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Climate change impacts on livelihood and water resources in Wa West District, Ghana: Mitigation and adaptation strategies

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Abstract

Climate change's impact on the Upper West Region's agriculture leads to altered precipitation, temperature increases, and extreme weather, affecting crop and livestock productivity. This study zeroes in on the Wa West District, assessing climate change's complex effects. We employed a logic regression model to analyze adaptation and mitigation responses by indigenous communities, using data from 330 farmers and 100 informants. The research unveils a spectrum of farmer-employed adaptive strategies, such as irrigation, drought-resistant crops, mulching, precise fertilizer use, and agroforestry. The study also identifies key mitigation strategies including subsidies, better weather information, dam construction, and sustainable policy development. Our weighted average index underscores the stark impacts of climate change: water scarcity, temperature rise, soil fertility reduction, biodiversity loss, and lower yields. We recommend that government agencies ramp up climate adaptation campaigns, improve weather information dissemination, and provide farmer training. Enhancing water conservation and exploring alternative livelihoods are vital for adapting to climate-induced challenges. These insights aim to guide policymakers and stakeholders in fostering sustainable agriculture amid climate change in the region.

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

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1. Introduction

The Food and Agriculture Organization (FAO) projects that by 2050, the world must feed approximately 15 billion people while simultaneously addressing biodiversity preservation, deforestation, carbon sink enhancement, and climate-resilient food security (FAO, 2015). At the same time, the global community must strive to provide affordable energy and clean water access to an estimated 1.5 billion individuals residing in remote regions of Africa and South America, where access to electricity and clean water remains limited (WFP, 2016; UNFCCC, 2020). In Africa, where 48 percent of the population, or 450 million people, lives in extreme poverty on less than $1.25 per day, with 63 percent reliant on agriculture for their livelihoods, the stakes are exceptionally high (FAO, 2012; World Bank, 2013).

Climate change's global impact is far-reaching, affecting vital aspects of human existence, including food security, health, and economic stability (IPCC, 2014; WWF, 2018). Changes in precipitation patterns, rising temperatures, and a surge in extreme weather events adversely affect water resources (UNEP, 2017), amplifying poverty in countries like Sudan, Mali, and Chad (IFAD, 2011; FAO, 2014; WFP, 2016). The ongoing extremes in weather conditions that disrupt agriculture and water resources also have security implications, particularly for African nations grappling with political unrest.

Ghana, akin to many African countries, confronts heightened vulnerability to climate change due to its reliance on agriculture, fishing, and forest resources for sustenance. Climate change's most pronounced impact is witnessed in Ghana's agriculture sector, where altered precipitation patterns and the increased occurrence of extreme weather events disrupt both crop and livestock production (Tey and Akomeah, 2019; Adomako, 2015). This disruption imperils the nation's food security and the livelihoods of smallholder farmers who heavily depend on agriculture (FAO, 2014; Antwi-Agyei et al., 2018).

Furthermore, climate-induced shifts in precipitation patterns are diminishing river flows and depleting groundwater levels in Ghana, straining the nation's water resources (Kyei et al., 2020). Water scarcity significantly impacts Ghana's economy, which heavily relies on hydropower generation and irrigation (Bonsu and Tano-Debrah, 2014). The consequences of climate change, such as altered precipitation patterns, increased drought frequency, and reduced water availability for agriculture and other activities, exacerbate rural poverty, food insecurity, and the challenges faced by local communities in adapting to these changes. Research conducted by Oteng-Ababio et al. (2017) reveals that climate change alters crop production timing, elevates production costs, and leads to diminished crop yields and farmer incomes. Vulnerable rural communities in the Upper West region are particularly affected.

Climate change's effects on Ghana's water resources extend to decreased water availability, heightened water scarcity, and an upsurge in water-borne diseases (Adiku et al., 2015; Awuah et al., 2016; Kyei et al., 2020), affecting communities reliant on water for agriculture, fishing, and other activities.

While international organizations, NGOs, and governments have initiated efforts to mitigate climate change effects in the Upper West Region, some farmers have independently developed techniques to conserve water resources, maintain soil moisture, lower soil temperatures, and enhance soil fertility. Stakeholders and international organizations regard adaptation and mitigation strategies as crucial policies to combat extreme poverty, hunger, food insecurity, and the consequences of climate variability in the region.

Despite some farmers' existing adaptation strategies, there is a pressing need to align these approaches with scientifically proven methods to enhance efficiency and productivity.

In light of the above, this study aims to assess the impact of climate change on indigenous livelihoods and water resources. Additionally, it seeks to evaluate the effectiveness of adaptation strategies employed by indigenous communities in mitigating climate change effects on livelihoods and water resources. The study will identify the most effective indigenous agricultural practices for building climate resilience and offer recommendations for policy interventions that combine indigenous wisdom with scientific mitigation and adaptation strategies.

2. Materials and methods

2.1. Study area

The Wa West District was established as an autonomous district, separating from the Wa Municipality through L.I 1746. Situated in the western part of the Upper West Region, it is located approximately between longitudes 9º 40’ N and 10º 10’ N, as well as latitudes 2º 20’ W and 2º 50’ W. The administrative hub of the district is Wechiau. It shares its borders with the Sawla-Tuna-Karlba District to the south, the Wa Municipal to the east, the Nadowli Kaleo District to the north, and the Ivory Coast to the west. As of the 2010 population and housing census, the district had a population of 81,348, comprising 40,227 males and 41,121 females.

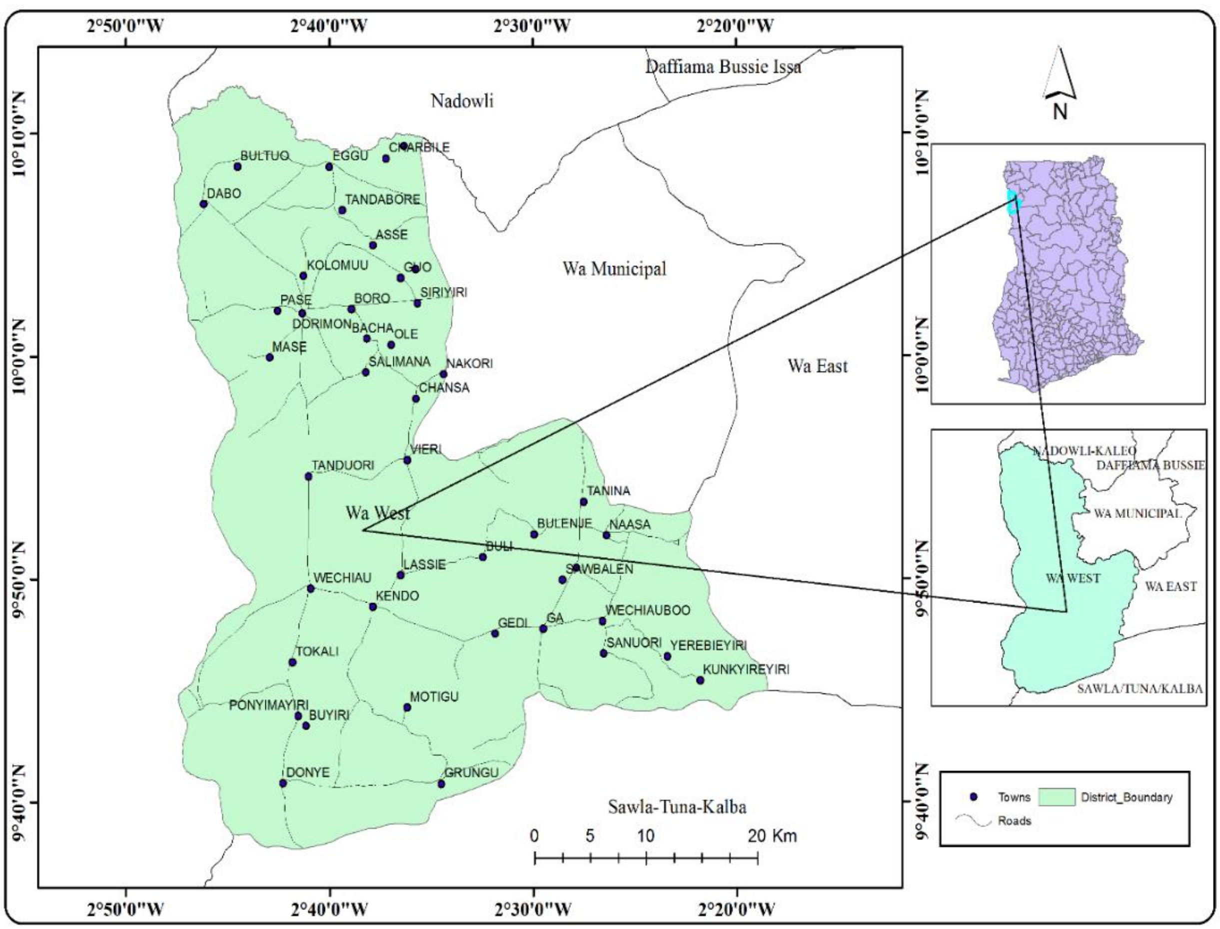

Figure 1. Map of study area

2.2. Sampling methodology

As per the 2022 Farmers Updated Census Data provided by the District Agriculture Development Unit (DADU), there were a total of 39,134 individuals aged between 15 and 65 engaged in agriculture, with a predominance of male workers. Out of the intended 399 farmers targeted for sampling, only 330 ultimately participated in the survey. To select representative communities, we collaborated with Agriculture Extension Agents (AEAs) and identified 10 communities. From each of these communities, we randomly selected 30 farmers to participate in the survey using semi-structured questionnaires. Additionally, we conducted separate Focus Group Discussions (FGDs) with 100 key informants, comprising 10 representatives each from the District Assembly, Ministry of Food and Agriculture (MOFA), Environmental Protection Agency (EPA), Forestry Commission (FC), and six Farmer-Based Organizations (FBO) groups. The objective of the FGDs was to gather diverse insights on the challenges related to adaptation constraints and strategies.

To determine the most effective approach for reaching respondents, we evaluated geographical features, settlements, and the community entry method used in a prior participatory rural appraisal study. Given the scattered nature of settlements in the district, we trained and supervised five field officers to assist in data collection. Data collection took place over a four-month period, from February 2022 to June 2022.

2.3. Data analysis

We employed the Statistical Package for Social Sciences (SPSS) version 23 to analyze the field survey data and generate tables that provide a clear overview of respondent responses. Additionally, SPSS was used to assess a logic regression model, which was instrumental in identifying the variables influencing adaptation.

2.3.1. Weighted Average Index

To examine farmers' adaptation and mitigation strategies for climate change, we utilized the Weighted Average Index (WAI). Respondents rated their use of various climate change adaptation tactics on a scale of 0 to 4 (0—Not at all interested, 1—Not very interested, 2—Undecided, 3—Somewhat interested, 4—Very interested). These tactics included fertilizer use, farmyard manure/mulching, planting season variations, irrigation, and others. Weather extremes were classified as low, moderate, or high on a scale of 0 to 2. The choice of scale for each variable was determined during pre-testing of the questionnaire. To obtain a comprehensive range of responses, we employed a distinct ranking scale. The formula below was used to calculate the WAI of the interviewees' variables:

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

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

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

2.3.2. Logistic regression analysis

Logistic regression analysis, akin to linear regression analysis but tailored for binary outcomes (e.g., true/false, low/high), is a widely used data analysis technique. It employs a logical regression approach to calculate the probabilities of specific event outcomes. In our study, logistic regression was employed to discern the variables that might influence farmers' adaptation to climate change. This technique is akin to its application in other studies where logistic regression was used to investigate relationships, such as the correlation between physical exercise and depressive symptoms, while controlling for factors like age, sex, education, and ongoing medical conditions (Liang et al., 2016). Essentially, the logic regression model can predict the probability of a specific event occurring. In logistic regression analysis, outcomes are typically coded as 0 or 1, with 1 representing a true result and 0 signifying 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:

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

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

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

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:

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

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.

3. Results and discussions

3.1. Demographic characteristics of respondents

The demographic characteristics of the respondents were subject to thorough analysis to gain deeper insights into how they might influence their climate change adaptation and mitigation practices. As depicted in Table 1, a significant proportion of indigenous individuals in the Wa West District had not received formal education, indicating a prevailing trend of increasing school dropouts as education levels advanced. This striking pattern underscores the pervasive issue of illiteracy within the community, which can pose substantial challenges when attempting to shift traditional farming practices towards more climate-resilient approaches. Furthermore, a noteworthy observation was made – farmers with extensive farming experience tended to have lower levels of education. This observation raises critical questions about their readiness and willingness to embrace modern technology for climate change adaptation and mitigation. The intricate interplay between demographic factors and climate resilience within this context merits thorough examination.

Table 1. Demographic characteristics of respondents

Age	Gender			Education level					Average Farming Experience
	M	F	Total	Non formal education	Primary	JHS	SHS	Tertiary	
15-25	38	11	49	13	16	11	8	1	8
26-35	64	21	85	33	20	22	7	3	15
36-45	69	24	93	39	28	13	10	3	25
46-55	55	15	70	47	13	8	2	0	35
56-65	24	9	33	24	7	2	0	0	44
Total	250	80	330	156	84	56	27	7	

Source: field survey 2022

**JHS: Junior High School, ** SHS: Senior High School*

3.2. Climate change effects on sustainable livelihoods and water resources

Focus group discussions were conducted with key informants from the Ministry of Food and Agriculture, the Environmental Protection Agency, the Forestry Commission, and the Municipal Assembly to assess the impact of climate change on sustainable livelihoods and water bodies in the study area (Table 2).

3.2.1. Water scarcity

The discussions revealed that water scarcity (WAI-1.90) poses the most significant threat to sustainable livelihoods. Residents of Wa West and the surrounding areas primarily rely on rain-fed agriculture and supplement their farming activities with irrigation during the dry season. However, climate change has led to droughts, dry spells, and increased evaporation of water bodies, negatively impacting agricultural activities and reducing crop yields. Many small dams, wells, dugouts, and streams dry up during the dry season due to high demand for domestic use, irrigation, and livestock watering. High temperatures caused by climate change further exacerbate the depletion of available water sources (Adiku et al., 2015; Kyei et al., 2020).

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)

3.2.2. High temperatures and post-harvest management

High temperatures (WAI-1.84) were identified as a significant obstacle to effective post-harvest crop management. Perishable crops, including vegetables, are highly susceptible to spoilage during storage due to high temperatures. Local storage methods, such as silos and barns, often prove inadequate to protect crops from excessive heat. This susceptibility to spoilage extends to crops stored in insufficiently treated or insulated facilities, which can accelerate the deterioration of grains, legumes, and nuts and promote mold and bacteria growth (Rosenzweig et al., 2014; FAO, 2015; UNEP, 2017). High temperatures can also disrupt pollination, slow plant growth, and increase water stress, leading to reduced crop yields (FAO, 2012; Maina et al., 2014).

3.2.3. Poor soil fertility

Poor soil fertility (WAI-1.81) ranks third among the effects of climate change on sustainable livelihoods. Continuous cropping on the same land, inadequate agricultural practices, and the impact of climate change have rendered farmland unproductive, resulting in declining yields. Poor soil fertility is primarily attributed to low soil organic matter content, which affects water retention, soil aeration, and nutrient retention. High soil organic matter is critical for maintaining soil health (Nath et al., 2013).

3.2.4. Poor yield and environmental deterioration

Poor yield (WAI-1.79) is fourth on the list of climate change effects. Climate change-induced dry spells, droughts, erratic precipitation, and the invasion of farms by exotic weeds, insects, and diseases contribute to environmental deterioration and low crop yields. This negatively impacts economic activities (Asseng et al., 2015).

3.2.5. Increased poverty

Increased poverty (WAI-1.72) ranks fifth among the effects of climate change on water resources and means of subsistence. The indigenous population's reliance on precipitation and other water resources for subsistence activities makes them vulnerable to climate change impacts. Variations in climate affect agricultural, fishing, and dry-season gardening activities, leading to food insecurity and slower economic growth (Mason et al., 2015; Awuah et al., 2016). Changes in temperature and precipitation patterns have also reduced crop yields (Christoplos et al., 2012; Kpabitey, 2015).

3.2.6. Land tenure issues

Land tenure issues (WAI-1.66) contribute to challenges in maintaining a sustainable way of life due to climate change's impact on water resources and arable lands. Population growth necessitates expanding farms and seeking alternative income sources, leading to conflicts over land. Some landowners engage in small-scale mining in addition to agriculture, making them reluctant to invest in climate change adaptation practices (such as altering land use) that may affect their economic activities.

3.2.7. Deforestation

Last on the list of climate change effects on livelihoods and water resources is deforestation (WAI-1.57). Indigenous people have turned to wood logging and charcoal production as alternative livelihoods due to climate change's impact on soil fertility and water resources. This suggests that these activities may increase without eco-friendly alternatives.

Understanding these climate change effects is crucial for developing effective mitigation and adaptation strategies to protect sustainable livelihoods and water resources in the study area.

3.3. Enhancing climate change adaptation strategies in indigenous farming communities

3.3.1. Leveraging improved seeds for resilience building

Utilizing a logistic regression model to scrutinize the outcomes of climate change adaptation strategies, as illustrated in Table 3, underscores the prominence of improved seeds (6.277). Farmers consistently endorse improved seeds as a paramount strategy for bolstering climate change resilience. Upon engaging with community members to discern the rationale behind farmers' resounding preference for improved seeds among a spectrum of available strategies, it became evident that improved seeds facilitate bountiful harvests when sown promptly and in accordance with essential cultural practices. This reliance on improved seeds not only enhances crop yield but also fortifies the community's ability to withstand environmental challenges.

3.3.2. Harnessing irrigation and water management

In addition to improved seeds, irrigation (5.37) stands out as a pivotal element of climate adaptation. The study sheds light on how irrigation, coupled with other adaptation strategies, has elevated the standard of living for indigenous communities. Frequent droughts, exacerbated by erratic rainfall patterns, truncate the cropping season, leaving farmers vulnerable to food insecurity. Addressing this, the provision of irrigation facilities and the conservation of water bodies to curtail excessive evaporation emerges as a solution. This proactive approach not only extends the cultivation period into the dry season but also augments the yield of main-season crops. In the context of developing nations grappling with extreme weather conditions due to climate change, the role of irrigation, accompanied by the construction of water storage infrastructure like dams, ponds, and dugouts, becomes paramount (Tachie-Obeng et al., 2013; Adiku et al., 2015; FAO, 2015). These interventions collectively foster year-round agricultural activities, enhancing the resilience of these communities against climate-related challenges.

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

Source: 2022 survey

3.3.3. Nurturing soil health through fertilizers

The judicious use of organic and inorganic fertilizers (5.18) emerges as a cornerstone adaptation strategy predominantly adopted by indigenous small-scale farmers. Sustained farming on depleted soils coupled with unpredictable weather conditions has necessitated the reliance on organic and inorganic fertilizers to bolster crop productivity. Organic manure, with its soil-enhancing properties, contributes to improved soil structure and fertility. Conversely, inorganic fertilizers such as NPK, ammonia, and urea primarily promote crop growth but do not address soil fertility concerns (Zhou et al., 2021). These insights highlight the vital role of soil management in climate adaptation, emphasizing the need for sustainable practices to ensure long-term agricultural viability.

3.3.4. Fostering agroforestry for microclimate enhancement

Agroforestry (5.021) emerges as a pivotal adaptation strategy for augmenting crop yields and mitigating climate-related challenges. Field observations within the study communities underscore the prevalence of cashew, mango, shea, and dawadawa trees integrated into farming landscapes. These trees serve not only as a source of income but also play a crucial role in microclimate regulation. Agricultural extension agents actively promote agroforestry techniques by providing farmers with cashew and mango seedlings. Decades of farming experience have instilled in many farmers, especially the elderly, a deep understanding of the role of agroforestry in fostering a favorable microclimate (Adomako, 2015; Li et al., 2017). This practice not only contributes to crop resilience but also enhances overall ecosystem sustainability.

3.3.5. Diversifying income sources for sustainability

Recognizing the importance of income diversification (4.328), indigenous communities have explored alternative livelihoods to bolster economic stability and conserve water resources. These endeavors encompass activities such as fishing, beekeeping, charcoal production, handicrafts, and animal husbandry. In light of climate variability and its impact on crop yields, especially among the youth, these alternative income sources provide a safety net, ensuring economic sustainability even in the face of adverse climatic conditions.

3.3.6. Embracing modern agricultural technology

Farmers are increasingly adopting modern agricultural technology (4.243) as an integral component of their adaptation strategies. This adoption encompasses the use of modern machines, such as tractors, for planting and harrowing, significantly reducing the physical exertion associated with traditional farming practices. By replacing obsolete tools like hoes, cutlasses, and bullocks, farmers not only enhance their efficiency but also reduce vulnerability to drought and dry spells. Observations indicate that mechanization leads to more extensive land cultivation, ultimately bolstering agricultural productivity and food security within these communities.

3.3.7. Overcoming post-harvest management challenges

The discussion among key informants reveals that post-harvest management (3.253) remains a challenging aspect of adaptation strategies for farmers. Despite their enthusiasm to enhance storage facilities and skills, the prohibitive cost of heat-resistant storage infrastructure presents a barrier. Addressing this challenge is essential to safeguard crops from pests and diseases, ensuring food security and preserving livelihoods. Insights from research underscore the potential of improved post-harvest management practices to reduce food losses, contribute to food security, and even mitigate greenhouse gas emissions (Oteng-Ababio et al., 2017; Kyei et al., 2020).

3.3.8. Navigating challenges of crop diversification

While crop diversification (3.159) is considered an adaptation strategy, it finds limited favor among farmers who predominantly practice monoculture. Farmers prioritize the cultivation of staple foods for personal consumption and surplus sale, reflecting a deep-seated preference for local staple crops. This resistance to diversify, even in the face of potential benefits, underscores the need for tailored strategies and incentives to encourage crop diversification as a means of enhancing livelihoods and climate resilience within these communities.

3.4. Enhancing climate resilience through mitigation strategies

3.4.1. Input subsidies

As demonstrated in Table 4, input subsidies (5.337) emerge as the most preferred mitigation strategy. This approach holds the potential to enable farmers to adopt a multitude of practices, including crop diversification, the adoption of improved seeds, and the responsible use of fertilizers, including weedicides and pesticides, all of which can significantly boost agricultural production. However, it's essential to recognize that subsidies, despite their merits, have been linked to adverse consequences such as environmental degradation and increased greenhouse gas emissions due to the excessive use of chemicals (Boadi et al., 2015; Srinivasan et al., 2019).

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	0.000
Capacity building and training	0.258	1.148	0.082
Access to weather information	4.559*	1.070	0.000
Dam construction	4.277*	1.165	0.001

Source: 2022 survey

3.4.2. Challenges in subsidy implementation

It's noteworthy that the high cost of agricultural inputs poses a substantial hindrance to farm expansion in the region. Despite the well-intentioned flagship program aimed at subsidizing inputs for farmers, its ineffectiveness becomes evident in the inflated prices of essential items like fertilizers, hybrid seeds, and chemicals on the open market. These market dynamics contribute significantly to poor harvests, especially in the face of extreme weather conditions.

3.4.3. Empowering agricultural policies

Conversely, improved agricultural policies (5.028) emerge as a potent mitigation strategy, holding the promise of enhancing the livelihoods and water resources of the natives of the Wa West District. Extensive interactions with farmers reveal that enhancing agricultural policies can lead to increased government budgetary support for agricultural activities, fostering the promotion of input subsidies, facilitating access to a well-structured road network in agricultural areas, providing essential agro-processing machines, and enabling capacity building and training for the adoption of modern agricultural technology. Additionally, an improved agricultural policy framework can lead to a higher number of agricultural extension agents (AEAs) and veterinary officers, thereby assisting farmers in acquiring the scientifically-proven, efficient, and easily applicable skills associated with climate-smart agriculture (Boadi etal.,2015; Diiro et al., 2021). These skills would be imparted through comprehensive capacity-building initiatives and practical demonstrations. Furthermore, it's crucial to recognize that improved agricultural policies have the potential to make a substantial contribution to food security, poverty alleviation, the sustainability of livelihoods, and the overall increase in the gross domestic product (GDP) of the region (Anyidoho et al., 2015; Antwi-Agyei et al., 2018; Hansen et al., 2018).

3.4.4. Access to weather information

Access to weather information (4.559) stands out as one of the most effective mitigation strategies, offering the potential to enhance the standard of living of the indigenes and safeguard precious water resources (Gbedemah, et al., 2017; Nyamwanza et al., 2018; UNFCCC, 2020). By improving early warning systems for critical agricultural activities such as ploughing, sowing, managing floods, harvesting, and post-harvest crop management, access to weather information mitigates the risks posed by droughts and unfavorable weather conditions, which can significantly disrupt seasonal agricultural activities. This strategic access empowers rural farmers to stay informed about weather conditions during crucial crop growing seasons, enabling them to make informed decisions to mitigate the impact of unforeseen adverse weather conditions.

3.4.5. Constructing dams for sustainable living

The construction of dams (4.277) is a recognized climate change and weather extremes mitigation strategy, perceived by indigenous people as an intervention that can substantially enhance their standard of living. The envisaged benefits of dam construction encompass provisions for irrigation, fishing opportunities, and improved access to water for livestock and household use. Remarkably, the vast arable land within the community presents a golden opportunity for intensive dry-season gardening, which can serve as a reliable income supplement for local farmers.

3.4.6. Enhancing market access

Market access (4.128) assumes a pivotal role as a valuable intervention, actively promoting activities that elevate livelihoods and bolster climate change resilience. Facilitating easier marketing of farm products, particularly perishable items, market access strategies are instrumental in reducing post-harvest losses (Alfaro et al. 2018; Akankasha et al., 2015; Mason et al., 2015). Given the challenges posed by climate change, such as extreme heat and unusual pest and disease invasions during storage, robust market access systems play a crucial role in protecting farmers' profit margins and overall livelihoods.

3.4.7. Access to a robust road network

Surprisingly, access to a good road network (3.128) emerges as the least preferred mitigation strategy among indigenous people. This preference is mainly attributed to the current deplorable condition of existing roads leading to farms, markets, and subsistence sources. Nonetheless, it's vital to recognize that a well-developed rural road network can be transformative in rural areas dominated by farmers. Such networks improve transportation systems, promote petty trading, enhance the marketing of farm products, provide convenient access to agricultural inputs, and offer alternative livelihood opportunities, thus reducing environmental overdependence. To maximize the effectiveness of road networks in promoting livelihood activities, it's crucial to construct roads resistant to adverse weather conditions, such as flooding, as suggested by local opinion leaders.

4. Conclusion

According to the findings of this research, climate change is having a significant impact on the indigenous population of the Wa West District in the Upper West Region of Ghana. Water scarcity, high temperatures, poor soil fertility, poor crop yields, increased poverty, and land tenure issues are some of the challenges faced by these communities as a result of climate change. To adapt to these challenges, farmers are employing various strategies, including the use of improved seeds, irrigation, organic and inorganic fertilizers, agroforestry, alternative sources of income, modern agricultural technology, and improved post-harvest management. Mitigation strategies include input subsidies, improved agricultural policies, access to weather information, dam construction, market access, and access to a road network.

These findings suggest that there is a need for targeted interventions to address the impact of climate change on the livelihoods and water resources of indigenous communities in the Wa West District. These interventions should focus on improving access to resources and information, promoting sustainable agricultural practices, and enhancing the resilience of communities to climate change. Additionally, policy reforms that support climate-smart agriculture and provide incentives for sustainable land and water management are essential for mitigating the impact of climate change in the region.

In conclusion, addressing the challenges posed by climate change in the Wa West District requires a multi-faceted approach that involves local communities, government agencies, non-governmental organizations, and other stakeholders. By implementing a combination of adaptation and mitigation strategies, the indigenous population can build resilience to climate change and secure their livelihoods and water resources for future generations.

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