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Analyzing impact of climate change on sustainable livelihood and water resources in Wa West District, Upper West Region- Ghana

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Abstract

According to research findings, the impact of climate change on sustainable livelihoods is most visible in agriculture, where changes in precipitation patterns, high temperatures, and the frequency of extreme weather events are disrupting crop and livestock productivity, including water resources. The Wa West District was used as a case study by the researchers to assess the impact of climate change on agriculture and water resources. The logic regression model was used in the study to determine the adaptation and mitigation strategies that indigenous peoples were employing to build their resilience to climate change. The study also used a weighted average index to assess the impact of climate change on agriculture and water resources (WAI). A total of 330 small-scale farmers were surveyed, and focus group discussions included 100 key informants. The study found that improved seeds, irrigation, fertilizer use, and agroforestry were the adaptation strategies used to build farmer resilience using the logistic regression model. The most common effects of climate change on livelihood were water scarcity, high temperatures, poor soil fertility, and poor yield, according to a Weighted Average Index. In addition, the preferred mitigation strategies used in the study area to reduce vulnerability were input subsidies, access to weather information, dam construction, and improved agricultural policies. Furthermore, the study found that the most preferred climate change adaptation strategies were agroforestry practices, drought-resistant crops, and mulching. According to the study, farmers' ability to adapt to climate change can be improved if the Environmental Protection Agency, the Ministry of Food and Agriculture, and the Forestry Commission intensify climate adaptation campaigns, increase access to weather information, and train farmers on adaptable and mitigation strategies, water resource conservation, and alternative sources of livelihood.

Keywords: Water; Agriculture; Livelihood; Climate change; Mitigation; Adaptation

Introduction

According to the Food and Agriculture Organization (FAO), the world will need to feed approximately 15 billion people by 2050 while addressing biodiversity and deforestation issues, increasing carbon sinks, and enhancing climate-resilient food security (FAO, 2015). In addition, the world will need to provide affordable energy and water access to approximately 1.5 billion people living in remote areas, primarily in Africa and South America, who lack access to clean water and electricity, while adhering to international environmental treaties [1]. Approximately 48 percent of Africa's population, or 450 million individuals, live in extreme poverty, earning less than $1.25 per day, with 63 percent of the continent's poor residing in rural areas and relying on agriculture for a living (World Bank, 2015).

Globally, the effects of climate change on sustainable livelihoods and water resources are significant. The effects of climate change are pervasive and impact numerous facets of human existence, including food security, health, and economic stability (IPCC, 2014). Changes in precipitation and temperature patterns, as well as an increase in the frequency and severity of extreme weather events, are being caused by climate change, which in turn impacts water resources (UNEP, 2016).

The effects of climate change pose a threat to sustainable livelihoods because they affect people's ability to provide for themselves and their families (IFAD, 2018). The effect of climate change on agriculture, forestry, and fisheries is one of the most significant threats to the livelihoods of those who depend on these industries (DFID, 2011). Changes in precipitation patterns and temperature variations, for instance, can reduce crop yields and fishing opportunities, thereby affecting the food security and income of many people (IPCC, 2014). Changes in precipitation patterns and temperature variations can lead to water scarcity in some regions and flooding in others as a result of the effects of climate change on water resources (UNEP, 2016). Increasing frequency and severity of extreme weather, such as droughts and hurricanes, can also disrupt water supply and sanitation services [2]. This can have severe health implications for populations that depend on clean water for survival.

Ghana, like many other African nations, is especially susceptible to the effects of climate change due to its reliance on natural resources for subsistence and its limited adaptability to changing conditions. In the agriculture sector, where alterations in precipitation patterns, temperature regimes, and the frequency of extreme weather events are disrupting the productivity of crops and livestock, the impact of climate change on sustainable livelihoods is most pronounced [3]. The decline in agricultural production threatens the nation's food security and threatens the livelihoods of smallholder farmers who rely on agriculture for their survival [4].

Changes in precipitation patterns as a result of climate change are reducing river flows and lowering groundwater levels in Ghana, which

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has an impact on water resources [5]. The decline in water availability has a significant effect on the country's economy, which relies heavily on hydropower and irrigation [6]. According to a study by [7], the effects of climate change on Ghana's water resources are being felt in the form of changes in precipitation patterns, an increase in the frequency of droughts and a decrease in the amount of water available for agriculture and other human activities. The study discovered that these impacts are aggravating rural poverty and food insecurity, and that local communities are struggling to adapt to these changes. Similar research by [8] examined the impact of climate change on the livelihoods of Ghanaian small-scale farmers. According to the study, climate change is altering the timing and quality of rainfall, resulting in decreased crop yields and income for farmers. In addition, the study discovered that the effects of climate change are felt unevenly across the country, with rural and disadvantaged communities being particularly vulnerable. A report by the World Wildlife Fund (WWF, 2018) describes the effects of climate change on Ghana's water resources, including decreased water availability, increased water scarcity, and an increase in water-borne diseases. These impacts are affecting the livelihoods of communities that rely on water for agriculture, fishing, and other livelihood activities, according to the report.

In light of the preceding insight, the purpose of this research is to evaluate the impact of climate change on the livelihood activities and water resources of the Wa West District. The study also aims to determine the adaptation strategies indigenous people in the study area have adopted to mitigate the effects of climate change on their way of life and water resources. The study would also determine which climate change resilience-building mitigation strategies indigenous people consider to be the most effective.

Materials and Methods

Study area

The Wa West District was curved out of the Wa Municipality and made an autonomous district by L.I 1746. The District is located in the western part of the Upper West Region, approximately between longitudes 9º 40' N and 10º 10' N and also between latitudes 2º 20' W and 2º 50' W. The administrative capital is Wechiau. The District Shares Boundaries with Sawla-Tuna-Karlba District to the south, Wa Municipal to the east Nadowli Kaleo District to the north and to the west with Ivory Coast. The population of the District according to 2010 population and housing census stands at 81,348 with 40,227 males and 41,121 females (Figure 1).

Sample size

The 2022 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

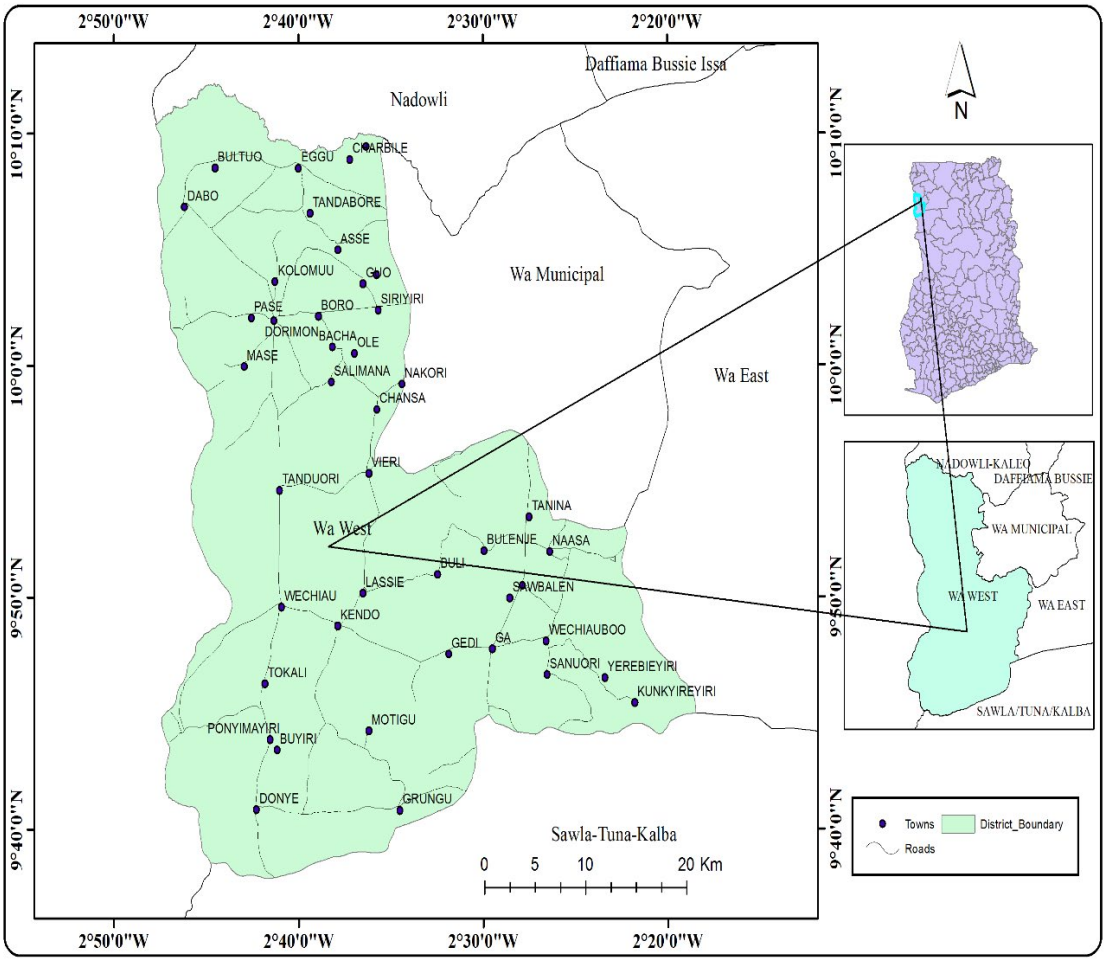

Figure 1: Map of Study Area.

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 100 key informants comprising 10 District Assembly officials, 10 Ministry of Food and Agriculture (MOFA) staff members, 10 Environmental Protection (EPA) personnel, 10 Forestry Commission (FC) staff members, and 6 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 was initially used to assess the geographical spatial 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 2012.

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

Weighted Average Index (WAI) was also used to analyze farmer's climate change adaptation and mitigation strategies. 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

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 indicates that logistic regression was used to examine the association between physical activity and depressive symptoms, controlling for age, sex, education level, and chronic conditions [9]." .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:

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

$$Logit\{P(outcome)\} = \frac{P(Outcome)}{1-P(Outcome)} = \{b_0 + b_1X_1 + b_2X_2 + b_3X_3 \ldots + b_pX_p\} \quad (1)$$

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

$$\frac{P(Outcome)}{1-P(Outcome)} = \exp\{b_0 + b_1X_1 + b_2X_2 + b_3X_3 \ldots + b_pX_p\} \quad (2)$$

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:

$$Lt\frac{PX}{1-P} = \{b_0 + b_1X_1 + b_2X_2 + b_3X_3 \ldots + b_pX_p\} \quad (3)$$

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.

Results and Discussions

Impact of Climate Change on Agriculture and Water Bodies

Focus group discussions organized for key informants from the Ministry of Food and Agriculture, the Environmental Protection Agency, the Forestry Commission, and the Municipal Assembly to determine the effects of climate change on sustainable livelihoods and water bodies determined that water scarcity (WAI-1.90) is the greatest threat to sustainable livelihoods (Table 2). It recognizes that the inhabitants of Wa West and its environs rely primarily on rain-fed agriculture and supplement their farming activities during the dry season with irrigation. However, as a result of climate change, drought, dry spells, and high evaporation of water bodies in the communities have a negative impact on agricultural activities, resulting in a low yield. The majority of small dams, wells, dug outs, and streams easily dry up during the dry season due to high demand for domestic use, irrigation, and livestock watering, according to the study. According to studies, high temperatures as a result of climate change contribute to the excessive depletion of the environment's water bodies [10]. Discussions with the study's key informants revealed that high temperature (WAI-1,84) is one of the primary obstacles to effective postharvest management of crops. According to the discussions, the majority of perishable crops, including vegetables, are susceptible to spoilage during storage due to the high temperature. The farmers have devised local methods for storing their crops in local silos and barns, but the storage facilities are insufficient to protect the crops from excessive heat; as a result, the majority of crops easily perish

Table 1: Sample questionnaire used in the study.

Variables	How Variables Were Coded
*Impact of climate change on water resources and livelihood	Water scarcity; 1= Increasing, 2= decreasing, 3= not sure
	High temperature; 1= Increasing, 2= decreasing, 3= not sure
	Poor soil fertility; 1= Increasing, 2= decreasing, 3= not sure
	Poor yield; Increasing, 2= decreasing, 3= not sure
	Increased poverty; 1= Increasing, 2= decreasing, 3= not sure
	Land tenure; 1= Increasing, 2= decreasing, 3= not sure
	Deforestation; 1= Increasing, 2= decreasing, 3= not sure
**Climate change adaptation strategies	Improved seed; 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
	Organic and in organic fertilizer; 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
	Use of modern technology; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Post-harvest management ; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Using improved seeds; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Alternative seeds; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Land rotation; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
**Mitigation strategies	Input subsidies;1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Access to weather; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Dam construction ; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Improve agricultural policies ; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Capacity building and training; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Access to market ; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested
	Access to road ; 1 = not at all interested, 2 = somewhat interested, 3 = undecided,4 = interested, 5 = very interested

Table 2: Impact of Climate Change on Agriculture and Water bodies.

Variables	High	Moderate	Low	Not sure	WAI	Rank
Water scarcity	46	18	16	20	1.90	1
High temperature	42	19	20	19	1.84	2
Poor soil fertility	39	21	22	18	1.81	3
Poor yield	37	24	20	19	1.79	4
Increased poverty	36	20	24	20	1.72	5
Land tenure issues	33	24	19	24	1.66	6
Deforestation	29	21	28	22	1.57	7

Source: Key informants; FBOs, Opinion leaders' discussions (2022).

or become infested with pests and diseases. Storing crops in silos, warehouses, and other storage facilities increases their susceptibility to spoilage. For instance, high temperatures can hasten the deterioration of grains, legumes, and nuts, whereas increased humidity can promote the growth of mold and bacteria that can cause food poisoning. High temperatures, especially during critical growth stages, can reduce crop yields by affecting pollination, slowing plant growth, and increasing water stress, according to scientific studies [11]. Similar research indicates that high temperatures, particularly in Africa, contribute significantly to post-harvest losses due to inadequate heat-resistant storage facilities and technologies [12]. Interactions with farmers indicate that the majority of crops are susceptible to heat as a result of the excessive use of inorganic fertilizers to grow the crops as a result of the impact of climate change on soil fertility. Poor soil fertility (WAI-1.81), which ranked third, was also viewed as one of the most significant effects of climate change on sustainable livelihood. It was discovered that continuous cropping on the same piece of land, poor farming technology, and the negative effects of climate change have rendered farmland infertile. As a result, yields continue to decline, affecting farmers' ability to make a living. Poor soil fertility is primarily a result of low soil organic matter content, whereas high soil organic matter improves the activities of soil microorganisms, resulting in good water retention, soil aeration, and soil nutrient retention [13]. Poor yield (WAI-1.79), ranked fourth in terms of the impact of climate change on livelihood, ranked fourth in terms of yield. According to the study, the effects of climate change include dry spells, drought, and erratic rainfall, as well as the invasion of farms by exotic weeds, insects, and diseases. As a result of climate change, the environment deteriorates, resulting in low yields that translate into economic activities that are unsustainable [14]. Increased poverty (WAI-1.72) ranked fifth on the list of climate change impacts on water resources and means of subsistence. Discussions with key informants revealed that reliance on precipitation and other water resources for subsistence activities increases the indigenous population's susceptibility to climate change. Climate variations causing soil infertility and depletion of water resources in the environment have an impact on the livelihood activities of the study area, such as farming, fishing, and dry-season gardening. A study published in "Proceedings of the National Academy of Sciences" discovered that the frequency of droughts in East Africa has increased since the 1970s, and that this increase has contributed to food insecurity and diminished economic growth [15]. In addition, similar research has found that alterations in temperature and precipitation patterns in Sub-Saharan Africa have reduced maize yields by up to 50 percent [16]. When communities' means of subsistence are hampered by climate change, poverty consequently becomes more prevalent. According to the study, land tenure issues (WAI-1.66) contribute to the inability of natives to maintain a sustainable way of life in the study area due to the impact of climate change on water resources and arable lands. In order to improve the well-being of community members, population growth necessitates the expansion of farms and the enhancement of alternative sources of income. Poor soil fertility and unfavorable climatic conditions have compelled natives of the study area to seek out virgin land for agricultural purposes. This has resulted in conflicts between individuals and families who require land to enhance their economic well-being. The discussions of the key informants revealed that deforestation (WAI-1.57) ranked last in terms of the effects of climate change on livelihoods and water resources. This implies that, as a result of climate changes affecting soil fertility and

water resources, indigenous people have resorted to deforestation and charcoal production to improve their standard of living.

Using a logic regression model to analyze the results of climate change adaptation strategies, as shown in Table 3, reveals that the use of improved seeds (6. 277) was recommended by farmers as one of the most effective strategies for building climate change resilience. Interactions with community members to explain why farmers view improved seeds as the best adaptation option among other available strategies revealed that improved seeds enable farmers to obtain a good harvest when crops are planted on time and in conjunction with necessary cultural practices. In addition, the study demonstrates that irrigation (5.37), as well as other adaptation strategies, improved the indigenous people's standard of living. The length of the cropping season is impacted by frequent drought as a result of a poor rainfall pattern, according to interactions with locals. Consequently, the provision of irrigation facilities and the protection of water bodies from excessive evaporation would enhance dry season gardening in order to supplement the yield of the main season crop. In developing nations experiencing extreme weather conditions as a result of climate change, irrigation and water storage facilities, such as dams, ponds, and dugouts, promote year-round agricultural activities [17-18].

Use of organic and inorganic fertilizer (5.18) has been identified as one of the most important adaptation strategies adopted by indigenous farmers, who are predominantly small-scale farmers. Interactions with farmers indicate that continuous farming on the same infertile piece of land and extreme weather conditions have forced farmers to rely on organic and inorganic fertilizers to increase crop yield. While organic manure (organic fertilizer) helps to improve soil structure and fertility, inorganic fertilizers (NPK, Ammonia, and Urea) only promote crop growth and do not improve soil fertility [19]. Agroforestry (5.021) was identified as a crucial adaptation strategy for increasing crop yield. Observations by researchers in the communities of the study area revealed that the majority of the farms are covered with cashew, mango, shea, and dawadawa trees. According to farmers, agricultural extension agents (AEAs) in the municipality train and provide them with cashew and mango seedlings to promote their agroforestry techniques. As a result of decades of farming experience, it was determined that the majority of farmers, particularly the elderly, possess prior knowledge regarding the importance of agroforestry in promoting microclimate.

Alternative sources of income (4.328) were implemented as one of the adaptation strategies that could boost their income and conserve water resources. Fishing, beekeeping, charcoal production, handicrafts, and animal husbandry are among the alternative livelihoods proposed by the community members. Interactions with the indigenes revealed that, as a result of climate variations, poor crop yield has compelled a portion of the indigenes, primarily the youth, to pursue alternative means of subsistence. Farmers are embracing the use of modern agriculture technology (4.243) as part of their adaptation strategies to enhance their farming activities and increase yield. According to farmers, the use of modern machines such as tractors for planting and harrowing and planters reduces the stress associated with agricultural activities. Interactions with farmers indicate that the use of obsolete tools, such as hoes, cutlasses, and bullocks, impedes the timely ploughing of vast acreages of land, thereby increasing their susceptibility to drought and dry spells. Personal observations revealed that the majority of farmers are unable to till and plant crops on all farmland, which ultimately affects their yield and means of subsistence. During the dry season, it was observed that harvesting crops manually leads to crop destruction by wildfires and termites.

Table 3: Logistic regression model results of adaptation strategies (N=330).

Variable	Coefficient	Standard error	P. value
Constant	6.987	1.637	0.001
Using modern agricultural technology	4.133*	1.256	0.003
Post-harvest management	3.253*	1.129	0.001
Using improved seeds	6.227*	1.186	0.002
Alternative livelihoods	4.328*	2.291	0.001
Agroforestry	5.021*	1.349	0.005
Use of organic and inorganic fertilizer	5.18*	2.222	0.000
Land rotation	0.258	1.148	0.082
Crop diversification	3.159*	1.070	0.000
Irrigation	5.37*	1.165	0.001

The discussion among the study's key informants also revealed that post-harvest management (3.253) was among the least prepared adaptation strategies by farmers. According to key informants, farmers are eager to improve their storage facilities and skills, but the high cost of heat-resistant storage facilities prevents them from gaining access to what is necessary to protect crops from pests and diseases. According to research, by 2030 [20], improved storage facilities in developing nations battling heat stress could contribute to food security and the improvement of 70 percent of farm family livelihoods [21]. Similarly, [22] discovered that improved post-harvest management practices, such as cooling and storage, reduced losses of tomato and pepper crops in the Netherlands due to heat stress. FAO (2014) estimated that reducing food losses by 50% through improved post-harvest management practices could reduce annual greenhouse gas emissions by up to 4.4 gigatonnes of carbon dioxide equivalent. In addition, other studies indicate that Africa's vast arable land could be a potential solution to hunger and poverty if, in the wake of climate change, farmers are provided with adequate storage facilities for their produce until they have access to favorable market prices [23].

The majority of farmers practice monoculture, so crop diversification (3.159) was the least preferred strategy, according to the study. According to the farmers and the researchers' personal observations, farmers cultivate staple foods for their families and sell the surplus. This implies that farmers prioritize local staple crops and are unwilling to change their preferences, even if the introduction of new crops could improve their standard of living.

According to the results of the study as presented in Table 4, input subsidies (5.337) are the most preferred mitigation strategy. According to studies, subsidies promote environmental degradation and increased greenhouse gas emissions as a result of the excessive use of fertilizer and other chemicals [24-25]. Farmers and key informants confirm that the high cost of agricultural inputs hinders farm expansion in the region. The farmers planting for food flagship program that subsidizes inputs for farmers was found to be ineffective. Fertilizers, hybrid seeds, and chemicals that were supposed to be affordable, according to the farmers, were sold at inflated prices on the open market. This contributes to a poor harvest in extreme weather conditions. The key informants also identified improved agricultural policies (5.028) as one of the advantageous mitigation strategies that can enhance the livelihood and water resources of the natives of Wa West District. Additional interactions with the natives reveal that enhancing agricultural policies would increase the government's budgetary support for agricultural activities. This will promote input subsidies, access to a good road network in agricultural areas, agro-processing machines, capacity building and training for the adoption of morning agricultural technology. In addition, it was recognized that improved agricultural policies aid in increasing the number of

agricultural extension agents (AEAs) and Veterinary officers who are readily available to assist farmers with seeds and provide farmers with climate-smart agriculture skills. Improved agricultural policies in Africa, particularly in countries vulnerable to extreme weather, contribute to food security, hunger reduction, improved sustainable livelihoods, and increased GDP [26].

According to the study, access to weather information (4.559) was regarded as one of the most effective mitigation strategies capable of enhancing the indigenes' standard of living and water resources. Access to weather information improves farmers' early warning systems for ploughing, sowing, flooding, harvesting, and postharvest management of farm produce, according to studies [27-29]. This will also reduce the risks posed by drought and unfavorable weather conditions that can impede seasonal agricultural activities. The construction of a dam (4.277) was realized as one of the climate change and weather extremes mitigation strategies indigenous people perceive as an intervention that can improve their standard of living. According to locals and opinion leaders, dam construction could provide irrigation, fishing, and water access for livestock and households. According to opinion leaders and key informants, the community's vast arable land presents an opportunity for intensive dry season gardening, which can supplement farmers' income. Discussions with the study's key informants revealed that market access (4.128) was one of the mitigation strategies perceived as good interventions that promote activities enhancing livelihoods and climate change resilience. According to the indigenes, market access enables farmers and indigenes to market their farm products, especially perishable ones, more easily, thereby reducing postharvest losses. Due to climate change, extreme heat and unusual pest and disease invasions cause a great deal of damage to crops during storage [30-32]. This impacts farmers' profit margins and livelihoods. Access to a road network (3.128) was rated as the least mitigation strategy indigenous peoples perceived as an intervention that can help build their climate change resilience. Interactions with the locals revealed that although the roads leading to farms, markets, and other sources of subsistence are in a deplorable state, they have access to other remote routes, which is why road was not the most preferred mitigation strategy. Studies have shown that a good road network in rural areas that are dominated by farmers improves the transportation system, petty trading, marketing of farm products, access to agricultural inputs, and provision of alternative livelihoods in order to reduce environmental overdependence [33]. Access to a good road network could enable farmers to transport their goods directly to the southern sector, where they can receive good prices for their produce, rather than dealing with middlemen who purchase their produce at a lower price, as determined through interactions with the indigenous population and some opinion leaders. However, opinion leaders suggested that, in the aftermath of climate change-related disasters, road networks constructed to improve livelihood activities should be resistant to adverse weather conditions, such as flooding. Because key informant discussions revealed that good agricultural policies by the government would include provisions for capacity building and training of farmers, it was determined that capacity building and training were not a pressing mitigation strategy.

Conclusion

This study revealed that climate change is regarded as a significant environmental threat to the food security and way of life of communities in Ghana's Upper West Region. Numerous impediments to farmers' efforts to enhance soil fertility and climatic conditions were identified by the findings of this study. If access to weather information is improved, the effects of insufficient precipitation and high temperatures causing frequent drought, dry spells, and the drying up of water bodies, which negatively affect crop production and other forms of subsistence, can be mitigated. For farmers to be better prepared for climate change adaptation and mitigation, weather data should be readily available, easily accessible, and applicable. This can be accomplished by strengthening the link between the Ministry of Foreign Affairs and the Department of Metrological Services to facilitate the dissemination of weather information.

Due to the importation of most agricultural inputs and inadequate government agricultural policies, farmers are prevented from acquiring the necessary input for adaptation. Due to the fact that the majority of farmers are small-scale, low-income farmers, high input costs would prevent the implementation of strategies that could improve soil fertility and yield. Increased government support for the agricultural sector would facilitate the acquisition of inputs required for adaptation and yield enhancement.

Land tenure issues were identified as a fundamental factor preventing farmers from investing in adaptation practices. By enacting land reform policies and land tenancy agreements to facilitate the adoption of an effective adaptation strategy, farmers' fears of losing farmland to rightful owners could be alleviated.

Adaptation to climate change is ultimately intended to maximize farmers' welfare. Poor soil fertility in the study area and the inability to afford farm inputs such as fertilizers, weedicides, and tractor services make farmers more vulnerable to the effects of climate change. Therefore, cultural practices such as improved seeds, changes in planting season, drought-resistant and short duration crops, composting, and mulching could serve as effective climate change adaptation strategies.

As the government is a major stakeholder in the agricultural sector, climate change adaptation and mitigation strategies could be vastly improved if the Forestry Commission, EPA, and MOFA had the resources to educate farmers on easily adaptable strategies, such as agroforestry, to improve vegetation and microclimate. In order to reduce reliance on rain-fed agriculture, additional campaigns should be implemented to promote livestock husbandry, beekeeping, weaving, and irrigation as alternative livelihoods. Agricultural communities are developing skepticism regarding the efficacy of current climate change mitigation and adaptation strategies; therefore, it is urgent to conduct additional research into more effective and cost-effective adaptation and mitigation strategies to increase farmers' resilience to climate change.

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