Climate change and farming resilience: Determinants of adaptation strategies among smallholder farmers in Wa Municipality, Ghana

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ABSTRACT

This study investigates determinants influencing maize farmers' adaptation to climate risks in Ghana's Wa Municipality. The study is underpinned by the rational choice theory complemented with the theory of planned behaviour and the sustainable livelihood framework. A stratified random sampling technique was used to ensure representation across various communities and simple random sampling applied in selecting the final respondents. Using cross-sectional data from 230 smallholder farmers and logistic regression analysis, it finds that farmers adopt multiple strategies to cope with climate variability and boost productivity. Adoption of drought-resistant crop varieties—practiced by 38.2% of farmers—emerges as the most dominant and effective measure for sustaining yields. Socioeconomic, cultural, farm-level, and institutional factors shape adaptation choices. Larger farm sizes reduce the likelihood of adopting strategies, while farming experience, labor use, and exposure to crime significantly increase it. Community conflicts and crime further exacerbate rural vulnerabilities, whereas cultural beliefs and practices lower adaptation odds by over 80%, highlighting how entrenched traditions can impede productivity. The study concludes that climate risk among smallholder farmers can be minimized and productivity enhanced through the use of drought-resistant varieties. Crop breeding and multiplication programmes for drought-resistant varieties are highly recommended for governmental support. The findings call for policies that address financial, sociocultural, and institutional barriers, reduce crime and community conflicts, and reconsider fertilizer use and farm size dynamics to strengthen climate resilience and ensure sustainable agricultural production and food security.

Keywords: Adaptation Strategies, Climate Risk, Determinants, Logit Model
JEL Codes: C25; D24; Q10; Q12; Q54

I. INTRODUCTION

Agriculture remains one of the most climate-sensitive sectors globally, with smallholder farmers in developing countries particularly vulnerable to the adverse impacts of climate change (Wainaina et al., 2020; Larbi-Koranteng et al., 2025). Rising temperatures, erratic rainfall patterns, prolonged droughts, and increased frequency of extreme weather events threaten crop yields, livestock productivity, and the stability of rural livelihoods (Khatri-Chhetri et al., 2017; Khanal et al., 2018; Baffour-Ata et al., 2025a). As climate variability intensifies, the capacity of farmers to adapt is increasingly recognized as critical to safeguarding food security and achieving sustainable development goals (Antwi-Agyei et al., 2018; Asante et al., 2021).

Farmers in many parts of the world have developed diverse adaptation strategies to cope with changing climatic conditions. These range from altering planting dates and crop varieties to investing in soil conservation, irrigation infrastructure, and agroforestry practices (Deressa et al., 2011; Zhai et al., 2018; Baffour-Ata et al., 2025b). However, the effectiveness and adoption of these strategies vary considerably across regions, communities, and households. Evidence shows that while some farmers readily adopt climate-smart practices, others fail to implement even basic adaptation measures, leaving them highly exposed to climate risks (Maharjan et al., 2021; Sertse et al., 2021).

This variation raises an important research question: What determines farmers' decisions to adapt, and what factors influence the type and extent of adaptation strategies they choose? Understanding these determinants is vital for designing targeted interventions that enable farmers to overcome barriers to adaptation. Existing studies have identified a range of influencing factors, including socioeconomic characteristics such as age, education, and household size (Aryal et al., 2020; Asante et al., 2021; Arfa et al., 2025); institutional support like extension services, credit, and climate information (Asfaw et al., 2016); farm-level conditions such as landholding size and soil fertility (Alemayehu & Bewket, 2017); and farmers' perceptions and awareness of climate change risks (Sertse et al., 2021; Boansi et al., 2023).

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Despite substantial progress in this field, knowledge gaps persist regarding the relative importance and interplay of these determinants, especially in low-income, rain-fed farming systems where vulnerability is highest (Di Falco & Veronesi, 2018). Furthermore, emerging challenges such as access to digital information tools, social capital, community conflicts, crime, and market integration require renewed empirical investigation (Gyimah et al., 2020; Adu-Boahene, 2023). Addressing these gaps is crucial for policymakers, development practitioners, and researchers working to build climate-resilient agricultural systems.

This study therefore seeks to contribute to this growing body of knowledge by empirically examining the determinants of farmers' adaptation strategies to climate change. By doing so, it aims to inform policies and programms that strengthen farmers' adaptive capacity, enhance agricultural sustainability, and promote rural resilience in the face of an increasingly uncertain climate future.

1.1 Statement of the Problem

Climate change poses a serious threat to agricultural productivity, food security, and the livelihoods of millions of smallholder farmers. In northern Ghana, agriculture remains highly sensitive to fluctuations in temperature and rainfall, yet adaptive capacity among farmers varies widely due to multiple socioeconomic, institutional, and environmental factors. Although farmers have developed various coping and adaptation strategies such as adjusting planting dates, diversifying crops, adopting improved seed varieties, or investing in irrigation, not all farmers adapt effectively or at the same pace.

Existing evidence shows that the adoption of climate change adaptation measures is influenced by a complex mix of demographic characteristics, access to resources, climate risk perception, market access, institutional support, and agroecological conditions. However, despite growing research, there remain significant knowledge gaps about how these determinants interact in different contexts, especially in low-income areas such as Wa municipality where climate impacts are most severe and adaptive capacity is weakest. Moreover, limited access to reliable information, extension services, and credit continues to constrain farmers' ability to implement effective adaptation measures. Without a clear understanding of the key factors shaping farmers' adaptation strategies, policy interventions risk being poorly targeted or ineffective, potentially undermining efforts to build resilient agricultural systems. Therefore, there is an urgent need to systematically identify and analyze the critical determinants that drive or hinder farmers' adaptation decisions to inform evidence-based policies and programs that strengthen farmers' resilience to climate change.

1.2 Research Objective (s)

The main objective of the study is to identify the factors that influence farmers decisions to adopt to adaptation strategies to climate change in the Wa Municipality of Ghana.

II. LITERATURE REVIEW

2.1 Theoretical Review

The study of farmers' adaptation strategies to climate change is grounded in multiple overlapping theories that explain how individuals make decisions under risk, uncertainty, and varying access to resources. This study draws primarily on three interrelated frameworks: the rational choice theory, the theory of planned behaviour, and the sustainable livelihood framework. The decision to adopt or reject adaptation measures can be understood through rational choice theory, which posits that farmers make decisions by weighing the costs and benefits of available options (Pindyck & Rubinfeld, 2018). Faced with climate risks, a rational farmer is expected to choose adaptation strategies that maximize expected utility, given their resource constraints and information access. However, this assumes that farmers have perfect information and the capacity to act rationally, which is rarely the case in reality, particularly in low-income, resource-constrained settings.

To account for behavioral and perceptual factors, the study also draws on the theory of planned behavior (Ajzen, 1991) which suggests that an individual's behavioral intention to adopt an adaptation practice is influenced by: attitude toward the behavior (e.g., perceived benefits of a new practice); subjective norms (e.g., influence of peers, community expectations); and perceived behavioral control (e.g., perceived ability to implement the practice given available resources and skills). Thus, even when adaptation measures are technically rational, factors such as risk perceptions, trust in information sources, cultural norms, and social influence shape adoption decisions (Adu-Boahene, 2023; Arfa et al., 2025). Finally, the sustainable livelihoods framework (Chambers & Conway, 1992) provides a holistic lens for examining the determinants of adaptation by highlighting the role of livelihood assets (human, social, natural, physical, and financial capital). Farmers' ability to adopt effective adaptation strategies depends not only on their knowledge and perceptions but also on access to key resources such as land, credit, labor, extension services, and market linkages (Ellis, 2000; Deressa et al., 2011; Opoku Mensah et al., 2025). The framework also emphasizes how institutional and policy contexts mediate access to these assets, shaping adaptive capacity.

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Integrating these frameworks/perspectives allows the current study to analyze adaptation behaviour as the outcome of rational economic calculation, behavioral intention, and resource-based constraints. The study therefore assumes that: Farmers will adapt if they perceive climate change as a risk, believe adaptation is beneficial, and feel capable of implementing the strategies. Socioeconomic, cultural and demographic factors (e.g., age, education, household size) affect knowledge and attitudes.

Institutional support (e.g., extension services, access to credit and market) reduces constraints and strengthens perceived behavioral control. Environmental and agroecological conditions (e.g., land size, soil fertility, rainfall variability) influence both the need for and feasibility of specific adaptation options. This theoretical framework underpins the empirical investigation of the relationships between these determinants and the types and extent of adaptation strategies adopted. It also guides the selection of the variables and the choice of appropriate analytical models to test how these factors interact to influence farmers' adaptive behavior.

2.2 Empirical Review

Climate change poses significant threats to agricultural productivity, food security, and rural livelihoods, particularly in developing countries where agriculture is largely rain-fed (Wainaina et al., 2020; Baffour-Ata et al., 2025a; Yiridomoh et al., 2025). In response, farmers adopt various adaptation strategies to minimize adverse impacts and sustain their livelihoods. Understanding the determinants that influence these adaptation decisions has become a central theme in climate change research (Deressa et al., 2011; Di Falco & Veronesi, 2018).

Socioeconomic characteristics of farmers, such as age, education, household size, and gender, significantly shape adaptation behavior (Aryal et al., 2020; Baffour-Ata et al., 2025a; Larbi-Koranteng et al., 2025). Younger farmers are often more open to innovation and risk-taking than older ones (Khatri-Chhetri et al., 2017). Education enhances farmers' capacity to understand climate information and adopt new technologies (Ali & Erenstein, 2016; Baffour-Ata et al., 2025b). Larger households may have greater labor availability, which facilitates labor-intensive adaptation measures like soil conservation and irrigation (Deressa et al., 2011). Gender also plays a vital role, as male-headed households generally have better access to resources, although women are increasingly engaged in adaptation decision-making despite facing structural constraints (Khanal et al., 2018).

Institutional and policy factors impact of climate adaptation strategies. Access to extension services, climate information, and credit are pivotal determinants of adaptation (Arslan et al., 2015). Extension services provide farmers with knowledge on climate-smart agricultural practices, while timely and accurate climate information helps them make informed decisions (Maharjan et al., 2021). Access to formal credit enables investment in costly adaptation measures, such as irrigation infrastructure or improved seed varieties (Duru et al., 2015). Membership in farmers' organizations also fosters knowledge exchange and collective action, improving adaptation outcomes (Karki et al., 2020). Economic and market-related factors also play a role in climate change. Farm income and market access strongly influence adaptation decisions (Arfa et al., 2025). Farmers with higher income levels are better positioned to invest in adaptation technologies and practices. Moreover, access to input and output markets provides incentives for farmers to adopt practices that enhance productivity and resilience (Antwi-Agyei et al., 2018). Market failures, such as lack of price stability or poor infrastructure, can hinder the adoption of effective strategies (Niles et al., 2013).

Farmers' perceptions of climate change and its impacts are significant behavioral drivers of adaptation (Sertse et al., 2021; Baffour-Ata et al., 2025a). Studies indicate that farmers who perceive changes in temperature and rainfall are more likely to adopt strategies like crop diversification, changing planting dates, or soil management (Zhai et al., 2021; Arfa et al., 2025). Conversely, inadequate or inaccurate perceptions may lead to maladaptation or inaction (Boansi et al., 2023). Furthermore, recent studies highlight the importance of social networks, trust, and cultural norms in shaping farmers' decisions (Gyimah et al., 2020). Digital tools and mobile-based climate information services are emerging as new enablers of adaptation, especially among younger and tech-savvy farmers (Adu-Boahene, 2023). Climate-smart subsidies and incentive mechanisms are increasingly discussed as policy instruments to encourage adaptation at scale (Maharjan et al., 2021).

Biophysical factors, including soil fertility, landholding size, and proximity to water sources, also affect adaptation choices (Alemayehu & Bewket, 2017). Farmers with larger plots are more likely to adopt mixed cropping, agroforestry, or conservation tillage. Those with access to irrigation or fertile land have greater flexibility in adopting certain practices (Alam, 2017; Adu-Boahene, 2023). Conversely, limited land or degraded soils constrain farmers' adaptation capacity. In sum, farmers' adaptation strategies are influenced by a complex interplay of socioeconomic, institutional, economic, perceptual, and environmental factors. Addressing barriers to adaptation requires integrated policies that improve farmers' access to information, credit, extension services, and markets while considering local contexts and social dynamics. Future research should continue to explore the effectiveness of emerging digital tools and policy instruments in supporting resilient agricultural systems.

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III. METHODOLOGY

3.1 Research Design

This study follows the positivist research paradigm and uses a purely quantitative research design in collecting and analysing the research data.

3.2 Study Area

Wa Municipality is situated in the south-central part of the Upper West Region (UWR) and bordered by Nadowli-Kaleo District to the north, Wa West District to the west, and Wa East District to the east (Figure 1). The district has a total population of around 200,672 people according to the 2021 Population and Housing Census (with Wa town being the largest urban center in the region). It is the most urbanized district in the UWR and agriculture is the dominant economic activity, focusing on crops such as maize, millet, yam, sorghum, and groundnuts as well as livestock production. Wa town serves as a commercial hub, with vibrant markets and growing service sectors (banking, transport, education, ICT, etc.). The municipality has an airport that has improved air connectivity, though flights are not always regular. The municipality faces infrastructure challenges such as inadequate roads, drainage, and water systems, especially in rural communities.

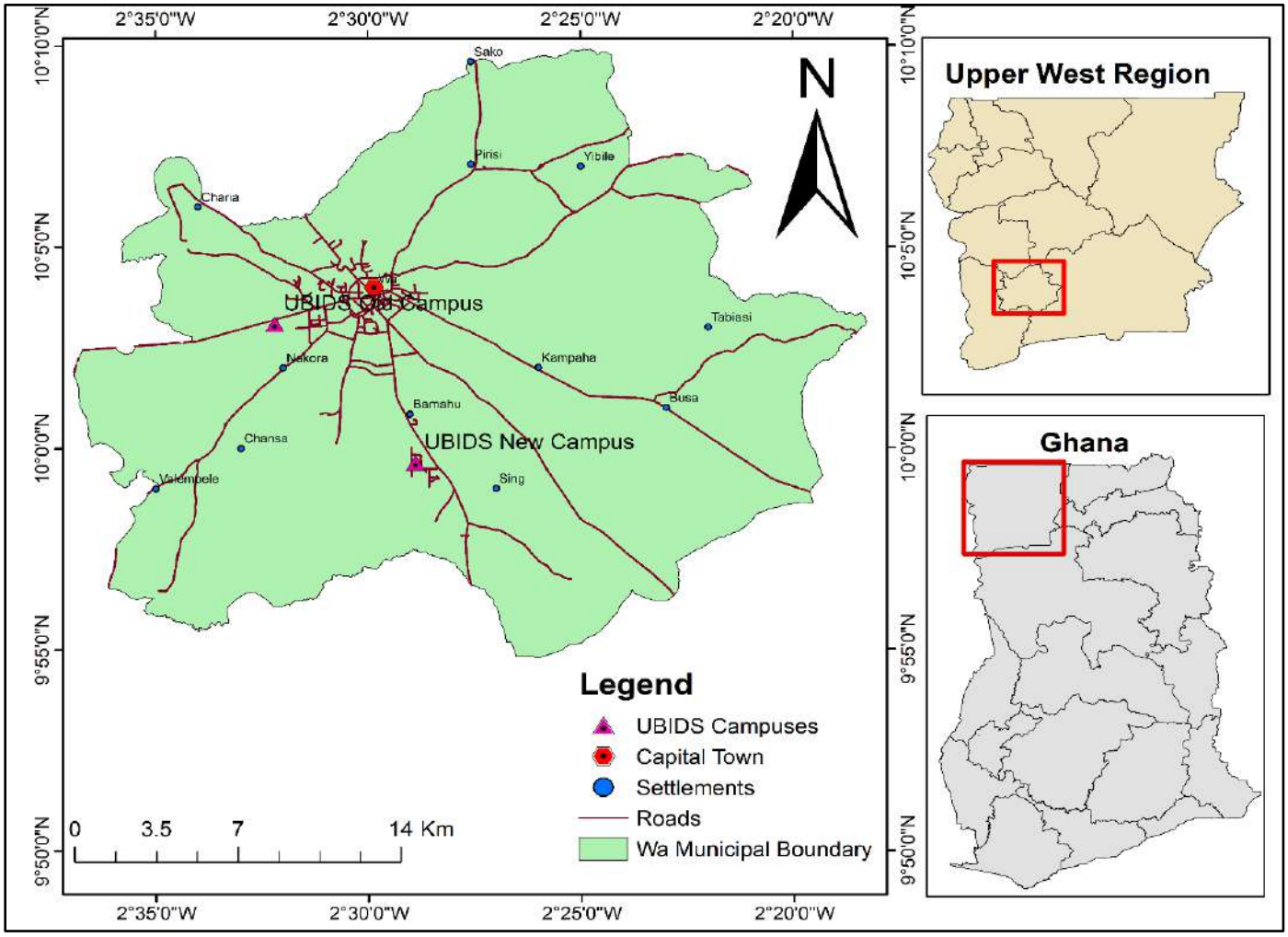

Figure 1

Map of Wa Municipality Depicting some of the communities

Source: Author's Construct (2025).

3.3 Target Population

The target population for the study was made up of all maize farmers operating in the Wa Municipality for the 2024 rainfed production season. Maize is a common cereal grown by most households in the Municipality and its production is affected by climate-related factors.

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3.4 Sampling and Sample Size

The respondents were drawn from various communities within the Wa Municipality (Figure 2). Selection of the communities was purposively done based on their level of engagement in agricultural production activities. Due to urbanization of the municipality which has made access to urban land difficult for production, all the communities selected were peri-urban in nature. The study covered more communities for a better understanding of climatic and sociocultural dimensions affecting agricultural production. This ensures that the study reflects the experiences and perspectives of farmers from different parts of the municipality, each possibly facing unique climate-related challenges and practicing various adaptation strategies as climate change persists. The total number of respondents covered in the study was 230 smallholder maize farmers and Figure 2 presents the sample distribution per community. The total sample size was obtained using the Yamane formula: Sample size = N/(1+N(e)2 where N is the population and e is the margin of error (5%). Simple random sampling was used to select the farming households for the survey.

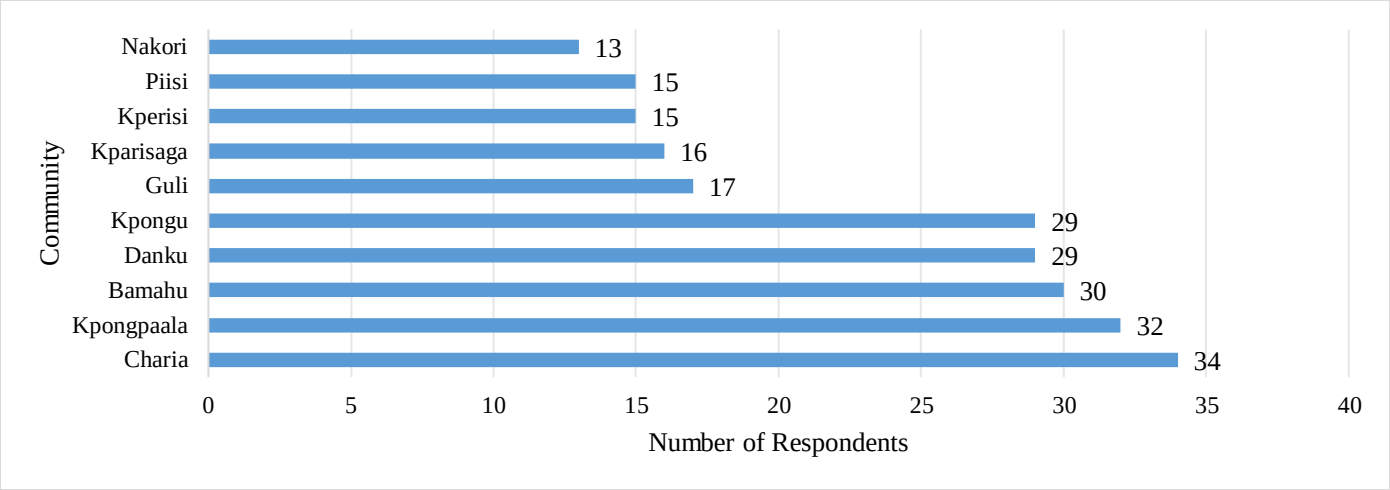

Figure 2
Sampled communities

3.5 Data Collection Instruments and Procedure

Primary data was collected using a structured questionnaire which was programmed using google forms. The survey explored key areas such as demographic details, agricultural productivity, climate variability, farm management practices, and adaptation strategies used by farmers. Face-to-face interviews were conducted and the questionnaire administered. Questionnaires completed were checked on the field for completeness and accuracy before the data was later downloaded, cleaned and few variables transformed before analysis.

3.6 Data Analysis

Data analysis was carried out using STATA version 17 econometric software. Prior to the quantitative analysis, descriptive statistics including the mean and standard deviation of the individual variables were estimated for a better understanding of the structure of the data and the emerging patterns.

3.6.1 Variables and Measurement

The variables included in the study and how they were measured is presented in Table 1. Selection of the variables was based on literature review. The variables reflect farm specific, sociocultural, institutional and biophysical factors that are common in the study area with likely impacts on climate adaptation strategies.

Majority of farmers (86.9%) were practising more than one adaptation strategy in an effort to cope with the effects of climate change. The mean age of the farmers was 49 years old and the average farm size was 5.5 acres. This suggests that both younger and older individuals are involved in farming, though older farmers may dominate decision-making. About 70% of the respondents were males and fertilize use was intense (5.5 bags per season on the average). Only few farmers (22%) received support from government and NGOs operating in the area to enable them cope with climate risk. More than half of the farmers (60%) had access to credit perhaps due to the Planting for Food and Jobs and other private sector agriculture-based firms that provide credit support to the maize, soybean and other crop value chains. Majority of respondents (81.6%) had access to market due to the urban nature of the municipality. However, only 42% had received training on climate change. Labour for agricultural production is not an issue as people commit 48 man-days in farm production. Respondents had a mean experience of 6 years in production, sufficient to understand the climate patterns and which effective adaptation strategies to employ on their farms. About 58% of the respondents indicated that cultural beliefs and norms discourage the adoption of climate adaptation strategies. Conflicts is an issue

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affecting production as indicated by 69% of the respondents. Land conflicts and herder-farmer conflicts are the commonest in the areas with likely impacts on farmers climate adaptation decisions.

Table 1

Variables and their measurements

Variable	Measurement	Mean	Std. Dev.
Climate Adaptation	Binary: 1 if a farmer adopts more than one adaptation strategy, 0 otherwise	0.869	0.338
Age	Number of years of respondent	49.03	12.622
Farm size	Total area of land planted to maize for the 2024/2025 farming season (in acres)	5.567	4.039
Gender	Binary: 1 if the farmer is a male, 0 otherwise	0.704	0.457
fertilizer use	Quantity of fertilizer applied for the season (bags)	5.633	5.62
Government support	Binary: 1 if a farmer received support from government or other sources to cope with climate risk, 0 otherwise	0.221	0.416
Access to credit	Binary: 1 if a farmer has access to credit, 0 otherwise	0.60	0.491
Access to extension	Binary: 1 if a farmer has access to extension services, 0 otherwise	0.704	0.457
Access to market	Binary: 1 if a farmer has access to market, 0 otherwise	0.816	0.231
Training	Binary: 1 if a farmer received training on climate change, 0 otherwise.	0.426	0.771
Labour	Number of people who worked on the farm for the cropping season (man-days)	47.834	12.278
Experience	Number of years engaged in crop production	5.865	4.327
Crime	Binary: 1 if crime has affected farming activities of the farmer, 0 otherwise.	0.695	0.462
Culture	Binary: 1 if there are cultural beliefs in the community that discourage the adoption of modern farming practices, 0 otherwise	0.582	0.121
Conflicts	Binary: 1 if community conflicts disrupted farming activities and adoption of climate adaptation strategies in the community, 0 otherwise	0.443	0.498

3.6.2 Analytical Framework

This study adopted the binary logistic regression to assess the factors that influence the adoption of climate adaptation strategies by farmers in an effort to mitigate the effects of climate change on crop production. The model is generally specified as:

$$Y_i = \beta X_i + u_i \quad (1)$$

Where Y is measured as a dummy variable with a value of one (1) if the farmer adopts more than one climate adaptation strategy, and zero (0) otherwise. The climate adaptation strategies considered in this study includes the use of drought tolerant seeds, irrigation, changing planting date, and crop rotation. The choice for these adaptation strategies was based on literature review (see Larbi-Koranteng et al., 2025; Baffour-Ata et al., 2025a; Yiridomoh et al., 2025) and prior interaction with farmers operating in the municipality. X_i denotes the independent variables which are farm-specific, sociocultural, and institutional in nature. β_i is a vector of the coefficients, and u_i is the error term. Thus,

$$Y_i = \left\{\frac{1, if\ Xi \geq X*}{0, if\ Xi \leq Xi}\right\} \text{ for all } i = 1,2\ldots n$$

From equation 1, the probability of a farmer adopting any given climate adaptation strategy (Y) is functionally related to independent variables (X) as:

$$Prob\ (Y_i = 1) = F\ (\beta' X_i) \quad (2)$$
$$Prob\ (Y_i = 0) = 1 - F\ (\beta' X_i) \quad (3)$$

where Y_i is the ith observation, X_i denotes the independent variables linked to the ith probability of adopting any particular adaptation strategies, and F is a function which may assume a logistic, normal, or probability form. The logit model was used to estimate the probabilities (P) as follows:

$$P\ (Y - 1) = \frac{e^{\beta' X}}{1 + e^{\beta' X}} \quad (4)$$

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$$P\ (Y-0) = \ 1 - \frac{e^{\beta' X}}{1+e^{\ \beta' X}} \ = \frac{1}{1+e^{\ \beta' X}} \quad (5)$$

Following Greene (2007), the conditional expectation of Y was regressed on X to generate the model probabilities as:

$$E\ \left(\frac{Y}{X}\right) = 1[F\ (\beta' X')] + 0\ [1 - F(\beta' X')] = F\ (\beta' X') \quad (6)$$

To obtain the relative effect of each independent variable on the probability of adoption, equation (6) was differentiated with respect to X_{ij} as depicted in equation (7).

$$\frac{\partial P_i}{\partial X_{ij}} = \ \left[\frac{\theta^{\beta' X}}{1-\theta^{\beta' X}}\right] \beta = F\ (\beta' X)[1 - F\ (\beta' X)]\beta \quad (7)$$

The maximum likelihood procedure was followed to estimate the model parameters which exhibits consistency and are asymptotically efficient. The empirical model applied is in line with recent studies (Larbi-Koranteng et al., 2025; Abubakari et al., 2024) as specified in equation 8.

$$Z_i = \log \frac{P_i}{1-P_i} = \alpha + \ \beta X_i + \ \varepsilon_i \quad (8)$$

where $\log\frac{P_i}{1-P_i}$ is the logarithm of the odds of a farmers' decision to adapt more than one climate change adaptation strategy, $X_i$is the total effect of the explanatory variables; and ε_i is the error term. The variables included in the model are stated in Table 1.

3.7 Ethical Considerations

The Research Ethics Review Board of the Simon Diedong Dombo University of Business and Integrated Development Studies (SDD-UBIDS) gave approval for the conduct of this research with Ethical Approval Number (UBIDS/RERB/001/2024/08/02). Informed consent was sort verbally from participants to ensure that participants freely consent to participate in the study before data collection commenced. Participants were assured of confidentiality of their data and they also consented to the publication of the findings of the research.

IV. FINDINGS & DISCUSSION

4.1 Descriptive Facts

The majority (64.35%) of respondents have no formal education and only few had tertiary level of education (Table 2). Education can influence farmers adoption to climate change strategies for farm performance.

Table 2

Level of education

Level of Education	**Frequency**	**Percentage**
Basic	37	16.09
No formal education	148	64.35
Secondary	23	10.00
Tertiary	22	9.57
Total	**230**	**100**

The adaptation measures practiced by farmers to cope with climate conditions for improved crop yields include changing planting dates (31.9%), crop rotation (27.8%), use of drought resistant crops (38.2%), and irrigation (Table 3). These strategies are largely production practice oriented and a greater number of farmers were implementing them. Clearly, farmers adapted multiple strategies rather than a single strategy to enable them cope with climate variability. Irrigation was the least adopted (1.88%) due to the high cost involved in setting up such schemes. Regarding the effectiveness of these adaptation strategies in sustaining crop yields and increasing productivity, the majority (47.39%) of farmers indicated that they were moderately effective while 22.17% said they were very effective. Only 5.6% stated that they were unsure of the level of effectiveness. This might be those farmers who did not adopt any of the climate adaptation strategies. As noted by Deressa et al. (2009), farmers may recognize climate risks but still not adapt any strategy due to barriers faced such as lack of money, knowledge, or tools. This suggests that awareness alone is not enough for farmer adaptation, rather support systems are needed.

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Table 3

Climate adaptation strategies by farmers

Adaptation strategy	**Frequency**	**Percentage**
Changing planting dates	102	31.97
Crop rotation	89	27.89
Using drought-resistant crop/varieties	122	38.24
Others (Irrigation systems)	6	1.88
Total	**319**	**100**

Note: Some farmers adopted more than one strategy, hence, increase in the sample size

The main challenges identified in implementing these adaptation strategies by farmers include financial constraints (69%), lack of information (19.5%) and limited access to resources (10%) such as drought resistant seeds. The labour intensive and fertilizer driven nature of agriculture was cited as the reason for finance to help purchase the needed inputs and pay for farm services such as ploughing and purchase of improved drought resistant seeds. Farmers also complained of insufficient contact with extension officers leading to limited information and knowledge on climate change related issues and their effects on crop production.

4.2 Determinants of Farmers Adaptation Strategies

The findings from the logistic regression analysis (Table 4 & 5) offers important insights into what factors influence farmers' decisions to adopt climate adaptation strategies in response to climate change in the Wa Municipality. The interpretation and discussion of the results is based on the odd ratios (Table 5).

Table 4

Factors influencing farmers climate adaption strategies

Adoption	**Coef.**	**Std. Err.**	**t-value**	**p-value**	**[95% Conf. Interval]**	
Credit (1)	-0.660	0.424	-1.56	0.120	-1.492	0.171
Extension	0.153	0.325	0.47	0.637	-0.483	0.789
Gender (1)	-0.434	0.396	-1.10	0.273	-1.211	0.342
Fertilizer use	-0.219***	0.049	-4.46	0	-0.315	-0.123
Age	-0.002	0.014	-0.12	0.903	-0.029	0.026
Farm size	-0.104*	0.056	-1.86	0.062	-0.213	0.005
Labour	0.103**	0.047	2.19	0.029	0.011	0.195
Experience	0.039**	0.015	2.56	0.010	0.009	0.069
Government (1)	0.464	0.407	1.14	0.254	-0.334	1.262
Market 1	-0.136	0.534	-0.25	0.799	-1.183	0.911
Crime (1)	1.154*	0.652	1.77	0.077	-0.124	2.432
Culture (1)	-1.693***	0.513	-3.30	0.001	-2.698	-0.688
Training	0.241	0.072	2.34	0.069	0.132	0.282
Conflicts (1)	0.393	0.452	0.87	0.384	-0.493	1.279
Constant	0.870	1.21	0.72	0.472	-1.501	3.241
Mean dependent var	0.580		SD dependent var			0.495
Pseudo r-squared	0.262		Number of obs.			226
Chi-square	80.473		Prob > chi2			0.000
Akaike crit. (AIC)	255.070		Bayesian crit. (BIC)			302.958

Table 5

Results of logistic regression (odd ratios)

Adaption	**Odd Ratio**	**Std. Err.**	**t-value**	**p-value**	**[95% Conf Interval]**		**Sig**
Credit (1)	0.517	0.219	-1.56	0.120	0.225	1.187	
Extension	1.166	0.378	0.47	0.637	0.617	2.202	
Gender (1)	0.648	0.256	-1.10	0.273	0.298	1.407	
Fertilizer use	0.804	0.039	-4.46	0.000	0.730	0.885	***
Age	0.998	0.014	-0.12	0.903	0.972	1.026	
Farm size	0.901	0.050	-1.86	0.062	0.808	1.005	*
Labour	1.108	0.052	2.19	0.029	1.011	1.215	**
Experience	1.040	0.016	2.56	0.010	1.009	1.071	**

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Government (1)	1.591	0.647	1.14	0.254	0.716	3.532	
Market (1)	0.873	0.466	-0.25	0.799	0.306	2.486	
Crime (1)	3.171	2.067	1.77	0.077	0.884	11.381	*
Culture (1)	0.184	0.094	-3.30	0.001	0.067	0.503	***
Training (1)	0.142	0.061.	2.34.	0.069.	0.023.	0.261.	
Conflicts (1)	1.481	0.669	0.87	0.384	0.611	3.592	
Constant	2.387	2.888	0.72	0.472	0.223	25.565	
Mean dependent var	0.580	SD dependent var	0.495				
Pseudo r-squared	0.262	Number of obs.	226				
Chi-square	80.473	Prob > chi2	0.000				
Akaike crit. (AIC)	255.070	Bayesian crit. (BIC)	302.958				
*** $p<.01$, ** $p<.05$, * $p<.1$							

The regression results reveal interesting dynamics between input use, farm characteristics, and the likelihood of adopting climate adaptation strategies. The odds ratio for fertilizer use is 0.804, indicating that an increase in fertilizer quantity is associated with a 19.6% decrease in the odds of adopting adaptation strategies (Table 5). This suggests that farmers who invest more in fertilizer may perceive less need to adopt complementary adaptation measures, relying instead on the short-term productivity gains of chemical inputs. Deressa et al. (2009) argue that access to modern agricultural inputs can sometimes act as a substitute for long-term adaptation practices, while Asfaw et al. (2016) emphasize that financial resource constraints may limit the simultaneous investment in both fertilizers and sustainable adaptation measures. In line with Di Falco and Veronesi (2013), this finding underscores the role of farmers' time horizons, where fertilizer use provides immediate returns while most adaptation strategies yield benefits only over the long run. Moreover, the perception of fertilizer as a buffer against climate variability may lower the urgency of adopting resilience-enhancing practices (Moser & Ekstrom, 2010). However, such reliance could exacerbate soil degradation in the long run, reinforcing concerns raised by Tilman et al. (2002) about the sustainability of intensive fertilizer use.

Similarly, farm size also demonstrated a negative relationship with adaptation (Table 5). The odds ratio of 0.901 implies that with each unit increase in farm size, the odds of adopting adaptation strategies decrease by approximately 9.9%, after controlling for other factors. Larger farms may naturally buffer risks through diversification across plots, reducing the perceived need for adaptation (Deressa et al., 2009). Farmers with larger plots are also more likely to adapt mixed cropping, agroforestry and conservation tillage practices (Alam, 2017). Moreover, the cost and labor requirements of implementing adaptation measures such as irrigation, agroforestry, or soil conservation scale up with land size, making adoption less attractive (Asfaw et al., 2016). Large-size farmers may also be more commercially oriented, prioritizing short-term productivity gains from mechanization or input intensification over long-term adaptation (Tilman et al., 2002). Institutional targeting may further explain this pattern, as many extension and adaptation programs in developing countries are directed at smallholders, often leaving larger-scale farmers less integrated into climate resilience initiatives (Moser & Ekstrom, 2010).

Furthermore, the odds ratio of 1.108 indicates that greater labor availability increases the odds of adopting climate adaptation strategies by approximately 10.8% per unit of labor (Table 5). Increasing labor availability is associated with greater likelihood of adopting climate adaptation strategies. This finding is consistent with emerging literature. In Ghana, family and hired labor were positively associated with labor-intensive practices such as mulching and no-tillage, highlighting labor's critical role in implementing such strategies (Sertse et al., 2021; Martey & Etwire, 2025). Conversely, labor shortages have been shown to impede adaptation uptake, prompting farmers to shift cultivation practices, invest in labor-saving technologies, or hire contractors instead (Win et al., 2025). Moreover, international labor mobility programs can enhance adaptive capacity by facilitating the transfer of agricultural knowledge upon workers' return (Dun et al., 2023; Davila et al., 2023). More labor (whether family or hired) encourages adoption of adaptation strategies, likely because many adaptation measures (soil conservation, agroforestry, irrigation, mulching) are labor-intensive. The quantity of labour available influences the adaptation decisions of farmers to climate change. Labour availability facilitates the adaptation of labour-intensive climate related measures (Deressa et al., 2011). These findings suggest that both the quantity of labor and the movement of labor are important determinants of climate adaptation.

Farming experience has a positive influence on the adoption of climate adaptation strategies (Table 5). The odds ratio of 1.040 suggests that each additional year of farming experience increases the likelihood of adoption by about 4%, holding other factors constant. This finding highlights the role of accumulated knowledge and learning-by-doing in shaping adaptive capacity. Experienced farmers are better positioned to recognize changing climate patterns, evaluate

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risks, and select appropriate responses. Maddison (2007) found that farmers with longer experience are more aware of climate variability and more inclined to adopt adaptation strategies. Similarly, Deressa et al. (2009) reported that experience significantly enhances the probability of adopting adaptation measures in Ethiopia, as seasoned farmers draw on past encounters with climatic shocks to guide present decisions. Below et al. (2012) further emphasize that farming experience provides practical knowledge that reduces uncertainty and improves the ability to experiment with innovative practices. Thus, while the effect of experience in this study is modest, it underscores that experiential knowledge is an important driver of adaptive behavior among farming households.

The results further show that crime has a strong positive association with the adoption of climate adaptation strategies. The odds ratio of 3.171 suggests that in areas experiencing higher levels of crime, farmers are over three times more likely to adopt climate adaptation measures compared to those in low-crime areas, holding other factors constant. This finding implies that crime, like climate variability, acts as a stress multiplier that threatens rural livelihoods and compels households to seek protective strategies. This might sound counterintuitive, but here are some possible explanations. As Moser and Ekstrom (2010) argue, perceptions of risk strongly shape adaptive behavior, and when farmers face compounded insecurities such as crime alongside climate stress, they may be more motivated to pursue resilience-enhancing actions. Similarly, Adger (2003) and Arfa et al. (2025) emphasizes that social and environmental stressors often interact, driving communities to adopt adaptive measures as part of broader livelihood security strategies. In contexts where institutional trust is weakened by crime, farmers may rely more on self-reliant adaptation practices, such as crop diversification, soil conservation, or water harvesting, to safeguard their production systems. This finding underscores the importance of viewing adaptation not only as a response to environmental pressures but also as a coping mechanism against broader socio-economic insecurities.

The regression results further indicate that cultural factors significantly reduce the likelihood of adopting climate adaptation strategies (Table 5). The odds ratio of 0.184 suggests that a one-unit increase in the influence of cultural norms or practices is associated with an 81.6% decrease in the odds of adoption, holding other variables constant. This implies that deeply rooted traditions and social norms can act as barriers to innovation in farming systems. Adger et al. (2009) argue that cultural values shape how communities perceive risks and determine what responses are considered legitimate or acceptable. Similarly, Grothmann and Patt (2005) note that adaptation behavior is strongly influenced by subjective risk perception, which may be framed through cultural or spiritual lenses rather than scientific evidence. In some cases, cultural norms may discourage experimentation with new techniques or the adoption of crops and practices perceived as "non-traditional". Semenza et al. (2008) further emphasize that strong social norms and community cohesion, while valuable for resilience, may also lead to resistance against practices that deviate from tradition. Thus, while culture provides social identity and stability, it can also hinder adaptive responses to climate change when traditional practices conflict with emerging resilience strategies.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Climate change poses significant threats to agricultural productivity, food security, and rural livelihoods due to high dependence on rain-fed agriculture in less developed countries. Farmers practice various adaptation strategies to help minimize the effects of climate variability and sustain livelihoods. Understanding the factors that influence the adaptation decisions of farmers has become a central theme in climate change research.

Using a sample of 230 smallholder farmers and applying the logistic regression analysis, the results revealed interesting outcomes. Farm size is a key determinant of farmers adaptation choices and increasing farm size is associated with lower odds of adopting climate adaptation strategies. An increase in the quantity of fertilizer use is associated with a 19.6% decrease in the odds of adopting adaptation strategies. Taken these findings together, highlight the complex trade-offs farmers face between short-term productivity strategies and long-term adaptation measures. Farming experience, labor use, and crime are positively associated with the adoption of climate adaptation strategies. Thus, for communities that experience an increase in crime, farmers are three-times more likely to adapt climate change adaptation measure relative to those in low crime areas. Cultural beliefs and practices also lower the odds of adopting climate adaptation strategies by more than 80% highlighting that deeply rooted traditions and social norms can act as barriers to innovation in farming systems.

5.2 Recommendations

These findings have both practical and policy implications. Policies that promote climate resilience must not only address financial, sociocultural and institutional barriers but must also reframe fertilizer use and farm size dynamics within broader adaptation planning. Policies that ensure adequate labor availability through family labor support, hired labor, or knowledge-sharing mechanisms must be prioritized to enhance farmers' resilience to climate challenges. Farmer education on the correct use of fertilizers and farm size selection needs to be intensified by the Ministry of Food and Agriculture to help increase productivity and enhance the welfare of farmers. Traditional and local authorities must

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work collaboratively towards reducing crime and community conflicts to accelerate the adoption of climate adaptation strategies and promote security for the needed investment in the agricultural sector.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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