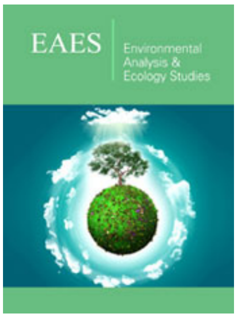
Crimson Publishers
Wings to the Research

Research Article

Analyzing Impact of Climate Change on Sustainable Livelihood and Water Resources in Wa West District, Upper West Region- Ghana

ISSN: 2578-0336



Clifford James Fagariba[1]*, Robert Yakubu Adjuik[2] and Asaah Sumaila Mohammed[3]

[1]Department of Environment and Resource Studies, Faculty of Integrated Development Studies, SDD University of Business and Integrated Development Studies, Ghana

[2]Department of History and Political Science, Faculty of Social Science and Arts, SDD University of Business and Integrated Development Studies, Ghana

[3]Department of Environmental Science, School of Environment and Life Sciences, CK Tedam University of Technology and Applied Science, Ghana

***Corresponding author:** Clifford James Fagariba, Department of Environment and Resource Studies, Faculty of Integrated Development Studies, SDD University of Business and Integrated Development Studies, Ghana

Submission: February 23, 2023
Published: March 28, 2023

Volume 10 - Issue 4

How to cite this article: Fagariba, C.J., Adjuik, R.Y. and Mohammed, A.S. (2023) Analyzing Impact of Climate Change on Sustainable Livelihood and Water Resources in Wa West District, Upper West Region- Ghana. Environ Anal Eco stud. 000745. 10(4). 2023. DOI: 10.31031/EAES.2023.10.000745

Abstract

According to research findings, climate change has the greatest impact on sustainable livelihoods 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 researchers utilized the Wa West District as a case study to evaluate the effects of climate change on agriculture and water resources. In the study, the logic regression model was used to determine the adaptation and mitigation strategies indigenous peoples were employing to strengthen their climate change resilience. The study also employed a weighted average index to evaluate the effects of climate change on agriculture and water supplies. 330 small-scale farmers were surveyed, and 100 key informants participated in the focus group discussions. Using a logistic regression model, the study determined that irrigation, drought resistant crops, mulching, fertilizer use, and agroforestry practices were the adaptation strategies farmers employed to improve resilience. In addition, input subsidies, access to weather information, dam construction, and improved agricultural policies were the most preferred mitigation strategies for reducing vulnerability in the study area. According to a Weighted Average Index used in the study, the most prevalent impacts of climate change on livelihood were water scarcity, high temperatures, low soil fertility, biodiversity loss and low yield. According to the study, the ability of farmers to adapt to climate change can be enhanced 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 livelihoods.

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

Introduction

The Food and Agriculture Organization (FAO) estimates that by 2050, the world will need to feed approximately 15 billion people while addressing biodiversity and deforestation problems, increasing carbon sinks, and improving climate-resilient food security (FAO, 2015). Furthermore, while adhering to international environmental accords, the world will need to provide cheap 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 (WFP, 2016: IFAD, 2018)[1-2]. Approximately 48 percent of Africa's population, or 450 million people, live in extreme poverty, earning less than $1.25 per day, with 63 percent living in rural areas and depending on agriculture for a livelihood (World Bank, 2015) [3].

Globally, climate change has a major impact on sustainable livelihoods and water supplies. Climate change has far-reaching consequences that affect many aspects of human life, including food security, health, and fiscal stability (IPCC, 2014) [4-5]. Changes in precipitation and temperature patterns, as well as an increase in the frequency and severity of extreme weather events, are all having a negative effect on water resources (UNEP, 2016) [6]. Drought and high temperatures are wreaking havoc on subsistence farms in developing countries, particularly in Africa, and have contributed significantly to the worsening of poverty in Sudan, Mali, and Chad [7-10]. According to FAO 2018, ongoing weather extremes affecting agriculture and water resources have security implications in African nations already experiencing political unrest. Ghana, like many other African countries, is particularly vulnerable to climate change effects due to its dependence on agriculture, fishing, and forest products for subsistence. Climate change has the greatest effect on sustainable livelihoods in agriculture, where changes in precipitation patterns and the frequency of extreme weather events are disrupting crop and livestock output Tey & Akomeah [9]. The decline in agricultural output jeopardizes the country's food security as well as the livelihoods of smallholder farmers who depend on agriculture for a living [11-12].

Changes in precipitation trends caused by climate change are reducing river flows and lowering groundwater levels in Ghana, putting a strain on the country's water supplies [13]. Water scarcity has a major impact on the country's economy, which is heavily reliant on hydropower and irrigation [14]. Climate change is affecting Ghana's water resources in the form of changes in precipitation patterns, an increase in the frequency of droughts, and a decline in the amount of water available for agriculture and other human activities, according to Adiku et al. [15]. According to the research, these impacts are exacerbating rural poverty and food insecurity, and local communities are struggling to adapt to these changes. Oteng-Ababio et al. [16] conducted a similar study on the effect of climate change on the livelihoods of Ghanaian small-scale farmers. Climate change, according to the research, is altering crop production timing and increasing crop production costs, resulting in lower crop yields and income for farmers. Furthermore, the research found that the effects of climate change are felt unevenly across the nation, with rural and disadvantaged communities being especially vulnerable. According to a World Wildlife Fund study WWF [17], climate change has had an impact on Ghana's water resources, including decreased water availability, increased water scarcity, and a rise in water-borne diseases. According to the study, these impacts are affecting the livelihoods of communities that depend on water for agriculture, fishing, and other livelihood activities. In light of the preceding insight, the goal of this study is to assess the impact of climate change on the Wa West District's livelihood activities and water resources. The study also seeks to ascertain the adaptation strategies used by indigenous peoples in the study area to mitigate the impacts of climate change on their livelihood and water resources. The study would also identify which indigenous peoples believe are the most effective climate change resilience-building mitigation strategies (Figure 1).

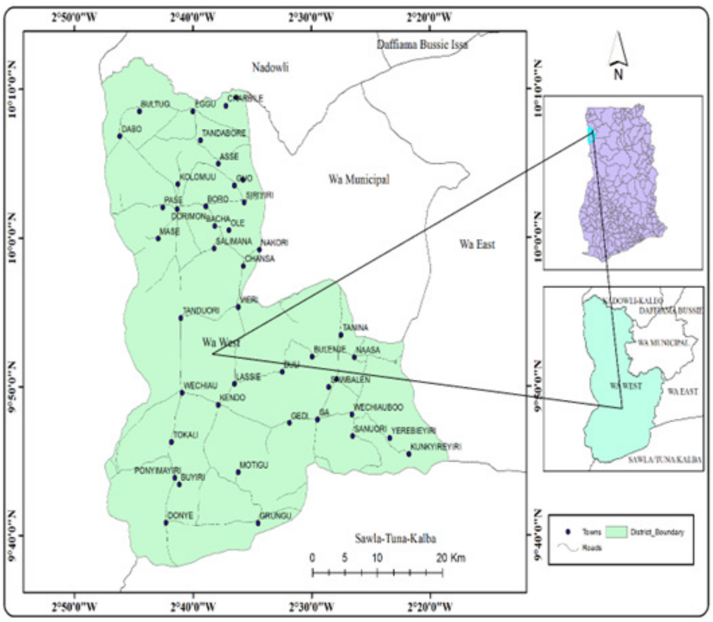


Figure 1: Map of study area.

Materials and Methods

Study area

The Wa West District was carved 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 9° 40' N and 10° 10' N and also between latitudes 2° 20' W and 2° 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.

Sample size

According to the District Agriculture Development Unit's (DADU) 2022 Farmers Updated Census Data, 39,134 people between the ages of 15 and 65 work in agriculture, with men making up the bulk of these workers. Only 330 of the 399 farmers who were intended for sampling ended up taking part in the poll. 10 communities were chosen with the assistance of Agric Extension Agents (AEAs), and 30 farmers from each of these communities were randomly chosen to participate in the survey with the help of semi-structured questionnaires. Focus Group Discussions (FGDs) were also organized separately for 100 key informants, including 10 representatives from the District Assembly, 10 from the Ministry of Food and Agriculture (MOFA), 10 from the Environmental Protection Agency (EPA), 10 from the Forestry Commission (FC), and 10 representatives from each of the six Farmer-Based Organizations (FBO) groups. The goal of these FGDs was to learn more about the limitations of farmers' ability to adapt as well as the approaches they use to do so. The goal of the focus group talks (FGDs) was to elicit a range of opinions on the problems related to adaptation constraints and strategies.

In order to identify the most effective strategy for contacting respondents, the geographical features, settlements, and community entry method used in the previous study-participatory rural appraisal-were originally evaluated. Due to the district's dispersed settlements, five field officers were trained and overseen to assist in data gathering. The data was gathered over a four-month span, from February to June 2012.

Analyses of data

The Statistical Package for Social Sciences (SPSS) version 23 was used to evaluate the field survey data and create tables that clearly depict the responses of the respondents. SPSS was also used to evaluate a logic regression model that was used to identify the variables affecting adaptation.

Weighted average index: Farmers' adaptation and mitigation tactics for climate change were also examined using the Weighted Average Index (WAI). On a scale of 0–4 (0–not at all interested, 1–not very interested, 2–undecided, 3–somewhat interested, 4–very interested), farmers' use of fertilizer, farmyard manure/mulching, planting season variation, irrigation, and other climate change adaptation tactics were also rated. On a range of 0 to 2, weather extremes were classified as low, moderate, or high. Due to the type of the questions posed and the results obtained during the questionnaire's pre-testing before the survey was conducted, a separate scale was used to rank the variables. To get a range of responses, a separate ranking scale was used. The formula below was used to calculate the WAI of the interviewees' variables:

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

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

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: Similar to linear regression analysis, but with a binary result (e.g., true/false, low/high), logistic regression analysis is a popular data analysis technique. The probabilities of an event's result are calculated using logic regression. It was applied in this case to identify variables that may have an impact on how farmers adjust to climate change. In other studies, logistic regression was employed to investigate the relationship between physical exercise and depressive symptoms while controlling for age, sex, education, and ongoing medical conditions Liang et al. [18]. This suggests that the logic regression model can forecast the probability of an event occurring. In logistic regression analysis, the result is frequently coded as either 0 or 1, with 1 denoting a correct result and 0 denoting a false result. The logic regression model can be written as: If P in the equation stands for the probability that a result is 1, then:

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

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

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

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

P is the expected probability that an outcome has the potential of being true or false. X1, X2, X3, up to Xp are independent variables that predict the outcome of P; b0, b1, b2, up to bp 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:

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

From the model equation, Px 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.

Table1: 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

*Impact of climate change on agriculture,

**adaptation and mitigation strategies questionnaire for focus group discussions (FGDs) comprising Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA), District Assembly, nongovernmental organizations (NGOs), and Farmer Base Organization (FBO).

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. 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 [15]. 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 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 [19]. Similar research indicates that high temperatures, particularly in Africa, contribute significantly to post-harvest losses due to inadequate heat-resistant storage facilities and technologies [20-21]. 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 [22]. 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 [23]. 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 [24]. 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 [25-26]. 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 (Table 2). 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.

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	1.9	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)

Evaluated climate change mitigation strategies

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 [27-28].

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
Land rotation	0.258	1.148	0.082
Crop diversification	3.159*	1.07	0
Irrigation	5.37*	1.165	0.001

Source: 2022 survey.

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 [29-30]. 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.

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 Adomako & Nakajima et al. [31-32], improved storage facilities in developing nations battling heat stress could contribute to food security and the improvement of 70 percent of farm family livelihoods [31-32]. Similarly, Van der Werf et al. [33] 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 [11] estimated that reducing food losses by 50% through improved post-harvest management practices could reduce annual greenhouse gas emissions by up to 4.4 gigatons 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 [31-34].

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.

Evaluated climate change mitigation strategies

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 [35-37]. 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.

Table 4: Logistic regression model results of mitigation strategies (N=330).

Variable	Coefficient	Standard Error	P. value
Constant	7.187	1.537	0.001
Market centres	4.128*	1.129	0.001
Input subsides	5.337*	1.186	0.002
Access to road	3.128*	2.291	0.001
Improved agricultural policies	5.028*	1.222	0
Capacity building and training	0.258	1.148	0.082
Access to weather information	4.559*	1.07	0
Dam construction	4.277*	1.165	0.001

Source: 2022 survey.

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, contributed to food security, hunger reduction, improved sustainable livelihoods, and increased GDP [38-40]. 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 Gbedemah et al. & Nyamwanza et al. [41-43]. 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 [40-44]. 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 [36,45]. 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 [46-47].

Conclusion

According to the findings of this research, climate change is regarded as a major environmental threat to the food security and way of life of communities in Ghana's Upper West Region. The findings of this research identified a number of impediments to farmers' attempts to improve soil fertility and climatic conditions. If access to weather information is improved, the impacts of insufficient precipitation and high temperatures, which cause frequent drought, dry spells, and the drying up of water bodies and have a detrimental impact on crop output and other forms of subsistence, can be mitigated. Weather data should be widely available, easily accessible, and applicable for farmers to be better equipped for climate change adaptation and mitigation. This can be done by strengthening the link between the Ministry of Food and Agriculture and the Ghana Metrological Services to facilitate the dissemination of weather information. Farmers are unable to obtain the required input for adaptation due to the importation of most agricultural inputs and insufficient government agricultural policies. Because the majority of farmers are small-scale, low-income farmers, high input costs would prevent the adoption of strategies that could improve soil fertility and yield. Increased government assistance for agriculture would make it easier to acquire the inputs needed for adaptation and yield enhancement. Land tenure issues were highlighted as a major barrier to farmers investing in adaptation techniques. Farmers' concerns about losing farmland to rightful owners could be alleviated by implementing land reform policies and land tenancy agreements to facilitate the adoption of an effective adaptation strategy.

Climate change adaptation is ultimately designed to maximize farmer welfare. Farmers are more susceptible to the impacts of climate change due to low soil fertility in the study area and an inability to afford farm inputs such as fertilizers, weedicides, and tractor services. As a result, cultural practices such as improved seeds, changes in planting season, drought-resistant and short-duration crops, composting, and mulching could be successful climate change adaptation tactics. Because 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. Additional campaigns promoting livestock husbandry, beekeeping, weaving, and irrigation as alternative livelihoods should be adopted to reduce dependence on rain-fed agriculture. Agricultural communities are becoming skeptical of the efficacy of current climate change mitigation and adaptation strategies; therefore, it is critical to conduct additional research into more effective and cost-effective adaptation and mitigation strategies to increase farmers' resilience to climate change.

References

1. World Food Programme (WFP) (2016) What is food security? World Food Programme, Rome, Italy.
2. IFAD (2018) Climate change and sustainable livelihoods. International Fund for Agricultural Development, Rome, Italy.
3. World Bank (2015) Socioeconomic impact of mining on local communities in Africa, World Bank Technical Report 2015, The World Bank, Washington DC, USA.
4. IPCC (2014) Climate change 2014: Impacts, vulnerability, and adaptation in developing countries. Intergovernmental Panel on Climate Change.
5. Intergovernmental Panel on Climate Change (IPCC) (2014) Climate change 2014: Impacts, vulnerability and adaptation. Cambridge University Press, Cambridge, UK.
6. UNEP (2016) Climate change and water resources. United Nations Environment Programme, Nairobi, Kenya.
7. DFID (2011) Climate change and sustainable livelihoods: An overview. UK Department for International Development, UK.
8. Food and Agriculture Organization of the United Nations (FAO) (2018) Irrigation in Africa in figures: AQUASTAT survey-2018, Rome, Italy.
9. Tey N, Akomeah FK (2019) The impact of climate change on sustainable livelihoods in the rural areas of Ghana. Journal of Sustainable Development 12(3): 116-128.
10. Food and Agriculture Organization of the United Nations (FAO) (2014) Module 1-weather and climate information for risk management, Climate-smart agriculture sourcebook, Rome, Italy.
11. FAO (2014) Food wastage footprint: Impacts on natural resources.
12. Adesina A, Kyei-Boahen S, Asuming-Brempong S (2017) Climate change and agriculture in Africa: Impacts, adaptations, and mitigation. Climate Change and Agricultural Development in Africa, Springer, Berlin, Germany, pp. 1-17.
13. Kyei B, Kyei-Boahen S, Asuming-Brempong S (2020) The impact of climate change on water resources and food security in Ghana. Sustainability 12(9): 3588.
14. Bonsu SK, Tano-Debrah K (2014) Climate change impacts on water resources and hydropower in Ghana. Energy Policy 68: 508-516.
15. Adiku SGK, Ofosu-Budu KA, Asante FO (2015) Climate change impacts on water resources and livelihoods in Ghana. Journal of Geography and Regional Planning 8(12): 306-317.
16. Oteng-Ababio M, Bawakyillenuo E, Apraku MK (2017) The impacts of climate change on the livelihoods of small-scale farmers in Ghana. Journal of Agriculture and Environmental Sciences 6(4): 80-89.
17. World Wildlife Fund (WWF) (2018) Climate change impacts on water resources in Ghana.
18. Liang Y, Wang L, He Y (2016) The relationship between physical activity and depressive symptoms in older adults: A systematic review and meta-analysis. International Journal of Environmental Research and Public Health 13(10): 1-15.
19. Rosenzweig C, Elliott J, Deryng D, Ruane AC, Müller C, et al. (2014) Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proc Natl Acad Sci USA 111(9): 3268-3273.
20. FAO (2011) Climate change and food security: A framework document, Food and Agriculture Organization of the United Nations, Rome, Italy.
21. Maina PN, Koome MM, Gathura PB (2014) Influence of temperature and relative humidity on the risk of fungal contamination of stored maize. Journal of Food Safety 34(2): 184-191.
22. Nath BC, Singh RP, Shukla PK (2013) Improving soil fertility for sustainable agriculture in India. Journal of Plant Nutrition and Soil Science 176(5): 561-568.
23. Asseng S, Ewert F, Rosenzweig C, Jones JW, Hatfield JL, et al. (2015) Rising temperatures reduce global wheat production. Nature Climate Change 5(2): 143-147.
24. Mason SJ, Smith J, Lesk C (2015) Increasing frequency of extreme El Niño events due to greenhouse warming. Nature Climate Change 5(6): 571-576.
25. Christoplos I, van der Mensbrugghe D, Valin H, Tchamba MN (2012) Impacts of climate change on food security in Sub-Saharan Africa. Global Environmental Change 22(2): 359-369.
26. Kpabitey K (2015) Climate change and sustainable livelihoods in Ghana: the case of small-scale farmers. Climate Change and Development in Africa 3(2): 127-135
27. Li Y, Wang L, Wu J (2017) Assessing the impact of China's Grain for Green program on agricultural sustainability: A perspective of ecosystem services. Sustainability 9(7): 1192.
28. Asem-Hiablie S, Pabi O, Ofori P (2020) Does irrigation reduce the effect of climate variability on maize yields in Northern Ghana? Evidence from survey data. Agricultural Water Management 230: 105979.
29. Alfaro MA, Jara J, Santibáñez F (2018) Organic fertilization as a key to sustainable agriculture: A review of concepts, advances and practices. Scientia Agricola 75(4): 287-303.
30. Zhou Y, Wang J, Liu J, Han Z, Lin X (2021) Effects of organic fertilizer on soil microbial community, enzyme activities, and greenhouse gas emissions in paddy fields. Environmental Science and Pollution Research 28(6): 7076-7087.
31. Adomako FK (2015) Climate change and its impacts on the livelihoods of rural farmers in the northern region of Ghana. Global Journal of Environmental Science and Management 1(3): 119-126.

32. Nakajima T, Kobayashi S, Koyama O, Inoue M (2019) Impact of climate change on rice and maize production and post-harvest losses in Indonesia and the Philippines. Regional Environmental Change 19(1): 85-96.
33. Van der Werf W, van der Helm AW, Kessel GJT, Kempkes FLK, Stanghellini C (2021) Postharvest measures to prevent losses of heat-sensitive crops under climate change. Acta Horticulturae 1301: 407-414.
34. Diiro GM, Gitonga LM, Kinyanjui PK, Omolo JO (2021) Adoption of post-harvest management practices in mitigating horticultural crop losses in Kenya. Agricultural Research & Technology: Open Access Journal 26(4): 13-18.
35. Boadi D, Adiku SGK, Wiafe JP (2015) Impacts of climate change on sustainable livelihoods and water resources in the brong-ahafo region of Ghana. International Journal of Climate Change Strategies and Management 7(2): 189-198.
36. Srinivasan P, Bedi AS (2019) Fertilizer subsidies and climate change: Evidence from India. World Development 119: 132-146.
37. Shiferaw B, Kebede T, You L, Larson DF (2014) Seed, fertilizer, and agricultural extension in Ethiopia. IFPRI Discussion Paper 01353. International Food Policy Research Institute (IFPRI).
38. Anyidoho NA, Antwi-Agyei P (2015) Climate change, agriculture, and food security in Ghana. The Journal of Development and Agricultural Economics 7(8): 168-174.
39. Hansen JW, Croz MD, Bogard JR, Hasegawa T, Zurayk R (2018) Ending global hunger: The role of policies for climate-resilient agriculture. Agricultural Systems 159: 57-66.
40. Chambwera M, Heal G, Dubeux C, Hallegatte S, Leclerc L, et al. (2014) Economics of adaptation. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
41. Gbedemah M (2017) Climate change and its impact on water resources and sustainable livelihoods in Ghana. Climate Change and Development in Africa 5(3): 144-150.
42. Nyamwanza R, Gwiriri L, Mutangadura G (2018) Impact of weather information on maize yields in Zimbabwe. Journal of Agricultural Science 10(7): 343-352.
43. United Nations Framework Convention on Climate Change (UNFCCC) (2021) The Paris agreement-What is the Paris Agreement?
44. Akankasha J, Adongo PB (2015) Climate change and its effects on the livelihoods of rural farmers in northern Ghana. The Journal of Development and Agricultural Economics 7(10): 264-270.
45. World Resources Institute (WRI) (2019) Reducing carbon emissions from transportation: Opportunities in the United States. World Resources Institute (WRI), Washington DC, USA.
46. Awuah RB, Owusu EK, Acheampong JK (2016) Climate change and sustainable livelihoods in northern Ghana. International Journal of Climate Change Strategies and Management 8(3): 368-379.
47. UNDP (2013) Water and climate change. United Nations Development Programme, New York, USA.