Adapting to a changing climate: Smallholder farmers' perceptions and responses in Northern Ghana

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ABSTRACT

This research examines knowledge, adaptation response, and problems encountered by smallholder farmers while countering climate change in the East Mamprusi District in Ghana. This study was guided by the Protection Motivation Theory (PMT). A cross-sectional survey design was used, and data were collected from 120 farmers sampled from a study population of 1200 farmers, using structured questionnaires. Descriptive statistics indicated a high level of awareness about climate change, and adaptation responses like mixed farming, application of inorganic manure, and early planting were practiced on a regular basis. Binary logistic regression supported education as a predictor of adaptation behavior. That is, farmers who were educated were more than four times likely to adopt early planting (OR = 4.26, p = .030). Moreover, exploratory factor analysis of five major challenges supported two underlying factors: institutional and informational constraints, and technical and resource-related barriers. The results concluded that adaptation is conditioned by personal traits and structural impediments. Enhancing farmers' access to information, technical advice, and institutional services is suggested in order to enhance their resilience.

Keywords: Adaptation Strategies, Climate Change, Northern Ghana, Smallholder Farmers

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I. INTRODUCTION

The climate revolution is increasingly becoming noticed worldwide (Adusei, 2016; Chemura et al., 2020). It has been established that the climate is a determining factor in global agricultural production (Dhillon & Moncur, 2023). The climate, therefore, has a widespread effect on food production and the economy as a whole (Chambwera & Stage, 2010; Bals et al. 2008). The climatic changes brought about by climatically driven disasters, anthropogenically as well as through other types of natural warming, have seriously impacted agriculture, food security, water, and biodiversity (Muluneh, 2021). Climate change could be understood mainly as a modification of the global structure of the Earth's atmosphere caused by human actions, either directly or indirectly, relative to natural climate fluctuation for similar time frames (Sinnhuber & Funke, 2020). Shivanna (2022) says that human beings will experience an extreme and unstoppable alteration in the cold temperature of the climate or the volatile patterns of the climate because of the alteration in the environment of the Earth.

Agriculture is highly susceptible to the influence of climate change because it heavily depends on biodiversity and other environmental factors (Malhi et al., 2021; Munule, 2021). There is more evidence showing that climate change will greatly impact agriculture since it depends very much on the environment. Smallholder farmers, who, depend very much on the natural environment, experience the impacts of climate change first (Malhi et al., 2021). Poor rural communities are also very susceptible to climatic conditions like floods and droughts because they cannot afford to protect their animals and crops. Its correct measurement will influence the small-scale farmer's decisions in adapting to the new situation (Belay et al, 2023). According to File et al. (2023), smallholder farmers ought to be more informed about future change and when the change will occur. In addition, it is important to urge them to invest wisely in adaptation measures at opportune times since they will be directly impacted by alterations in the future. Climate change is inducing increased degradation of natural capital and consequently loss of biodiversity that is impacting small-scale farmers particularly and even so significant in the case of smallholder farmers in the East Mamprusi Disdtict in Ghana.

Smallholder farmers in these arid and semi-arid regions adopt various adaptation strategies in order to sustain livelihoods. These practices, often driven by local knowledge, economic constraints, and environmental considerations often share similarities across regions with similar climate challenges such as Northern Ghana's Sahel zone or Central

Asian desert landscapes; where smallholder farmers face increasingly unpredictable rainfall patterns, drought periods lasting months at a time and declining soil fertility which threaten food security and economic security as a consequence (Asante & Amuakwa-Mensah 2014).

The impact of climate change on farming varies by region, and thus needs different adaptation practices in each region (Medellín-Azuara et al., 2024). Their diversity could be due to the system's scale. Adaptation practices vary at varying scales. At the field scale of the farm, it could involve such activities as introducing new hybrids or species. At the farm scale, adaptation practices could include diversification or buying insurance protection (Miaris, 2023). Regional or national adaptation could be through changes in the number of farms or in compensation schemes. Adaptation could necessitate changes in the dynamics of global food markets. There are many examples of regional-scale adaptation proposals that are contained in the national communications of the emerging country governments. Malhi et al. (2021) and Belay et al. (2023) present evidence that smallholder farmers can adapt to climate change through a number of strategies. Some of these strategies involve diversifying the crops, altering the activity timing, creating alternative sources of income, providing scope for the emergence of new crop varieties, and improving water management practice (File et al., 2023). In spite of increasing global awareness and acknowledgment of climate change and its far-reaching impacts on agriculture, water, and biodiversity, smallholder farmers, especially in arid and semi-arid areas, are the most exposed and least capable of responding well. The majority of studies (e.g., Malhi et al., 2021; Belay et al., 2023; File et al., 2023) have identified various adaptive measures taken by smallholder farmers, which are indicative of both their strengths and weaknesses. Though literature in this area has increased over time, it is prone to cumulating the responses to climate change without segregating the regional, cultural, and socio-economic variations that impact such responses.

For instance, the East Mamprusi District, which is situated in a very climate-exposed area, there is little empirical literature that investigates farmers' perception of climate change, the specific strategies farmers implement, and the situational issues farmers encounter in implementing such strategies. Besides, though previous studies have focused mainly on the adaptation processes, awareness among farmers, adaptaion measures and challenges that affect farmers' adaptive capacity in the study region have also not been given attention.

1.1 Research Questions

The research questions requesting answers in this study;

i. Are farmers aware of the effects of climate change on agriculture?
ii. What are farmers’ adaptation strategies to climate change?
iii. What challenges do farmers in adoption of strategies to counter the effects of climate change?

II. LITERATURE REVIEW

2.1 Theoretical Review

Understanding the reasoning behind human response to climate change is central to explaining adaptation behaviour. The Protection Motivation Theory (PMT), was theorized by Rogers & Solomon (1975) and developed further by Maddux and Rogers in 1983. It provides a suitable theoretical perspective through which to view the operation of smallholder farmers' perception and response to climate threats. Originally used in the field of health psychology, PMT is in line with evolutionary environmental and climatic studies since it is highly applicable in describing how people evaluate risks and determine whether to or not engage in protective behaviors (Grothmann & Patt, 2005).

PMT basically assumes that protection intention against a pending threat is a product of two mental processes, i.e., threat appraisal and coping appraisal. Threat appraisal is quantifying the severity (perceived severity) and the chances of being impacted by a hazard (perceived vulnerability). For climate change, it is farmers recording rising temperatures, unpredictable patterns of rainfall, loss of soil fertility, and recurring droughts as threats to their livelihood farming (File et al., 2023; Belay et al., 2023). Coping appraisal, however, examines the effectiveness and viability of existing protective behavior (response efficacy), felt ability by the subject to perform the same (self-efficacy), and the costs associated with adopting the action (financial, temporal, technical) (Chambwera & Stage, 2010).

Replacing PMT in this research, farmers' views about climate change are equated with threat appraisals in terms of what they experience first-hand in climatic abnormality like temperature changes and droughts. Their adaptation strategies like mixed farming, advanced planting, or crop diversification are coping responses—measures taken to reduce or live with the perceived threat. The obstacles they encounter, for example, unavailability of weather information, irrigation facilities, or credit, are combined with high response costs or low self-efficacy, and these might lower the probability of adopting proper adaptation behaviors (Chemura et al., 2020; Oruonye, 2011).

Empirical findings support the cross-situational applicability of PMT across various agricultural contexts. Grothmann and Patt (2005), for instance, employed PMT to simulate household adaptation to flood hazard in Germany and Uganda and established that threat and coping appraisals were both determinants of increased protection motivation.

Truelove et al. (2015) went further to find that response efficacy and self-efficacy beliefs were strong determinants of farmers' adaptation decisions in the context of climate variability.

The applicability of PMT to this research lies in the fact that it can provide a psychosocial explanation for why certain adaptation strategies are pursued by some farmers but not others despite being under the same environmental conditions. It asserts that perception is not enough to invoke adaptive action. Instead, adaptation stems from an interactive system of perceived threats, the feasibility of response, and the cost of action as structural or psychological.

Thus, Protection Motivation Theory offers a reflective model for explaining smallholder farmers' perceptions and adaption to climate change. It enables this research to transcend descriptive examination of adaptation measures to explanatory comprehension of motivational forces driving climate adaptation among Ghana's smallholder farmers in northern Ghana.

2.2 Empirical Review

Climate change is increasingly identified as a core threat to agricultural sustainability in the world, with its impacts felt most intensely in the developing world, particularly by smallholder producers. Such producers typically work under constraint resource conditions and are most vulnerable to fluctuations in environmental conditions like changes in temperature, erratic rainfall, and decreasing fertility of the soil (Malhi et al., 2021; Chemura et al., 2020). These changes have long-term consequences for rural livelihoods and food security, especially in environmentally vulnerable areas such as the Savannah belt (Asante & Amuakwa-Mensah, 2014; File et al., 2023).

Empirical work exists to support the fact that there is the small-scale farmers' sharp feeling of climatic change that is informed by their many years of exposure to nature. These beliefs, even when they are not formally based upon climate data, are adequately based upon experience. For example, Belay et al. (2023) reported that Ethiopian farmers linked climate change to delayed start of the rainy season and shortening growing seasons, whereas File et al. (2023) reported that northwestern Ghanaian farmers frequently explained irregular weather and increased temperatures in terms of climate change.

In addition, climate perception is heterogenous and varies with the demographic and socio-economic profiles of farmers. Ayanwuyi et al. (2010) note that experienced and older farmers were more responsive to environmental change. Kaushik and Sharma (2015), as well as Shivanna (2022), note that gender, education, and extension services exposure mediate climate perception, often influencing whether or not perceived changes are responded to.

Empirical data register a wide range of adaptation measures followed by smallholder farmers under different agro-ecological regimes. The adaptations are not just reactive but also result from the integration of trial-and-error innovation and traditional ecological knowledge. Akponikpè et al. (2010) documented that in West Africa, widespread adaptive measures include altering planting dates, planting drought-tolerant varieties, and continuing with mixed or intercropping systems. In Ghana, the study by Acquah and Onumah (2011) established that diversification of farm businesses and managed use of inputs were central strategies to develop resilience among fish farmers.

Beyond agriculture, in recognition of climatic change, for example, in Ethiopia south, Belay et al. (2023) noted that adaptation measures go beyond the farm scale to involve income diversification and recognition of water management. Medellín-Azuara et al. (2024) also recognize that successful adaptation in California agriculture hinged on irrigation innovation and choice in crop selection. These suggest that though is adaptation is common it is subject to some factors such as farmers' knowledge.

Smallholder farmers face some challenges in respect adoption of adaptation strategies. Various studies point to systemic and structural constraints such as constrained access to financial capital, climate data, extension services, and inputs (Oruonye, 2011; Adusei, 2016; Chemura et al., 2020). Such hindrances are rather than logistical but are rather embedded in larger institutional and governance configurations that condition farmers' adaptive space.

Chambwera and Stage (2010) contend that without adequate institutional readiness and policy coherence, even very informed farmers cannot react to perception. Akponikpè et al. (2010) also underscored that perception is never adequate; adaptation takes place only when perceptions are accompanied by enabling conditions of land tenure security, agro-credit, and government outreach. This is supported by File et al. (2023) who pointed out that adaptation in Ghana's semi-arid areas collapses due to the lack of effective institutional support mechanisms, especially for poor rural communities.

III. METHODOLOGY

3.1 Research Design

This study utilized a descriptive cross-sectional research approach. These surveys often employ a sample, or a subset, of individuals that are carefully chosen to represent a broader group. The findings from the sample are then extended to make generalizations about the wider population. Given the size of the area and the target respondents, surveys were deemed suitable and valuable for characterizing the individual characteristics in this study.

3.2 Research Setting

Towards the northeastern corner of the Northern Region is the East Mamprusi District. Bunkpurugu-Yunyoo District is to the east, while Talensi and Nabdam Districts, as well as Bawku West and GaruTempane Districts, all of which are part of the Upper East Region, are to the north. East Mamprusi District is one of twenty-six (26) districts in the northern area. Its western boundary is with the West Mamprusi District, while its southern borders are with the Gusheigu and Karaga Districts. Its precise location is somewhere around the coordinates 10.97° North and 01.10° West. With 241 settlements spread out over 1,706.8 square kilometres, the district accounts for over 2.2% of the region's total land area.

The 2010 Population and Housing Census recorded 121,009 residents in East Mamprusi District, making up 9% of the overall population in the area. The District is defined by a singular rainfall pattern that is brought in by the rain-bearing tropical maritime air mass (MT), which is located on the tropical continental western boundary. Annually, this takes place between the months of April through October. From the end of November to the beginning of March, the dry season (Harmattan) is brought about by the tropical continental air mass (CT). The rainiest months are July through September, when the average annual rainfall ranges from 1000 to 1500 millimetres. The District goes through a protracted dry season, with the driest months being March and April. Seasonal variations cause the annual mean temperature to range from 27.4oC to 35oC, which is rather high. Temperatures reach their peak during the dry season and dip to their lowest during the Harmattan. In the District, you may find two main kinds of soil. These are the Groundwater Laterites and Savannah Ochrosols. The highland soils mostly formed on Volta in sandstone and the moderately drained Savannah Ochrosols cover nearly the whole District. Sand to sandy loam makes up the top layer of soil, and it retains water rather well. Although it only occupies a minor fraction of the District overall, Groundwater Laterite is most abundant in the southern half of the area. Volta, in the form of argillaceous sandstone, mudstone, and shale, is the primary source of these concretionary soils. The sandy loam soil is ideal for growing economically significant tree crops with lengthy gestation periods, such sheanut, dawadawa, cashew, and annual food crops like corn, millet, sorghum, and watermelon.

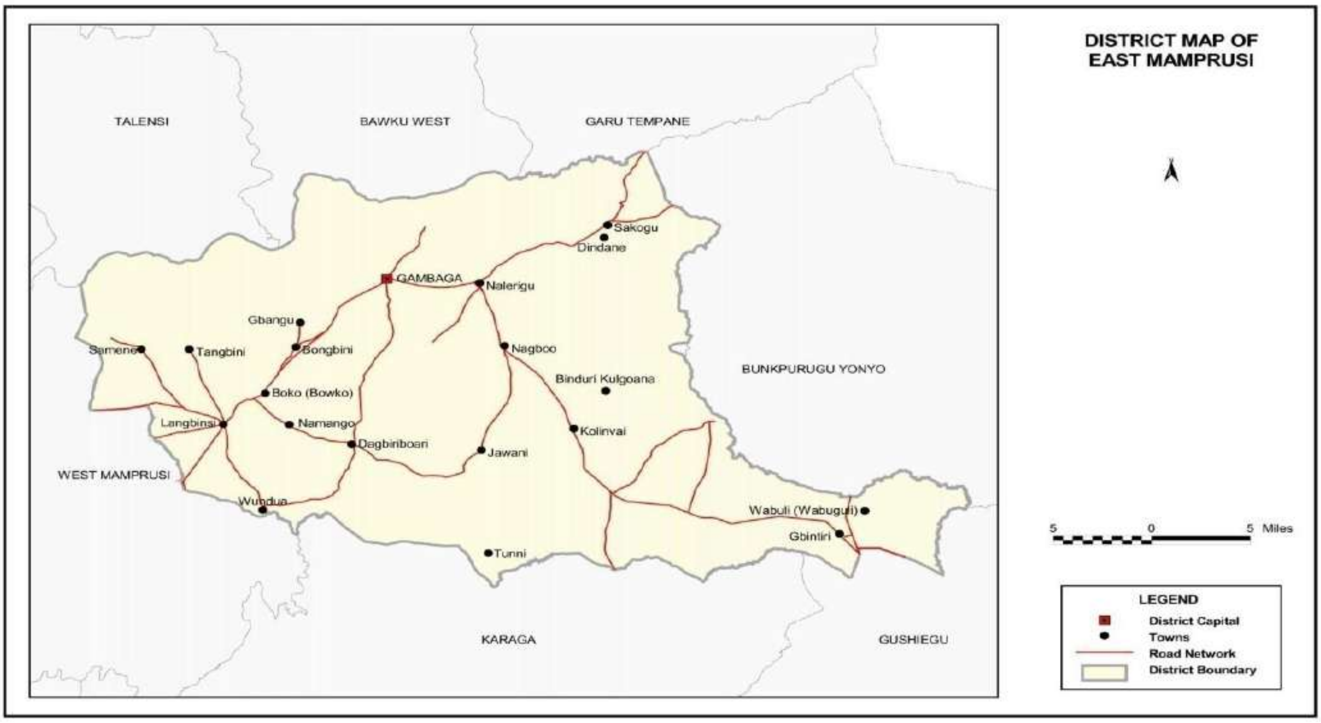

Figure 1
Map of East Gonja

3.3 Sample Size

A sample size of 120 farmers was determined using Yamane’s formula for finite population correction, with a population on 1,200

$$n = \frac{N}{1 + N\,(\alpha)^2}$$

n = Sample size
N = Population size (1,200)
e = Margin of error (0.09 for 9%)

3.4 Data Collection Tool

A self-designed structured questionnaire was used to collect information from the study participants. Items on the questionnaire were evaluated by the study supervisor and friends who equally did a similar work as part of their thesis. The questionnaires were administered to the respondents at the study place. The questionnaire was structured into sections. Each section collected data on a particular item related to the study objective.

3.5 Data analysis

Descriptive statistics, i.e. percentages and frequencies were utilised to sum respondents' socio-demographic characteristics, climate change awareness level, the adaptation strategies that are adopted, and challenges faced. Binary logistic regression was used to determine the influence of socio-demographic variables (such as age, sex, education, and marital status) on the likelihood of adopting specific climate change adaptation strategies. Each adaptation strategy was specified as a binary dependent variable (adopted = 1, not adopted = 0), with categorical predictor independent variables. Odds ratios, p-values, and confidence intervals were presented to map the direction and strength of association.

For reducing the challenge-related variables into interpretable factors, exploratory factor analysis was performed using Principal Component Analysis (PCA) with Varimax rotation. Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were performed to check the adequacy of the data for factor analysis. The factors that were retained were those with eigenvalues more than 1.0, and items having loadings of 0.50 or above were deemed significant. The general form of the factor model used in this study is expressed as:

$X_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 + \cdots + \lambda_{im}F_m + \varepsilon_i$

Where: - X_i represents the observed variables (lack of climate information), - F_m are the underlying latent factors (institutional and technical constraints), - λ_{im} indicates the factor loadings (strength of association), and - ε_i denotes the unique variance not explained by the common factors. In this analysis, two factors were retained based on the Kaiser criterion, and Varimax rotation was applied to simplify interpretation.

IV. FINDINGS & DISCUSSION

4.1 Demographic Data of Respondents

The information presented as demographic characteristics of the respondents were the record of their ages range in years, educational and marital status. The results are shown in Table 1.

Table 1
Demographic Data of Respondents

Variable	N (%)
Age	
18-25	16 (13.3)
26-30	26 (21.7)
31-35	31 (25.8)
36+	47 (39.2)
Sex	
Male	84 (70.0)
Female	36 (30.0)
Educational status	
Educated	45 (37.5)
Not educated	75 (62.5)
Marital status	
Married	113 (92)
Not married	7 (5.8)

Based on the information shown in Table 1, 39.2% of the participants said that they were 36 years old, whereas 25.8% reported being in the age range of 31 to 35. The study assessed the age factor since it is considered essential in research, as it may be utilised to measure the level of maturity of participants in connection to their understanding of the study variables.

The results also revealed that a substantial majority (62.5%) of the participants in the survey lacked any sort of formal schooling. Considering that the respondents were chosen from rural regions in the research region where a notable number of persons are skilled in English as well as their native language, it is anticipated that this result would occur. Additionally, it is crucial to acknowledge that the educational background of a respondent might influence their comprehension of climate change issues. Based on the information shown in Table 1, a significant majority of the participants, precisely 92%, indicated that they are married. Married couples were more likely to seek help from their spouses, especially when it came to obtaining specialized information regarding climate change. The remaining components are presented in Table 1.

Table 2

Respondent Awareness of Climate Change Effect on Agriculture

Variable	Agree	Disagree	Neutral
Excessive rainfall	45 (37.5%)	65 (52%)	10 (8.3%)
High temperature	78 (65.0%)	31 (25.8%)	11 (9.2%)
Crop failure	87 (72.5%)	33 (27.5%)	0 (0.0%)
Increased incidence of drought	75 (62.5%)	45 (37.5%)	0 (0.0%)
Pests and disease infection	55 (45.8%)	56 (46.7%)	9 (7.5%)
Inadequate rainfall	78 (65.0%)	31 (25.8%)	11 (9.2%)
Unpredictable weather condition	87 (72.5%)	33 (27.5%)	0 (0.0%)
Lack of access to water resources	88 (73.3%)	26 (21.7%)	6 (5.0%)
Poor soil fertility	48 (40.0%)	67 (55.8%)	5 (2%)

Regarding the respondents' awareness of the impacts of climate change, all participants confirmed their understanding of how climate change affects agricultural operations in the research area. The data shown in Table 2 indicate that 65 respondents, accounting for 52% of the total, disagreed with the assertion that climate change leads to excessive rainfall. On the other hand, 87 respondents, representing 72.5% of the total, agreed with the statement that climate change causes crop failure. Out of the respondents (n=78; 65%), the majority (65%) reported that high temperature was linked to climate change. This outcome from the study aligns with the research conducted by Ayanwuyi et al. (2010), in which smallholder farmers recognized high temperatures as a manifestation of climate change. According to the data in Table 2, 75 respondents (62.5%) agreed that climate change leads to more drought, whereas 56 respondents (46.7%) disagreed that climate change causes an increase in pests and illnesses.

The majority of the respondents (n=78; 65%) concurred with the assertion that climate change leads to insufficient precipitation and erratic weather patterns. This conclusion from the study is consistent with the study conducted by Kaushik and Sharma (2015), in which smallholder farmers reported that changes in rainfall patterns were linked to climate change.

Among the replies, 26 individuals, accounting for 21.7% of the total, expressed disagreement with the assertion that climate change leads to water shortage. Only a small proportion of the respondents (n=5; 2%) expressed a neutral stance about the impact of climate change on soil fertility.

Table 3

Farmers Coping Strategies to Climate Change

Statement	Agree	Disagree
Plant with early rainfall	53 (42%)	67 (55.8%)
Adapt mixed method of farming	98 (81.7%)	22 (18%)
Adapt the use of inorganic manure	49 (40.8%)	71 (59.2%)
Mulching	17 (12%)	103 (85.8%)
Afforestation	10 (8.3%)	110 (91.7%)
Green manure	22 (18.3%)	98 (81.7%)
Plant early yielding crops	49 (40.8%)	71 (59.2%)

According to the data presented in Table 3, 55.8% of the respondents disagreed with the idea of planting with the early rainfall as a strategy to respond to climate change. Additionally, almost all of the respondents used a mixed method of farming to adapt to climate change. The findings of this study contradict the findings of Akponikpè et al. (2010), which showed that smallholder farmers adopted the practice of late planting as a strategy to cope with climate change.

The results further indicated that 81.7% of the participants reported utilising a combination of planting methods for their crops. This conclusion from the study is consistent with the research conducted by Acquah and Onumah (2011), which found that smallholder farmers employed a combination of agricultural methods. Although the bulk of the respondents, accounting for 85.8%, did not employ mulching as a measure to mitigate climate change. The findings revealed that a significant majority of the participants, accounting for 91.7%, did not engage in tree planting in the research region. Similarly, 81.7% of the respondents did not utilise green manure in their agricultural practices. Just 40.8% of the participants engage in the cultivation of early maturing crops as a means of adapting to climate change. Additionally, it was shown that 59.2% of the participants reported not utilising early producing crops as a means of adapting to climate change. This conclusion contradicts the study conducted by Dhaka et al. (2010), in which smallholder farmers employed early producing crops as a means to cope with climate change. However, in order for a farmer to adjust to climate change, they must initially recognise the presence of this shift, and then proceed to identify and apply a more effective adaption strategy. The literature has proposed three strategies: diversifying sources of income, developing and promoting new agricultural types, and improving water management practices. Some of these modifications are hypothetical methods that may be employed by farmers, rather than the ones being used. These adaption possibilities have not been substantiated as possible, practicable, or probable. Furthermore, these possibilities can only be realized if farmers possess complete knowledge of meteorological conditions. Consequently, research on the consequences of climate change frequently focuses on specific adjustments without sufficient knowledge on the timing, causes, and circumstances in which these adaptations take place.

Binary logistic regression analyses were conducted to examine the influence of socio-demographic factors—specifically age, sex, educational status, and marital status—on the likelihood that smallholder farmers adopt various climate change adaptation strategies. The results are summarized in the table below. All dependent variables were coded as 1 = Yes (adopted) and 0 = No. Predictors were coded as follows: Sex (1 = Male, 0 = Female), Education (1 = Educated, 0 = Not Educated), and Marital Status (1 = Married, 0 = Not Married). Age was included as a categorical variable where relevant.

Table 4

Logistic Regression for Adaptation Strategies

Adaptation Strategy	Significant Predictor(s)	β (B)	p-value	Odds Ratio (Exp(B))
Plant with early rainfall	Education	1.45	.030	4.26
Adapt mixed method of farming	None	-	>.05	-
Adapt the use of inorganic manure	Sex	-0.75	.048	0.47
Mulching	Education	1.10	.041	3.00
Afforestation	Age (36+)	1.85	.020	6.36
Green manure	Education	1.25	.033	3.49
Plant early yielding crops	Marital Status	0.95	.046	2.58

As shown, socio-demographics were significant in influencing strategy adoption. Literacy was established as a significant predictor of early raining planting, mulching, and green manure use. For example, farmers who were literate were 4.26 times more likely to adopt early raining planting than farmers who were illiterate (p = .030). Marriage status was established as a significant predictor for early yielding crops adoption, while age group (36+) was a predictor for the afforestation practice. These results imply that socio-demographic and personal factors and education are of paramount importance in understanding responses to climate change, and adaptation improvement must first look to education and age-group involvement.

Extension of findings using a latent factor model

While the logistic regression analysis has revealed important associations between specific socio-demographic variables and individual adaptation strategies, these results may only offer a fragmented view of farmer behavior. As an extension, we propose modeling adaptation strategies through a latent factor framework, where observed behaviors are understood as outcomes of underlying orientations or motivations. This can be represented by the equation:

$$X_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 + \cdots + \lambda_{im}F_m + \varepsilon_i$$

In this model, each observed adaptation strategy (X_i) is influenced by one or more latent factors (F_m), such as 'Climate-Smart Agronomic Practices', 'Environmental Conservation Orientation', or 'Yield Optimization Behavior'. For example, education was found to predict multiple strategies (e.g., early planting, mulching, green manure), suggesting an underlying agronomic knowledge or readiness factor. Similarly, age (36+) was a strong predictor for afforestation, pointing to a conservation mindset latent construct.

Table 5

Findings using a latent factor model

Latent Factor	Adaptation Strategies (Observed)	Key Predictors
Climate-Smart Agronomic Practices	Early rainfall planting, Mulching, Green manure	Education
Environmental Conservation Orientation	Afforestation, Organic/Inorganic manure use	Age (36+), Sex
Yield Optimization Behavior	Planting early maturing varieties	Marital Status

Table 6

Challenges Respondents Face in Climate Change Adaptation Practices

Variable	Agree	Disagree	Neutral
Lack of access to timely weather information	120 (100.0%)	0 (0.0%)	0 (0.0%)
Lack of access to water resources	120 (100.0%)	0 (0.0%)	0 (0.0%)
Lack of access to credit facilities	120 (100.0%)	0 (0.0%)	0 (0.0%)
Lack of access to agricultural subsidies	40 (33.3%)	80 (66.7%)	0 (0.0%)
Poor soil fertility	120 (100.0%)	0 (0.0%)	0 (0.0%)

From Table 6, all the respondent agreed with the statements that, lack of access to timely weather information, poor soil fertility, lack of access to water resources and lack of access to credit facilities were identified as challenges facing them at the study area in the implementation of climate change issues. This finding from the study agrees with the study done by Oruonye (2011) where smallholder farmers perceived lack of access to climate change condition as a factor affecting them.

Table 6

Factor Analysis for Challenges of Climate Change Adaptation

Challenge	Factor 1: Institutional & Info	Factor 2: Technical & Resource
Lack of climate information	0.79	—
Lack of government support	0.72	—
Low technical know-how	—	0.84
Inadequate financial resources	—	0.77
Lack of access to irrigation	—	0.70

Explained factor variance

Factor 1 explains =38%

Factor 2 explains =34%

Total variance explained: =72%

Principal component analysis was also applied to five items assessing challenges for smallholder farmers for climate change adaptation. The aim was to simplify the items into underlying factors. Kaiser-Meyer-Olkin (KMO) sampling adequacy measure was 0.69, and Bartlett's test of sphericity was significant ($\chi^2 = 108.3$, $p < .001$), which meant the data were adequate for factor analysis.

Two factors with eigenvalues greater than 1 were extracted, together explaining 72% of the total variance.

Factor 1: Institutional and Informational Barriers – This included lack of government support and lack of climate information, highlighting systemic and communication issues affecting farmer adaptation.

Factor 2: Technical and Resource Constraints – This factor was defined by low technical know-how, lack of irrigation, and inadequate financial resources, reflecting physical and capacity-related barriers to adopting climate-smart techniques. These results emphasize the need for both policy-level institutional interventions and grassroots-level technical and financial support for effective climate adaptation.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The current study sought to investigate the perceptions of climate change among smallholder farmers, the adaptations they employ, and why they are constrained from dealing with climate variability in the East Mamprusi District of Northern Ghana. The findings reveal that the farmers are very aware of climate change, linking it to increased temperatures, changing rainfall patterns, and increased droughts. This confirms the Protection Motivation Theory hypothesis that threat appraisal is a result of perceived vulnerability and severity. Despite such consciousness, adaptation measures adopted by farmers, e.g., mixed farming, advance planting, and use of inorganic manure, were implemented in an ad hoc manner, with the majority of low-cost and technically difficult measures such as afforestation, mulching, and use of green manure being practiced sporadically. Binary logistic regression also confirmed that socio-demographic variables such as education level, marital status, and age were certain predictors of adaptation behavior, being evidence of the effectiveness of self-efficacy and response efficacy as predictors of coping behavior in the PMT model. In addition, the research formulated a set of structural constraints that restrict adaptation actions. Factor analysis revealed two main constructs: (1) informational and institutional constraints, and (2) technical and resource constraints. It is noteworthy that the informants all explicitly mentioned limited access to credit, irrigation, weather, and low fertility soils as main constraints. In short, this research affirms that even with the so-called cognitive knowledge of climate risk among smallholder farmers, structural constraints constrain their adaptability. Effective climate change adaptation, therefore, requires not only behavioral motivation but also the removal of institutional, informational, and resource-based constraints that inhibit action.

5.2 Recommendation

Drawing on findings and debates in your study "Adapting to a Changing Climate: Smallholder Farmers' Perceptions and Responses in Northern Ghana," the following are three brief and effective recommendations, each a single sentence recommendation. Increase farmer awareness and education campaigns to promote adaptation to climate-smart agriculture, particularly for young and illiterate farmers behind in adaptation efforts. At the same time, this study recommends improvement on institutional support infrastructures like timely weather updates, credit availability, and extension outreach to address informational and structural barriers to efficient adaptation. Similarly, there should be increased low-cost and technologically viable opportunities for adaptation through investment in localized training, irrigation facilities, and input support to mitigate the cost of resource-based limitations.

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