrigation, and mixture of rain-fed and irrigation. Figure 2 presents data about the prevailing agricultural practices by respondents. The result of the study indicated that about 93% of farming activities depended on rain-fed. This overdependence on rain is a major challenge and consistent with a study by MoFA (2015). Though irrigation practices were available in the locality, its level was still inadequate. From the Figure 2, just 3% of the farmers relied on irrigation farming system. The main reason for inability of the farmers to use irrigation technology was mainly due to limited financial capacity. Nevertheless, about 4% of the respondents employed both rain-fed and irrigation farming systems.

3.3 Risk and exposure levels of farms

Different reports indicate that increase in temperatures, droughts, floods, variations in precipitation quantities and forms, and aquatic-level increase are a few risks pose by climate change in the West Africa sub-region to the cultivation of crops (Christensen et al., 2007; Di Falco and Veronesi, 2013; Serdeczny et al., 2016; Pereira, 2017;). The major risks posed to farmers in this research were summarized in Figure 3. This result confirms a results of Antwi-Agyei et al. (2016) that floods in the Northern Savanna zone followed by long periods of drought affected about 325,000 people because of climate change. The bar chart in Figure 3 represents the distribution of risks faced by farmers in the locality.

3.4 Scale of Agricultural Production

Subsistence farming was common and the most dominant farming practice in the study area. About 98% of farmers Were into subsistence farming. This means that farming is basically to feed the family while the remaining 2% represented both commercial and cash crop farming. This is illustrated in Figure 4. This finding is in line with previous studies which argued that, the northern regions are the most climate stressed in Ghana and have the highest prevalence of subsistence and smallholder agriculture (Abbam, Johnson, Dash and Padmadas, 2018; Abdul-Razak and Kruse, 2017).

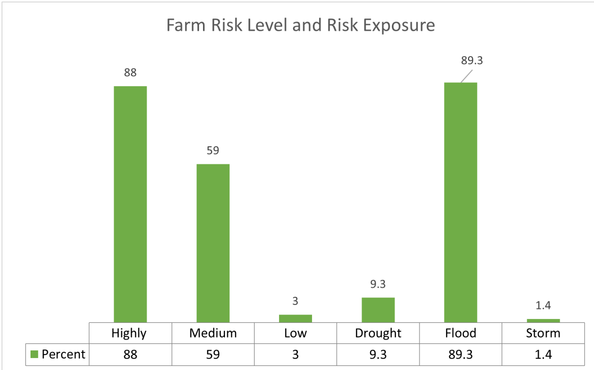

Figure 3. Risk level and risk exposure of farms. Source: Author's computation, 2021

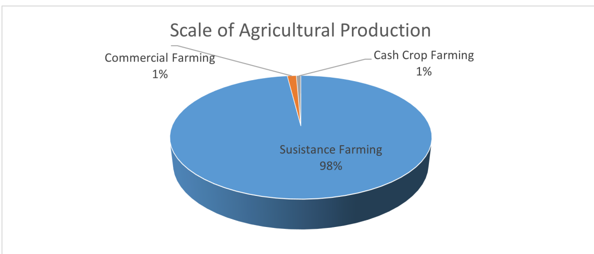

Figure 4. Types of Agriculture. Source: Author's computation, 2021

3.5 Source of Climate Change Information for Farmers

As shown in Table 3, 44% of the farmers indicated that it is through their own discovery that they source climate change information, while 6.67%, 13.33% and 36% of the farmers indicated that they source climate change information via extension officers, radio broadcasters and from their colleague farmers, respectively. Despite their several abilities, smallholder farmers are challenged with the problems posed by the erratic nature of climate variables. Providing farmers with useful information such as weather and flood forecast, coupled with the best agronomic practices can help reduce the effect of environmental variation on agriculturalists. With improved adaptive capacity, smallholder farmers will be empowered to adjust to climate changes (De Pinto et al., 2012).

Table 3. Farmers Sources of Climate Change information

Source of Information	Frequency	Percent
Personal Discovery	66	44
From Extension officers	10	6.67
Radio broadcasting	20	13.33
From other Farmers	54	36
Total	**150**	**100**

Source: Author's computation, 2021

3.6 Perceived Impacts of Climate Change on Smallholder Farmers

The farmers indicated that there is an increasing trend of the impacts of climate change over the years. In this study, about 79% of the respondents indicated that there is an increasing trend of climate change impact within their communities (Figure 5). This result confirms a similar study in Northern Region of Ghana by De Pinto et al. (2012). who concluded that, the general trend for temperature change is predicted to increase more in that region than the rest of the country.

Smallholder farmers are among the groups often adversely affected by climate change. This may be due to their location in unreliable landscapes such as hillsides, deserts and floodplains. These places are considered unreliable farmlands because farmlands and activities are exposed to several climatic hazards (Donatti et al., 2018). Figure 5 shows the prevalence of climate change extreme events as experienced by farmers. From the table, 35% of the respondents indicated that climate change has resulted into seasonal flooding, while 20% indicated that there is prolonged drought as a results of climate change. Also, 18%, 12% and 15% of the respondents indicated that climate change has resulted into crop yield reductions, increased temperature regimes, and incidence of pest and diseases respectively. These findings are in consistent with the report by Graphic online (2020), that several residents along the White-Volta in the Mamprugu-Moaduri were affected by floods. Many farmlands were covered with water while other business activities came to a standstill. A lead farmer lamented because about 20-acre of his maize farm was heavily affected and destroyed by the flood. Another farmer, who was also affected by the incident feared for severe hunger and poverty due to the magnitude of damages caused by the floods in the area. Residents in the area are therefore appealing to the government and other support organizations to come to their aid.

The perception of farmers clearly confirms the environmental change of the Mamprugu-Moaduri district. Observations made by these farmers are like that of Jawid and Khadjavi (2019); Omerkhil et al. (2020). The farmers reported that environmental change negatively affected their net farm output. Climate change has become a serious problem for both on farm and off farm activities. The livelihoods of farmers are affected through several changes, such as rise in temperature, inconsistent rainfall and prolonged drought (Thanh et al., 2014). Farmers were asked whether they perceived changes in the rainfall and temperature in their locality? Those who have perceived the change in rainfall and temperature were asked to identify the direction of the change. About 7% and 79% of the respondents perceived a decreasing trend of temperature and rainfall, respectively, while about 80% and 6% had perceived an increase in the trend of the tem-

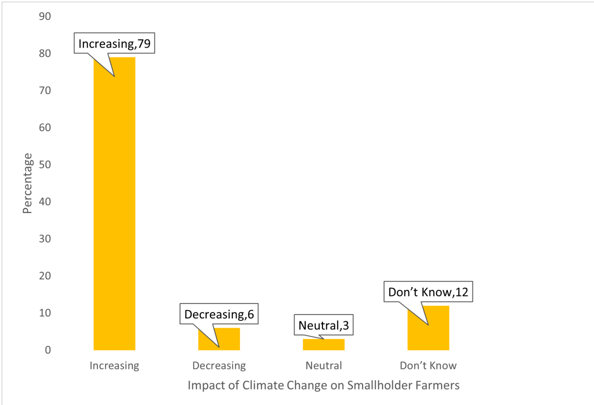

Figure 5. Perception on Trend of Climate Change Impact by Smallholder Farmers. Source: Author's computation, 2021

perature and rainfall respectively. This result indicates that, climate change has caused temperature increases and rainfall decreases in the study area.

3.7 Smallholder Farmers' Adaptation Strategies to Climate Change

Withstanding and making life better for smallholder farmers by building up their resistance to environmental change is very necessary to help them fight the effects of climate change. Accordingly, there are many ways and means in agriculture in which farmers can build their resistance to environmental change. These are, agroecology (Pandey et al., 2017a), Climate-Smart Agriculture (CSA), climate-smart landscapes, conservation agriculture, and sustainable intensifications (Kongsager, 2018). Farmers are decision makers who also accept techniques that will help them manage water during excess rains, control soil moisture during drought (Altieri et al., 2015); change inputs such as crop variety with appropriate planting time and high output requirements, increased resistance to the heat and water stresses and rates of fertilizer inputs (Mueller et al., 2012). The adaptation in production also include changes in irrigation that help in water logging, soil erosion and nutrient leaching reduction (Malano and van Hofwegen, 2018). Moreover, agricultural crop management for climate change also includes changing the cropping activities (Varadan, 2014); cultivation of locally improved disease and pest resistant varieties (Khanal and Mishra, 2017).

As shown in Table 4, the most important exercise farmers used to decrease the impacts of temperature changes is changing crop planting date. During long-term shifts in rainfall, farmers change crop planting dates (41.3%) and practice mixed cropping (21.3%). In instance of extreme rainfall, farmers migrate to the upland farms (18%). At present, Crop Rotation (10%) and the use of different crop varieties (9.4%) are other common practices. Similarly, during long-term shifts in Temperature, smallholder farmers used various adaptation strategies to climate change. Here, they farm at lowlands (23.3%) and practice cover cropping (22.7%) as well as early planting (19.3%). Alternatively, some of the farmers chose to practice mixed cropping, mulching, use of animal droppings while other households were planting trees. The results showed that, among the adaptation strategies practiced by smallholder farmers in the study area, change of crop planting dates was practiced by more households, whereas only a few respondents practiced irrigation. Even though there is a dam in the study area, they are inaccessible for irrigation because there was a need for high capital investments in designing the irrigation infrastructure.

Table 4. Farmers adjustments to climate change

Adjustment during Long-term shifts in rainfall	Frequency	Percent
Mixed Cropping	32	21.3
Change Planting Date	62	41.3
Farming at upland	27	18
Crop Rotation	15	10
Use improved crop variety	14	9.4
Total	**150**	**100**
Adjustment during Long-term shifts in Temperature		
Irrigation	11	7.3
Cover Cropping	34	22.7
Planting of tress	9	6.1
Use of Organic Manure	11	7.3
Farming at Lowlands	35	23.3
Mixed Cropping	21	14
Early Planting	29	19.3
Total	**150**	**100**

Source: Author's computation, 2021

In the survey, smallholder farmers reported their understanding and need to be well furnished, to modify their production methods and livelihoods in order to have positive influence for their living. However, these approaches were limited, as majority of these farmers are poor and largely on subsistence agriculture. Farmers' insufficient adaptation plans are as a result of increased levels of household food insecurity caused by lower productivity and small farm sizes. These inhibit them from the adoption of new schemes that could have better their farming and food levels (Morton, 2007). Farming families were interviewed on their primary adaptation strategies during hard times of climate change and variability. The results as testified by these farmers indicated that, most importantly change their crop planting dates (42.7%) and practice of mixed cropping (33.3%). In addition, the use of better-quality crops (14%) and afforestation (planting of trees) (10%) were other strategies used by farmers. The results show that among the adaptation strategies practiced by smallholder farmers in the study area, change in crop planting dates was practiced by many households. The increased in tree planting was mainly to provide feed for their livestock and shade for on-farm crops during the prolonged dry periods.

4. Conclusion

The study sought to examine the effects of climate change and farmers' adaptation strategies in the Mamprugu-Moadugri District of Ghana. The analysis revealed that some of the impacts of climate change on smallholder farming systems are seasonal flooding, crops yield reduction, pest and diseases, high temperature and frequent drought. In response to climate change induced drought, farmers employ adaptation strategies such as mixed cropping, change in planting dates, farming at lowlands, crop rotation and the use of improved varieties. Further, farmers respond to higher temperatures through the use of irrigation, cover copping, tree planting, use of organic manure, farming lowland, mixed cropping and early planting. Farmers in the district are imposed with various constraints of adaptation viz: lack of access to early weather warnings, limited knowledge on adaptation measures, high cost of adaptation, unreliable seasonal forecast and lack of access to improved seeds. Based on the findings, it is recommended that the Ministry of Food and Agriculture and other relevant stakeholders should enhance the provision of climate change adaptation information to farmers to boost their adaptive capacity. Secondly, the Ghana Meteorological Agency should enhance the provision and timely delivery of Early Warning Information (EWI) to farmers in the district. Also, non-Governmental Organizations and other community-based organizations should enhance their efforts in educating farmers on effective adaptation strategies.

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