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# Smallholder Farmer Adaptation Strategies to Climate Change in Northern Ghana: Evidence from Gushegu Municipality

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**Abstract**
Climate change has become a global phenomenon in recent times. The geographical characteristics of Northern Ghana exposes the region to the adverse consequences of climate variability. The northern sector of Ghana is characterized by a unimodal rainfall pattern occurring between May and September. Agricultural productivity and food security are threatened by the effects of climate change. Climate change adaptation strategies are expected to reduce the negative impacts of climate change through improvements in the resilience of the existing agricultural systems. The study sought to investigate the factors influencing smallholder farmers' choice of adaptation strategies to reduce the negative impact of climate variability in the Gushegu Municipality of the Northern Region of Ghana. Since farmers in the study district adopt a mix of adaptation strategies to reduce the negative impact of climate change, the choice of a set of bundle of adaptation strategies becomes a multivariate decision. This study therefore adopted the multivariate probit econometric technique to establish the relationships between climate change adaptation strategies (dependent variables) and the factors influencing the choice of the adaptation strategies (independent variables). With a sample size of 175 farm households, the study revealed that the dominant climate change adaptation strategies in order of popularity were; mixed farming, use of improved varieties of crops and animal breeds, income diversification, adjusting planting time, crop rotation, and use of farm belts. The independent variables were; age, gender, size of household, farm experiences, level of education, membership of farmer-based organization, access to credit, and income level of the farmers. The study recommends that farmers should be supported in terms of financial and technical assistance to improve their adaptive capacity to deal with the adverse effects of climate change. Sensitization campaigns against climate change are essential to equip farmers with the requisite know-how to minimize agricultural losses associated with climate change.

**Keywords: climate change, adaptation strategies, smallholder famers, multivariate probit**

## 1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) conceptualized climate change as long term significant changes in either the average state of the climate or its variability (IPCC, 2001). Climate change and its impact on livelihoods have attracted the attention of governments and policy makers in many parts of the world, particularly in tropical Africa [IPCC, 2014; FAO, 2015; Akudugu et al. 2018]. At the global level, policy interventions have been implemented to deal with the negative effects of climate change. For instance, the Sustainable Development Goal (SDG) 13 is aimed at combating climate change and its impact. To comprehensively tackle the issues of climate, the World Bank has drawn up a medium term climate change action plan spanning between 2021 and 2025. Unlike the first climate change action plan of 2016-2020, the World Bank current plan on climate change is intended to be integrated into the development agendas of participating countries (World Bank, 2021). The primary focus of the ongoing World Bank plan on climate change is to accelerate the eradication of poverty on sustainable basis through its green, resilient and inclusive development approach. In Africa, appropriate climate change adaptation strategies are required to insulate agricultural productivity from the adverse effects of climate change, (IPCC, 2014, Riede et al, 2016). Considering the heavy reliance of Ghana on the agricultural sector for foreign exchange earnings, employment, and source of livelihood, much more attention needs to be focused on climate change. Agricultural production is the main economic activity of the people of northern Ghana. Northern Ghana is situated within the Savanna enclave, which is more susceptible to the Inter-Tropical Conversion Zone (ITCZ) as it oscillates between the north and south (Antwi-Agyei et al. 2017). The geographical location of northern Ghana exposes it to higher levels of climate change vulnerabilities with the attendant consequences of low agricultural productivity, vicious cycle of poverty and food insecurity (UNDP, 2018). Rain-fed agriculture that characterizes agricultural production system in Northern Ghana is projected to suffer the consequences of climate change due to rising temperatures in tropical regions of Africa (IPCC, 2014).

In terms of causes of climate change, observed climate variability is mainly attributed to either natural occurrences or through the actions of humans (ISDR/UNEP, 2009; UNFCCC, 2001). As a result of human actions, there is presently an upward trend of emission of greenhouse gasses coupled with the depletion of the vegetative cover which have become the major agents of global warming (IPCC, 2007, 2014; Alhassan et al. 2018). The natural causes of climate change on the other hand emanate from natural events such as drought, floods, pest and disease outbreak (Akudugu et al. 2018). Evidence of climate change in Ghana shows that annual rainfall pattern has become highly erratic (World Bank, 2010). Between 2010 and 2050, temperatures are projected to rise across the entire country, with northern Ghana experiencing the highest levels of heat (World Bank, 2010). The evidence of distressed levels of climate change in northern Ghana can be drawn from the drying up of major rivers during the dry season, culminating into low levels of water from the northern territories into the Akosombo Dam (Alhassan et al. 2018; Kamkam-Yeboah et al. 2011). The low levels of water in the Akosombo Dam partly accounts for the problems of intermittent power outages in the country.

Characteristic of climate change trend analysis of rainfall pattern in northern Ghana between 1950 and 2000 shows that the onset of the rainy season has considerably changed from April to June and the dry season ending abruptly (Laux et al. 2008). Furthermore, dry spells in the rainy season are common occurrences in recent times (Tahiru, 2019). These observed trends are not only projected to last longer but also facilitate the occurrence of extreme conditions of droughts and floods as well as worsening food insecurity (Van de Gissen et al. 2010). Unlike Southern Ghana that has major and minor agricultural seasons, the northern sector of Ghana is characterized by a unimodal rainfall pattern occurring between May and September. The rainfall pattern is increasingly becoming unpredictable (Alhassan et al. 2019). Agricultural production in the Savanna ecological zone is largely dependent on rainfall. Farmers in the Northern Region are more exposed to shocks of climate change because of the heavy reliance on rain-fed agricultural systems with the attendant high levels of poverty and food insecurity (Yiran and Stringer, 2016). Northern Ghana is widely recognized for the production of food staples such as maize, yam, sorghum and rice (Fagariba et al. 2018). However, the negative impacts of climate variability on agricultural production systems remains a serious threat to food security, poverty reduction and wealth creation (IPCC, 2014). Furthermore, northern Ghana has recorded mass movement of able-bodied from the north to the south of the country mainly because of the negative impacts of climate change on agricultural performance in many rural communities of the north. In terms of gender dimension, rural women whose livelihoods are directly connected with agriculture are more susceptible to climate variability. The susceptibility of rural women to climate change has often been exacerbated by discriminatory practices facing them (Tahiru, 2019).

Globally, climate change has dire consequences on livelihoods and therefore remedies are put in place to reduce its impact on society. Depending on the levels, severity and perception of the effects of climate change on livelihoods, different farmers may deploy different adaptive mechanisms to mitigate its negative impacts (Kusakari et al. 2014). Climate change adaptation strategies are designed mechanisms intended to respond to either an actual or anticipated negative occurrences of climate and leverage on available opportunities (if any) presented by such climate variabilities (FAO, 2011). It is the expectations of policy makers, researchers and climate change practitioners that the adaptation strategies will primarily reduce the negative impacts of climate variability through improvements in the resilience of the existing systems (FAO, 2011). Farmers adaptation strategies are either planned or spontaneous, proactive or reactive, self-induced or externally planned, deployed on-farm or off-farm (Asare-Nuamah and Amungwa, 2021). Efforts of government, local and international non-governmental organisations at combatting the negative effects of climate change in northern Ghana and the country at large are documented in the literature (Tahiru, 2019, Alhassan et al, 2019, 2018, Kusakeri et al. 2014). To combat the negative effects of climate change, and in line with international best practices, Metropolitan, Municipal, and District Assemblies (MMDAs) are increasingly integrating adaptations strategies in their programmes (Republic of Ghana 2015). Among other initiatives, the government of Ghana introduced the 'Ghana National Climate Change Adaptation Strategy (GNCCAS)' in 2013. The Ghana government initiative was targeted at improving the resilience of various ecosystems. Similar programmes aimed at addressing the adverse effects of climate change have been introduced in northern Ghana by non-governmental organisations (Tahiru, 2019). In northern Ghana for instance, well known adaptation strategies of farmers reported in the literature are; crop rotation, mixed cropping, use of drought/flood resistant varieties, early-maturing crops, tree planting, mulching, (Mabe et al. 2014, Akudugu et al. 2018). While admitting that climate change is real, researchers and climate change practitioners bemoan that in spite of farmers exposure to variety of climate change adaptation strategies, the outcome of such strategies have failed to adequately reduce the negative impacts of climate change in many parts of the country (Yaro, 2013). A successful deployment of any intervention programme to deal with the adverse effects of climate change depends on the understanding of the factors influencing the choice of the adaptation strategies. Therefore, to achieve the full impact of the adaptation strategies employed by farmers, policy makers and other stakeholders need to take into account the major factors that influence farmers adaptation of climate change strategies in different parts of the country (Atube et al. 2021). Generally, there is low adaptation capacity among smallholder farmers, therefore intervention programmes designed to assist farmers adapt to climate change have become necessary. Farmers decision to use any form of adaptation strategy depends on socioeconomic and cultural considerations such as farming system, expected yields, land topography, demographic characteristics of the farmer (Mabe et al. 2014).

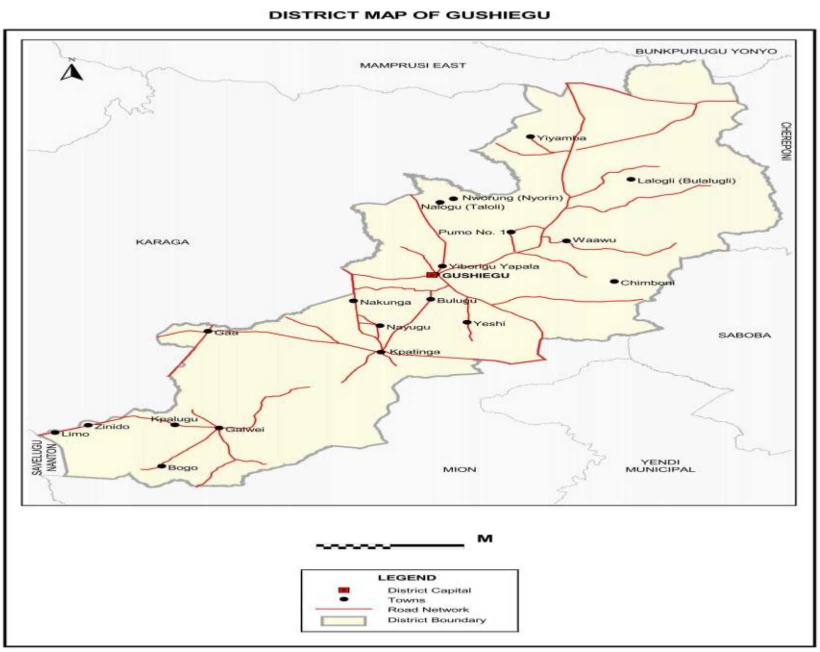
## METHODOLOGY

### Study area

Gushegu Municipality is one of sixteen (16) Metropolitan, Municipal and District Assemblies (MMDAs) in the Northern Region of Ghana. It was created in 1993 by an Act of Parliament. Gushegu is the capital of the Municipality. It is located within the Eastern Corridor enclave of the Northern Region. It shares boundaries to the East with Saboba District, Karaga District to the West, Yendi District to the South and borders East Manprusi District to the North. Majority (57.5%) of the inhabitants are Dagombas, Konkombas constitute 33% of the total inhabitants of the Municipality (GSS, PHC, 2020).

The dominant economic activities in the municipality are farming, rearing of animals and trade in foodstuff. Almost every household in the municipality (98%) is engaged in crop farming and 62.4% are into livestock rearing. It is estimated that 90.3 percent of males and 86.7 percent of females are involved in agriculture (GSS, PHC, 2020).

Fig. 1: Map of Gushegu District




Source: Ghana Statistical Services, 2020

### Study Design

The study relied on survey research design. Both quantitative and qualitative techniques were employed to establish the major determinants influencing the choice of climate change strategies employed by the farmers in the district.

### Data Collection

The study used both primary and secondary data. Structured questionnaire was used to elicit primary data from farmers. To gain insight on the subject, staff of the district agricultural department were interviewed.

**Sampling Design and Sampling Size**

The study relied on multi-stage sampling technique to determine the study district and the farm households. The first stage involved the purposive selection of the Gushegu District. The district was selected on purposive basis for two reasons; i. the district is predominantly agrarian, thus, most of the households in the districts (98.0%) are engaged in crop farming and 62.4% are involved in livestock farming (GSS, 2014), and ii. there is scanty researched findings on farmers adaptation strategies to climate change in the district. The second stage of the multi stage sampling technique involved a random selection of seven (7) farming communities in the district. The farming communities served as clusters. In the third stage, a total of 175 heads of farm households (Fisher et al 1998) were randomly and proportionally selected from the seven (7) farming communities for interviews. The district agricultural census data was used as sample frame.

**Econometric Analysis and Model Specification**

Utility maximization underpins the behavior of every rational farmer in terms of the application of any designed adaptation strategy to curb the negative impacts of climate. The choice of any climate change adaptation strategy depends on the expected net benefit to be derived from the deployment of such adaptation strategies, therefore, subject to a set of constraints, farmers adapt strategies which maximize net expected utility (Zivanomoyo and Mukarati, 2013; Minale 2012). Though the utility of the economic agents is unobservable, their choices of the adaptation strategies are observable. Recent developments in terms of technology adoption suggest that farmers choose from possible bundles of technologies that maximize productivity and minimize cost (Assaye et al. 2020). Depending on the negative impacts of climate change, farmers may adopt a mix of adaptation strategies to remedy the menace, therefore the choice of a set of bundle of adaptation strategies becomes a multivariate decision. This study therefore adopted the multivariate probit econometric technique to establish the relationships between climate change adaptation strategies (dependent variables) and the factors influencing the choice of the adaptation strategies (independent variables).

In this study, the adaptation strategies commonly employed by the farmers in the study area constituted the dependent variables. These factors were; crop rotation, adjusting planting time, use of improved varieties, mixed farming, income diversification, crop rotation, and farm belts, On the other hand, the factors influencing the farmers' choice of adaptation strategy which constituted the independent variables were derived from literature. These factors were largely based on the demographic characteristics of the farmer, topography of the land and nature of the farming systems. These factors include; farming experience of the head of household, gender of head of household, age of head of household, size of household, level of education, income level, access to credit, availability of farm land, farm size, and access to agricultural extension services.

The econometric model is specified as;

$$Y = \beta 0+\beta 1X1+\beta 2X2+\beta 3X3+\beta 4X4+\beta 5X5+\beta 6X6+ \varepsilon$$

Where;

Y represents a vector of climate change adaptation strategies employed by farmers, Y assumes a value of 1 if a farmer adapts a climate change strategy, and 0 if not.

X1-X6 represent a vector of variables influencing the choice of adaptation strategies

B1-B6 represent a vector of parameters to be estimated
$B_0$ represents the constant term, and $\varepsilon$ represents the error term

**Table 1. Description of Variables**

| Independent Variables | Type of Variable | Expected Sign/Citation |
|---|---|---|
| Gender | Dummy; male=1, Female=0 | + |
| Age | Continuous | + |
| Marital Status | Dummy; married=1, unmarried=0 | +/- |
| Education level | Dummy, Educated=1 uneducated=0 | + |
| Farm Experience | Continuous | + |
| Household size | Continuous | +/- |
| Access to credit | Dummy; Access=1, Otherwise=0 | + |
| Extension Services | Dummy; Access=1, Otherwise=0 | + |
| Farm size | Continuous | + |
| Farm Income | Continuous | + |
| Membership of FBO | Dummy; Access=1, Otherwise=0 | + |
| Access to climate information | Dummy; Access=1, Otherwise=0 | + |

**The dependent variables were the climate change adaptation strategies of the farmers;**

Farm belts, mixed farming, income diversification, crop rotation, adjusting planting time, and use of improved varieties.

## RESULTS AND DISCUSSION

### Analysis of sampled households

The socio-economic and demographic characteristics of the sampled households are presented in Table 2. As summarized in Table 2, the study shows that majority (62%) of sampled households were headed by males. The dominance of males in the agricultural sector demonstrates the prevalence of patriarchal system of practice in northern Ghana and most parts of Africa. This outcome is consistent with many studies, eg (CCAFS, 2021; Lambrecht and Karof, 2020; Britwum and Akorsu, 2016). The study further revealed that the average age of the sampled head of households was 57 years. This suggests how older people continue to engage in agriculture for their livelihood. In most parts of rural Ghana, there exist an exodus/drift of youth from the rural areas to urban centers in search of greener pastures (Ansong, 2022). Furthermore, the marital status of the sampled heads of household revealed that majority (83%) were married. In terms of education, only 16% of sampled head of household pursued one form of formal education or the other. The low rate of farmers with formal education in this study buttresses the point that agriculture is considered as an occupation for those who do not have the required formal education and training, therefore are unable to find jobs in the formal and semi-formal sectors of the economy in Ghana and Africa as whole (Oduro-Ofori et al. 2014). The study further showed that the average farm experience of the sampled heads of household was 21 years. Several studies show that farmers with relatively high experiences consider climate change adaptation strategies more serious than those with lower farm experiences (Karki et al. 2019, Jha et al. 2021). This study also shows that 38% of the sampled households got access to credit from various sources (microfinance institutions, banks, savings and loans organisations, individual money lenders, etc). It is perceived that access to funding opportunities enable farmers to employ climate change strategies effectively than those without access to such credit facilities (Nyangau et al. 2021). In terms of access to extension services, 64% of the sampled households had access to extension services. Farmers with adequate information on the consequences of climate changes are more likely to insulate themselves against avoidable losses associated with climate change. Since the study was mainly on smallholder farmers, the average farm size stood at 4 acres with an average income of GHc 34,200 per annum. The study also showed that 60% of the sampled farm households belonged to some form of farmer-based organization (FBO). Farmers who belong to farmer-based organizations are perceived to appreciate issues of climate change better than those who do not belong to any of such groupings.

**Table 2: Descriptive Statistics of Respondents**

| Variable | Mean/proportion | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Gender (male=1, female=0) | 0.62 | 0.48 | 0 | 1 |
| Ag e | 64 | 24 | 24 | 82 |
| Marital Status (married=1, unmarried=0) | 0.83 | 0.36 | 0 | 1 |
| Education Level | 0.16 | 0.42 | 0 | 1 |
| Farm Experience (yrs) | 21.3 | 14.0 | 3 | 36 |
| Household Size | 7.7 | 4.1 | 3 | 16 |
| Access to Credit (yes=1, No=0) | 0.38 | 0.51 | 0 | 1 |
| Extension Service (yes=1, No=0) | 0.64 | 0.43 | 0 | 1 |
| Farm Size (Acres) | 4.2 | 1.3 | 1.0 | 9 |
| Farm Income (Ghc) | 34,200 | 25,600 | 8,200 | 75,600 |
| Membership of FBO (yes=1, No=0) | 0.60 | 0.36 | 0 | 1 |
| Access to climate information (yes=1, No=0) | 0.86 | 0.28 | 0 | 1 |

**Farmers Adaptation Strategies to Climate Change**

The results show that there were six (6) major adaptation strategies employed by famers in the study area to deal with the adverse consequences of climate change. To reduce the negative impacts of climate and thereby maximize productivity, most farmers employed more than one adaptation strategy. The commonly used adaptation strategies were; Farm belts, mixed farming, income diversification, crop rotation, adjusting planting time, and use of improved variety.

**Table 3: Usage of Climate Change Adaptation Strategies**

| Adaptation Strategy | Frequency | Percentage | Rank |
|---|---|---|---|
| Mixed farming | 167 | 95.4 | 1st |
| Improved Variety | 159 | 90.8 | 2nd |
| Income diversification | 142 | 81.1 | 3rd |
| Adjusting planting time | 121 | 69.1 | 4th |
| Crop rotation | 119 | 68.0 | 5th |
| Farm belts | 92 | 52.6 | 6th |

**Determinants of Farmers Choice of Climate Change Adaptation Strategy**

Multivariate probit model was used to examine the factors influencing farmers' choice of climate change adaptation strategies in the study area. The use of the multivariate probit model was informed by the farmers' use of multiple adaptation strategies to reduce the impact of climate variability. The independent variables consisted of the socioeconomic and demographic characteristics of the farmers, they included; age, gender, size of household, farm experiences, level of education, membership of farmer-based organization, access to credit, and income level of the farmers. The dependent variables on the other hand consisted the climate change adaptation strategies employed by the farmers; they included the use of mixed farming, improved varieties, income diversification, farm belts, crop rotation, and adjusting planting time. The estimated results suggested that the model was significant for all the adaptation strategies employed by the farmers. This was supported by the rejection of the null hypothesis at 1% level of significance. The goodness-of-fit of the model was explained by the likelihood ratio test of significance. Thus, a rejection of the null hypothesis that all the Rhoij values were jointly equal to zero. The Wald $X^2$ test value of 175.76 was significant at 1%, which implied a biased separate estimation of the choice of adaptation strategies. The outcome indicates that the model used was suitable for the dataset. The results in Table 4 show the different levels of impact of the explanatory variables on the climate change adaptation strategies of the farmers.

**Gender of head of household**: It can be deduced from the multivariate probit results that sex (gender) of the farmer had a positive influence on the use of almost all the identified climate change adaptation strategies in the study. The positive coefficients for gender (with the exception of the use of improved varieties) imply that male-headed farmers in the study area were more likely to employ adaptation strategies to mitigate the negative impact of climate change than their female counterparts. The multivariate probit results show that the gender of head of household had a positive and significant influence on the deployment of farm belts and mixed farming as strategies against climate change. These findings are consistent with the findings of the study conducted by Obayelu et al. (2014). Generally, male farmers do not only have broader access to information on climate change but also possess higher adaptive capacity than their female counterparts (Belaineh et al. 2013).

On the contrary, the negative coefficient for the use of improved variety suggests that the female headed respondents were more likely to employ improved varieties of crops as an adaptation strategy than their male counterparts, though not statistically significant. The findings are consistent with the results of Assaye et al. (2020) where the gender of head of farm household was negatively related with the likelihood of employing climate change adaptation strategies.

**Level of education of the head of farm household;** the role of education in addressing the negative impacts of climate variability cannot be overstressed. It is expected that enlightened (educated) farmers are more likely to employ climate change adaptation strategies than the uninformed (illiterate) farmers. Consistent with the hypothesis of this study, the results revealed that adequately informed (educated) farmers embraced the use of improved crop and animal varieties than the uninformed (illiterate) farmers. The results also show that income diversification (non-farm income sources) and the use of improved varieties were common practices among the educated farmers than their illiterate counterparts. The deployment of improved varieties and income diversification (non-farm ventures) as strategies against the negative impacts of climate were statistically significant at 1% and 5% respectively. The results further show that farm households headed by illiterates were more likely to employ mixed farming practices as adaption strategy against the negative impacts of climate change. This outcome is consistent with Nyangau et al. (2021). Broadly, educated farmers are willing and capable of accepting new practices that maximise yield and minimize cost. On the contrary, some illiterate famers remain conservative and unwilling to accept new practices (Karki, 2019).

**Farm Size;** the results of the multivariate probit reveal that farm sizes have positive influences on mixed farming, income diversification, crop rotation, adjusting planting time, and improved varieties. The results further show that income diversification and the use of improved varieties were statistically significant at 1% and 5% respectively as adaptation strategies against climate variability. All things being equal, holders of large tracks of farm lands try to maximize returns of economic of scale by employing climate change adaptation strategies than their counterparts with smaller farm holdings. Larger farm sizes allow higher returns, thereby improving the ability of farmers to engage in other economic ventures in order to diversify their risk (income diversification). This outcome is consistent with similar studies on climate change (Pilo et al. 2021, Deressa, 2007, Fosu-Mensah, 2012).

**Size of farm household;** with the exception of income diversification, the results of the study show a positive relationship between the household size and the adaptation strategies employed by the farmers. Broadly, lager farm households are characterized by larger workforce thereby increasing the likelihood of employing such climate change adaptation strategies as mixed farming, crop rotation, use of improved varieties, among others. These findings are consistent with similar studies on climate change (eg, Daberkow and McBride 2003, Maddison, 2007, Nuhu and Matsui, 2019).
On the other hand, the negative correlation between the size of farm household and income diversification may be attributable to poor savings and investments associated with larger households in rural Ghana (GSS, 2010).

**Table 4: Multivariate Probit Results on Climate Change Adaptation Strategies**

| **Explanatory Variables** | **Farm belts** | **Mixed Farming** | **Income Diversication** | **Crop Rotation** | **Adjusting Planting Time** | **Improved Variety** |
|---|---|---|---|---|---|---|
| | **Coef. (S.E)** | **Coef.(S.E)** | **Coef.(S.E)** | **Coef.(S.E)** | **Coef.(S.E)** | **Coef.(S.E)** |
| Sex | 2.11***(0.438) | 2.313***(0.602) | 0.194 (0.479) | 0.211 (0.506) | 0.127 (0.404) | -0.358 (0.427) |
| Education | 0.338 (0.236) | -0.071 (0.311) | 0.788** (0.265) | 0.016 (0.283) | 0.133 (0.235) | 1.29*** (0.242) |
| Farm Size | -0.013 (0.022) | 0.048 (0.036) | 0.082*** (0.030) | 0.006 (0.029) | 0.013 (0.022) | 0.062** (0.024) |
| Household size | 0.096** (0.039) | 0.138** (0.055) | -0.028 (0.044) | 0.020 (0.448) | 0.033 (0.038) | 0.027 (0.036) |
| FBO membership | 0.090 (0.233) | 0.287 (0.319) | 0.136 (0.262) | 0.224 (0.308) | 0.30*(0.238) | 0.041 (0.223) |
| Farm Experience | 0.004 (0.027) | 0.005 (0.037) | 0.016** (0.033) | 0.015 (0.032) | 0.026 (0.204) | 0.036** (0.028) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Access to climate information | -0.102 (0.235) | 0.261** (0.322) | -0.038 (0.286) | -0.187 (0.306) | 0.801*** (0.237) | 0.772*** (0.241) |
| Access to credit | -0.254 (0.239) | 0.447 (0.346) | 0.036 (0.273) | 0.586* (0.347) | 0.437* (0.238) | 0.282 (0.245) |
| Farm income | 2.580 (0.000) | 7.790 (0.000) | 2.030** (0.000) | -0.000 (0.000) | -0.000 (0.000) | 3.950* (9.556) |
| Constant | 0.178 (0.724) | 0.468 (1.106) | -0.124 (0.928) | -1.753* (0.886) | 0.416 (0.726) | 0.060 (0.717) |
| Number of observation | | 175 | | | | |
| Wald $X^2$ (df) | | 175.76 | | | | |
| Log likelihood | | -416.681*** | | | | |
| Likelihood ratio test of $H_0$; Rhoij=0 | | $X^2(15)$ = 67.262*** | | | | |
| | | | | | | |
| | | | | | | |

**Membership of Farmer Based Organisation:**
Though not statistically significant, the multivariate results show that farmers membership of farmer-based organization has positive impact on the likelihood of employing all the climate change adaptation strategies to ameliorate the negative consequences of climate variability. The results of this study depict that agricultural extension services are often extended to organized groups such as those belonging to farmer-based organizations. Farmers who belong to farmer-based organisations have better chances of receiving sharing relevant information on climate change among themselves than their counterparts who do not belong to any farmer-based organisation. The positive impacts of membership of farmer-based organization on the deployment of climate change adaptation strategies in this study are consistent with previous study on the subject (Mwinkom et al. 2021).

**Farm Experiences;** In agreement with the hypothesis of this study, the relevant experiences of farmers have positive impact on the deployment of all the climate change adaptation strategies. The results show that the relevant experience of the farmers had positive all the climate change adaptation strategies. The results further show that income diversification and the use of improved varieties were statistically significant at 5% level of significance. Farmers levels of experiences are positively correlated with their acceptance of new agricultural remedies, including new approaches to combatting the negative effects of climate variability. The finding in this study is consistent with Amare et al. (2018).

**Access to climate information;** As hypothsised in this study, easy accessibility of the farmer to climate information increases the likelihood of deploying adaptation strategies to reduce the adverse effects of climate change. The multivariate probit results revealed that the respondents' access to climate information had positive and significant impact on income diversification, adjusting plan size, and improved crop varieties. Farmers ability to timely obtain the relevant pieces of information on climate change improve their readiness to roll out the appropriate mitigation measures (Scheffran et al. 2012, Rademacher-Schulz, 2014). Agricultural extension services play a critical role of providing the right education campaign to the farmers towards remedying the negative effects of climate variability (Kumasi et al. 2019).

**Access to credit;** The study shows that access to credit opportunities was positively correlated with all the climate change adaptation strategies with the exception of the use of farm belts. Crop rotation and adjusting planting time were statistically significant at 10% percent. Access to credit facilities improves the financial and technical abilities of the farmers to employ the climate change adaptation strategies to address the negative impacts of climate variability. The positive correlation between access to credit and the deployment of the climate change adaptation strategies in this study is consistent with previous studies (Deressa, 2007, Fosu-Mensah et al. 2012, Nyangau et al. 2021).

**Level of farm income;** Farm income was hypothesised to impact positively on the adaptation strategies to climate change. Income level of farmers remain a critical factor in propelling farm practices that improve productivity. Thus, wealthier farmers are more likely to deploy climate change adaptation strategies than poor farmers. The multivariate probit results show that the income levels of the head of farm household was positively related with the deployment of farm belts, improved varieties, income diversification and mixed farming as climate change adaptation strategies. For instance, farm households with higher incomes were 2.580, 7.790, 2.030 and 3.950 times more likely to employ farm belts, mixed farming, income diversification and improved varieties respectively as climate change adaptation strategies than their counterparts with lower levels of income. These outcomes are consistent with previous studies (Nhemachena and Hassan, 2007, Kramer et al. 2013, Sun, 2015, Atube et al. 2021).

## Conclusion

We set out to investigate the factors influencing smallholder farmers' choice of adaptation strategies to reduce the negative impact of climate variability in the Gushegu Municipality of the northern region of Ghana. With a sample size of 175 farm households, the study revealed that the dominant climate change adaptation strategies in the study area in order of popularity were; mixed farming, use of improved varieties of crops and animal breeds, income diversification, adjusting planting time, crop rotation, and use of farm belts. Since farmers in the study district adopt a mix of adaptation strategies to reduce the negative impact of climate change, the choice of a set of bundle of adaptation strategies becomes a multivariate decision. This study therefore adopted the multivariate probit econometric technique to establish the relationships between climate change adaptation strategies (dependent variables) and the factors influencing the choice of the adaptation strategies (independent variables).

## Recommendations

On the strength of the findings of this study, we recommend to stakeholders, comprising, government, Ministry of Food and Agriculture (MoFA), Municipal and District Assemblies, agricultural oriented non-governmental organisations, and others, to intensify efforts at supporting the farmers to reduce the negative impacts of climate change. Financial and technical support for the farmers are critical in addressing the menace of climate variability. Improving the adaptive capacity of farmers in dealing with the problem of climate change has to be promoted to achieve food security in the study area and the country at large. Sensitization campaigns against climate change are essential to equip farmers with the requisite know-how to minimize agricultural losses associated with climate change. In the face of limited numbers of agricultural extension assistants, agricultural extension services should be intensified to cover many more farmers in different parts of the districts, region and country as a whole. Government should as a matter of priority support colleges of agriculture to train many more agricultural extension assistants to fill the existing gaps.

**REFERENCES**

1. Akudugu M.A., Alhassan S. and Adam H. (2018).Factors to consider in promoting high adoption of climate change adaptation strategies: Evidence from northern Ghana.
2. Alhassan, I. S., Shaibu, M. T., Kuwornu, J. K. M., & Osei-Asare, Y. B. (2017). Determinants of Smallholder Women Farmers' Adaptive Capacity to Climate Change and Climate Variability in Northern Region, Ghana.
3. Assaye A, Ketema M, Bekele A (2020). Smallholder Farmers' Adaptation Strategies to Climate Change: The Case of Ankesha Guagusa District of Awi Zone, Northwestern Ethiopia. Journal of Agricultural Economics and Rural Development, 6(2): 821-833.
4. Alhassan, I. S., Shaibu, M. T., Kuwornu, J. K. M., & Osei-Asare, Y. B. (2017). Determinants of Smallholder Women Farmers' Adaptive Capacity to Climate Change and Climate Variability in Northern Region, Ghana. In D. Nukpezah, A. Mensah, B. Ofori, B. Rapp, & J. M. Gomez (Ed.), *Dialogue on Sustainability and Environmental Management: International Conference*, February 15 - 16, 2017, University of Ghana, Legon, Accra, Ghana. Oldenburger Schrifted zur Wirtschaftsinformatik, Band22, pp. 190 - 199. Oldenburg, Germany: Deutsche National bibliothek. https://www.shaker.de/de/content/catalogue/index.asp?lang= de&ID=8&ISBN=978-3-8440-5461-3
5. Alhassan, S. I.; Kuwornu, J. K.M.; & Osei-Asare, Y. B.: (2018) "Gender dimension of vulnerability to climate change and variability: Empirical evidence of smallholder farming households in Ghana", *International Journal of Climate Change Strategies and Management*, https://doi.org/10.1108/IJCCSM-10-2016-0156
6. Alhassan, S. I.; Osei-Asare, Y. B.; Kuwornu, J.K.M. (2019): Assessing the vulnerability of smallholder women rice farmers to climate variability in the Northern Region of Ghana: The livelihood vulnerability index approach. In J.K.M., Kuwornu (Ed): *Climate Change and Sub-Saharan Africa: The Vulnerability and Adaptation of Food Supply Chain Actor.s* Publisher: Vernon Press, Series on Climate Change and Society, 29–64. https://vernonpress.com/books?sid=78
7. Amare Z.Y., Ayoade J.O., Adelekan I.O., Zeleke M.T. (2018). Barriers to and determinants of the choice of crop management strategies to combat climate change in Dejen District, Nile Basin of Ethiopia. Agricultural Food Security. 2018;7(1):37. https ://doi.org/10.1186/s4006 6-018-0188-y.
8. Ansong G. (2022). The challenges of curbing North-South migration of teenage girls in Ghana. American Journal of Industrial and Business Management, 12, 231-276
9. Antwi-Agyei, P.; Quinn, C.H.; Adiku, S.G.K.; Codjoe, S.N.A.; Dougill, A.J.; Lamboll, R.; Dovie, D.B.K. (2017). Perceived stressors of climate vulnerability across scales in the Savannah zone of Ghana: A participatory approach. *Reg. Environ. Chang.* *17*, 213–227.

10. Antwi-Agyei, P.; Dougill, A.G.; Stringer, L.C. (2015). Barriers to climate change adaptation: Evidence from northeast Ghana in the context of a systematic literature review. *Clim. Dev.* 2015, *7*, 297–309.
11. Antwi-Agyei, P.; Fraser, E.D.; Dougill, A.J.; Stringer, L.C.; Simelton, E (2012). Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Appl. Geogr*. *32*, 324–334.
12. Atube F., Malinga G.M,. Nyeko M., Okullo D.M., Alarakol S.P., and Okello-Uma I. (2021).Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda.
13. Belaineh L. Yared A., and Woldeamlak B. (2013). Smallholder farmers' perceptions and adaptation to climate variability and climate change in *Doba district*, West Hararghe, Ethiopia**.** *Asian Journal of Empirical Research*, 3(3): 251-265.
14. Britwum A. O and Akorsu A. D.(2016). Qualitative Gender Evaluation of Agricultural Intensification Practices in Northern Ghana.
15. Climate Change Agriculture and Food Security (CCAFS)(2021). Gender Profile for Climate Change, Agriculture and Food Security, West African Programme, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Livestock Research Institute (ILRI).
16. Daberkow S.G., McBride W.D (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. Precis Agric. 2003;4(2):163–77. https ://doi.org/10.1023/A:10245 57205 871.
17. Deressa, T.T.; Hassan, R.M.; Ringler, C.; Alemu, T.; Yesuf, M (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Glob. Environ. Chang.* 2009, *19*, 248–255.
18. Deressa TT (2007). Measuring the economic impact of climate change on Ethiopian agriculture: Ricardian approach. The World Bank; 2007.
19. Fagariba C.J., Song S., Soule Baoro S.K.G. (2018). Climate change adaptation strategies and constraints in northern Ghana: Evidence of farmers' in Sisala West District.
20. Food and Agricultural Organisation (2011). FAO adapt Framework programme on climate change adaptation. Electronic publishing policy and support branch. Viale delle Terone di Caracalla, 00153, Rome, Italy.
21. Food and Agricultural Organisation (2015). The economic lives of smallholder farmers'. Food and Agriculture Organisation of the United Nations, Rome, Italy.
22. Fosu-Mensah BY, Vlek PL, MacCarthy DS (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environ Dev Sustain. 2012;14(4):495–505.
23. Francix X.K. Mwinkom, Lawrence Damnyag, Suhiyini I.A. Alhassan (2021). Factors influencing climate change adaptation strategies in North Western Ghana: Evidence of farmers in the North Volta Basin in Upper West Region
24. Ghana Statistical Service (*2010). Population and Housing Census*; Ghana Statistical Service: Accra, Ghana, 2014.
25. Ghana Statistical Service, GSS (2014). Ghana Living Standard Survey Round 6 (GLSS-6), Poverty profile in Ghana (2005-2013), Accra, Ghana.
26. Ghana Statistical Service, GSS (2020). District Analytical Report for Gushegu Municipality; Ghana Statistical Service, Accra, Ghana.

27. IPCC, (2001). Climate Change 2001. *Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. WMO for Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.
28. IPCC (2007). Climate change impacts, adaptations and vulnerability, construction of working group II to the fourth assessment report of the Inter-government Panel on Climate Change, Cambridge, Cambridge University Press.
29. IPCC (2014). IPCC fifth Assessment Synthesis Report. Approved Summary for Policy makers.
30. IPCC (2018). IPCC special report on the impacts of global warming of 1.5oc. Summary for policy makers, IPCC, Incheon, retrieved from http://www.ipcc.cn/report/sr
31. ISDR/UNEP (2009). The defining challenge of our age; United Nations Climate Change Conference. United Nations Environment Programme. Copenhagen,
32. Jha C.K., and Gupta V. (2021). Farmers perception and factors determining the adaptation decision to cope with climate change: An evidence from rural India.
33. Kamkam-Yeboah K., Adjei K.A., Ren L., Appiah-Adjei E.K, & Agyapong A. A (2011). Validation of TRMM data in the Black Volta Basin of Ghana. Journal of Hydrolic Engineer, 17(5), 647-654.
34. Karki S., Burton P., and Markey B. (2019). The experiences and perceptions of farmers about the impact of climate change and variability on crop production: A review, …………………….
35. Krämer I, Borenäs K, Daschkeit A, Filies C, Haller I, Janßen H, Karstens S, Kule L, Lapinskis J, Varjopuro R (2013). Climate change impacts on infrastructure in the baltic sea region. Sectoral impact assessments for the baltic sea region–climate change impacts on biodiversity, fisheries, coastal infrastructure and tourism. Coast Reports;21:55–90.
36. Kumasi, T.C.; Antwi-Agyei, P.; Obiri-Danso, K. (2019). Small-holder farmers' climate change adaptation practices in the Upper East Region of Ghana. *Environ. Dev. Sustain.* 2019, *21*, 745–762.
37. Kusakari, Y.; Asubonteng, K.O.; Jasaw, G.S.; Dayour, F.; Dzivenu, T.; Lolig, V.; Donkoh, S.A.; Obeng, F.K.; Gandaa, B.; Kranjac-Berisavljevic, G. (2014). Farmer-perceived effects of climate change on livelihoods in Wa West District, Upper West region of Ghana. *J. Disaster Res.* 2014, *9*, 516–528
38. Lambrecht I. and Karof T. (2020). Land ownership and the gender gap in agricultural decision making in northern Ghana.
39. Laux P.Kunstmann H. Bardossy A. (2008). Predicting the regional onset of the rainy season in West Africa. International Journal of Climatol 28: 329-342.
40. Mabe F.N., Sienso G. Donkor S. (2014). Determinants of choice of climate change adaptation strategies in Niorthern Ghana. Journal of Applied Economics
41. Maddison D (2007). The perception of and adaptation to climate change in Africa. The World Bank; 2007 Nov 8.
42. Minale Kifle Yemeru. 2012. Smallholder farmers' choice of climate change adaptation mechanisms: The case of Kersa Woreda, East Hararge Zone, Oromia National Regional State, Ethiopia. An MSc Thesis Submitted to the Graduate Studies of Harmaya University, Haramaya, Ethiopia.
43. Ministry of Food and Agriculture (MOFA)(2015). Agriculture in Ghana; Facts and Figures, Accra. http://agrihome.com/wp.content/uploads/2017/07AGRICULTURE-In-GHANA-FACTS-and-Figures-2015pdf

44. Mwinkom F.K., Damnyag L. Abugre S. and Alhassan S. (2021). Factors Influencing Climate Change Adaptation Strategies in North-Western Ghana: Evidence of Farmers in the Black Volta Basin in Upper West Region.
45. Nyangau J., Mohammed J.H., Mango N., Makate C., and Wangeci A.N. (2021). Smallholder farmers perception of climate change and adaptation of climate smart agricultural practices in Masaba South Sub-country, Kisii Kenya.
46. Nhemachena C, Hassan R. (2007). Micro-level analysis of farmers adaption to climate change in Southern Africa. Intertional Food Policy Research Institute.
47. Nuhu, M.G.; Matsui, K. (2019). Climate change and farmers' coping strategies in the Upper East Region of Ghana. *Int. J. Clim. Chang. Impacts Responses* 2019, *11*, 11.
48. Obayelu O.A, Adepoju A.O and Idowu T. (2014). *Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria.* s.l.:Journal of Agriculture and Environment for International Development - JAEID 2014, 108 (1): 3-16.
49. Oduro-Ofori E. Aboagye A. P. and Acqyaye-Naa A. (2014). Effects of Education on the Agricultural Productivity of Farmers in the Offinso Municipality
50. Pilo M., Gerber N., and Wunscher T. (2021) Impacts of adaptation to climate change on farmers income in Savanna region of Togo.
51. Rademacher-Schulz, C.; Schraven, B.; Mahama, E.S.(2014). Time matters: Shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity. *Clim. Dev.* 2014, *6*, 46–52.
52. Republic of Ghana (2015). Ghana's Third National Communication Report to the United Nations Framework Convention on Climate Change. Available online: http://unfcc.int/resource/docs/natc/ghanc3.pdf (access on 22 August 2022).
53. Riede, J.O.; Posada, R.; Fink, A.H.; Kaspar, F (2016). What's on the 5th IPCC Report for West Africa? In *Adaptation to Climate Change and Variability in Rural West Africa*; Springer: Cham, Switzerland, 2016; pp. 7–23.
54. Scheffran, J.; Marmer, E.; Sow, P.(2012). Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in Northwest Africa. *Appl. Geogr.* 2012, *33*, 119–127.
55. Tahiru A. (2019). Smallholder farmers' susceptibility to climate change variability: Assessing adaptation strategies and impact on livelihoods. Environmental Management and Sustainable Development, 8(1), 2164-7682.
56. Tahiru A (2019). Climate change adaptation intervention by Non-governmental Organisations in Savelugu Municipality and West Mamprusi District in Northern Ghana: Implication for livelihoods of smallholder farmers', PhD thesis, University of Ghana.
*57.* UNFCCC. (2001). *United Nations Framework Conversion on Climate Change: Text, Geneva, World Meteorological Organisation and United Nations Environment Program.*
58. Yaro, J. A. (2013). The perception of and adaptation to climate variability/change in Ghana by small-scale and commercial farmers. *Regional Environmental Change, 13*(6), 1259-1272. Retrieved November, 2022
59. Yiran G.A., Stringer L.C. (2016). Spatio-temporal analysis of impacts of multiple climate hazards in a Savannah Ecosystem of Ghana. Climate Risk Management 14: 11-26.

60. Zivznomoyo J. and Mukarati J. (2013). Determinants of choice of crop variety as climate change adaptation option in arid region of Zimbazwe. Russian Journal of Agricultural and Socio-Economic Sciences, 3(15): 54-62.