Determinants of Smallholder Women Farmers' Adaptive Capacity to Climate Change and Climate Variability in Northern Region, Ghana

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Abstract

Agriculture remains the mainstay of people in Northern Ghana, employing 70 % of the labour force especially females. Agriculture in Northern Ghana is dominated by women who mostly cultivate on small scale and their farming activities are rain-fed. In general, the adaptive capacities of female farmers to climate change and variability are low due to under-resourcing of females' agricultural activities. This study explored the factors influencing the adaptive capacity of smallholder women farmers to climate change and variability in the Northern region of Ghana. Questionnaire was administered to 210 randomly selected smallholder female farmers. The adaptive capacity index for farmers were computed and the generalised least square regression model was employed to determine factors influencing farmers' adaptive capacities to climate change and variability. The empirical results revealed that membership of a farmer-based group, formal extension services, off-farm income, access to tractor, land ownership and participation in decision making significantly influence the adaptive capacities of female farmers to climate change and variability positively while farmers' age and hired labour have negative influence on the adaptive capacities of smallholder female farmers . Therefore, the study recommends that smallholder women farmers should form farmer-based associations to share farming experiences; agricultural extension official should intensify contacts with farmers to educate them on modern agronomic practices; and women farmers be given priority in terms of income generation projects of government and Non-Governmental Organisations in the region to increase their resilience to climate change and variability.

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1. Introduction

Climate change and variability is undoubtedly a major global issue that entices the attention of most stakeholders. Historical data shows that the African continent has experienced an average warming of 0.7 $^{\circ}$C in the 20th century [15]. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) also revealed that warming in Africa is likely to be higher than the global annual mean warming throughout the continent and in all seasons, with drier sub-tropical regions warming more than the moister tropics [8]. The Environmental Protection Agency (EPA) reported an increase in temperature by 1°C across Ghana with 1960 as a baseline [2]. Nonetheless, the effect is expected to differ based on agro-ecological regions as well as socio-economic clusters such as gender differentials. Regions which rely heavily on rain-fed and subsistence agriculture are noted for their high climate-sensitivity in relation to systems of agricultural production and are thus, more vulnerable to climate variability especially when their adaptive capacities are low.

In Africa, investment in capacity building has being and needs to be augmented to improve the adaptive capacity of organisations, institutions and individuals [9]. The Intergovernmental Panel on Climate Change [19] observed that the occurrence of multiple stresses and low adaptive capacity makes Africa one of the most vulnerable continents to climate change and variability. Across the tropical region of which Ghana is located, agricultural productivity of smallholder farmers is hindered by climatic stressors. Climate change and variability is predicted to unduly affect smallholder farmers, making their livelihood more precarious. In Ghana, Northern region is relatively vulnerable to climate variability compared to the rest of the country mainly because of the high rate of illiteracy and relatively underdeveloped infrastructure [28]. In terms of adaptive capacity to climate variability, women farmers in Northern region are known to possess the least capacity [26].

Generally, the agricultural activities of female farmers lack the needed resources vis-à-vis their male compatriots. This difference affects efficient capacity of female farmers to adequately adapt to the adverse effects of climatic stressors [14]. In Northern region, relative to male farmers, female farmers have less tenures over and access to land including other supporting production resources [11].

Farmers in the region especially women have limited capabilities to adapt and information on the extent of their total vulnerability and adaptive capacity is virtually non-existent in the literature [18]. The findings of [5], [21] and [12] showed that women with low adaptive capacity are more hit with the impact of climate change and variability. The need to investigate the determinants of women adaptive capacity to climate change and variability for informed policy formulation is therefore necessary to improve upon the livelihood of women farmers who are the majority of the labour force employed in the agricultural sector in the Northern region. Therefore, this study sought to investigate the determinants of smallholder women farmers' capacity to adapt to the numerous effects of climate change and variability in the Northern region of Ghana.

2. Study Area and Methods

2.1. Determinants of adaptive capacity

Adaptive capacity of farmers and vulnerability to climate change and variability are conversely. Thus, given the same level of exposure and sensitivity to climate change and variability, farmers with low adaptive capacities are more vulnerable to climate change and variability than farmers with high adaptive capacities. A system's adaptive capacity to climate change and variability is a ratio scale and varies based on resource endowment, time and location [5]. Adaptive capacity is the ability of a system to adjust to climatic stressors and reduce the likely damages, by adopting available opportunities [5].

The determinants of adaptive capacity have been classified into hazard specific and generic factors, and into endogenous and exogenous factors [7]. Generic determinants of adaptive capacity in social systems comprise non-climatic factors suchas economic resources, technology, information and skills, infrastructure, institutions, and equity [29]. Endogenous factors refer to the physiognomies and behavior of a given population group whereas exogenous factors include the wider economic and geopolitical context.

There exist considerable factors influencing the adaptability of households which cut across socio economic, technological and institutional. Socio – economic factors such as age, gender, educational level of the adaptor and household characteristics such as household size, income and land size accessible by the household are key significant determinants of farmers'' adaptive capacity [27]. Also, technology availability, farmers' awareness of the existence of technology, access to financial service and farmers' association with social networks or groups are factors enhancing farmers' ability to adapt to climate change and variability [5]. Lack of collateral security to borrow, absence of good yielding seed, land tenure insecurity and inaccessibility of market are some constraints to effective adaptation among farmers [26]. It has been reported that large farm size had a significant positive influence on the adoption of tree planting, new seed varieties and soil and water conservation strategies [1]. Land size is a proxy for measuring wealth and is a vital determinant of farmers' capacity to adapt to climatic stressors [10].

In examining determinants of adaptive capacity of farmers in Northern Ghana, [5] first computed farmers' adaptive capacities based on [24] adaptive capacity model premised on the risk management approach and classified farmers into low, moderate and high adaptive capacities. The ordered logistic regression was then employed to determine factors influencing farmers' adaptive capacity using the categorised computed adaptive capacity as the dependent variable with socio-economic, infrastructural, technological and institutional factors as independent variables. This study could not employ the ordered logistic regression model in determining the factors influencing adaptive capacity of farmers because the computed adaptive capacity is a ratio rather than nominal scale variable.

2.2. Study area

The study area was Northern region, specifically Central Gonja and Tolon districts. Tolon district lies between latitude 9°15' and 10°02' N and longitude 0°53' and 1°25' W. The district has a population of 72, 990, representing 2.9 % of the region's population and 50.2% are females with 76.7% of the female population are illiterates [16]. About 88.4% of the district population is rural and agriculture employs 92.4% of the economically active population. The mean annual rainfall ranges between 950mm – 1200mm and mean annual temperature is between 33°C – 39°C [16]. On the other hand, Central Gonja district is located at the south western part of Northern region and lies within longitude 1°05' and 2°58'W and latitude 8°22' and 10°02' N with a land size of 7,555 km2[16]. The population of the district stands at 87,877, representing 3.5% of the region's population and constitutes 50.1 % females out of which 75.3% are illiterates [16]. About 80% of the district population is rural and 68.4% of females 15years and above are engaged in agriculture, forestry and fishing [16]. The district has tributaries of the White and Black Voltas. The mean annual temperature is between 17°C – 35°C while the mean annual rainfall is between 1000mm – 1500mm [16]. The main vegetation of both districts is grassland, with guinea savannah woodlands, characterised by drought resistant trees such as acacia, shea, baobab, dawadawa, mango and neem. Majority of the districts inhabitants are peasant and subsistent farmers who cultivate on small-scale basis.

2.3. Sources of data and sampling procedure

Central Gonja and Tolon districts were purposively selected for this study for the reason that the perennial occurrence of floods due to climate change and variability is frequent in these two districts of the Northern region. Within each district, two communities were randomly selected and simple random sampling technique was used to select women farmers after listing all women farmers in the community. Yapei and Mpaha in the Central Gonja district and Tali and Kasuliyili in the Tolon district were the communities selected for the study. Based on population, 95 women farmers were sampled from Tolon district (Tali- 55 and Kasuliyili-40) and 115 women farmers from Central Gonja district (Yapei – 65 and Mpaha - 50). This study was a survey type and the required data was mainly primary. Questionnaire was used to collect data from smallholder women farmers and focus group discussions were held in all four study communities.

2.4. Model specification for determinants of adaptive capacities

In examining the determinants of farmers' adaptive capacities to climate change and variability, the Adaptive Capacity Index (ACI) was first computed for each farmer based on the IPCC [19] adaptive capacity contributors and Livelihood Vulnerability Index (LVI) [17]. Three of the seven major components of the LVI (socio-demographic profile, livelihood strategies and social network) have been used by [19] to compute the adaptive capacity of farmers. Each major component consists of several sub-components which are measured on different scales and were standardized using equation (1).

$$Index_{fi} = \frac{S_{fi} - S_{\min}}{S_{\max} - S_{\min}} \qquad (1)$$

Where S_{fi} is the observed sub-component indicator i for farmer f, S_{Min} and S_{Max} are the minimum and maximum values respectively for sub-component i from the combined data. The sub-component indicators are now averaged using equation (2) to obtain the index of each major component:

$$M_{fi} = \frac{\sum_{i=1}^{n} Index_{fi}}{n} \qquad (2)$$

Where M_{fi} is one of the three major components [Socio-Demographic Profile (SDP), Livelihood Strategies (LS) and Social Network (SN)]. The three major adaptive capacity components are then averaged to ascertain the Adaptive Capacity Index (ACI) for each farmer using equation (3).

$$ACI_f = \frac{\sum_{i=1}^{3} w_{Mi} M_{fi}}{\sum_{i=1}^{3} w_{Mi}} \quad (3)$$

Where ACI_f is the adaptive capacity index for farmer *f* and is a ratio ($0 \leq ACI \leq 1$), M_{fi} are the major component indicators for farmer *f*, wM_i is the weight of each major component.

Given that the dependent variable (ACI) is a ratio, the Tobit, Ordinary Least Squares (OLS), Generalise Least Squares (GLS), and the Two Stage Least Squares (2SLS) are the appropriate, multiple regression models in examining the determinants of farmers' adaptive capacity to climate change and variability [16]. This study employed the GLS ahead of the other regression models on the premise that it yields a relatively better econometric estimates with the presence of heteroscedasticity and also best fit when the dependent variable (ACI) is measured on ordinal or ratio scale [4]. The general specification of the GLS is given by equation (4)

$$Y_i = \beta_0 + X_i \beta_i + \varepsilon_i \quad (4)$$

Where β is a vector of unknown coefficients to be estimated from the regression model, ε_i is the error term, Y_i and X_i are the response and explanatory variables respectively. The GLS model assumes that the conditional mean of Y given X is a linear function of X and the conditional variance of Y given X is Ω.

To ensure that the parameter estimates remains BLUE with suspected presence of heteroscedascity, it depends on whether the variance of the error term (σ^2) is known or not. This study assumes that the variance is unknown and proceeds with the assumption that the error variance is proportional to the square of one of the explanatory variables.

$v(\varepsilon_i) \alpha X_i^2, \quad v(\varepsilon_i) = E(\varepsilon_i^2) = k * X_i^2$, where k is a constant and ε_i is identical and normally distributed with $E(\varepsilon_i) = 0$. According to [3] and [16], equation (4) is transformed by dividing through by X_i

$$\frac{Y_i}{X_i} = \frac{\beta_0}{X_i} + \beta_i \left(\frac{X_i}{X_i}\right) + \frac{\varepsilon_i}{X_i} \quad (5)$$

The empirical model is given by equation (6)

$$ACI_i = \beta_0 + \beta_1 Age + \beta_2 Edu + \beta_3 Weather + \beta_4 Exp + \beta_5 FBO + \beta_6 Extention + \beta_7 farmsize + \beta_8 Decision + \beta_9 Off - farm + \beta_{10} Hlab + \beta_{11} Flab + \beta_{12} Land + \beta_{13} Tractor + \beta_{14} Location + \varepsilon_i \quad (6)$$

Where ACI_i, the dependent variable is the Adaptive Capacity Index, β_0 is the intercept (constant), β_1 to β_{14} are the parameter coefficients to be estimated and ε_i is the disturbances term which is independent, identical and normally distributed with zero (0) mean and constant variance. Table 1 presents description, measurements and a priori expectations of the variables considered in the model.

Three main assumptions underpin the GLS regression model: the conditional variance of the error term is constant (homoscedasticity); the independent variables are not strongly correlated with each other (multicollonearity); and the independent variables do not correlate with the error term (endogeneity). The Breusch Pagan Langrange test, Variance Inflation Factor and the Wu-Hausman test were used to test for homoscedasticity, multicollinearity and endogeneity respectively.Data was entered, cleaned and analysed using Stata 14. A contingent coefficient test was conducted to exclude highly correlated independent variables.

Variable	**Description**	**Measurement**	**A prior expectation**
ACI	Adaptive Capacity Index of farmer	0 ≤ ACI ≤ 1	+
Age	Age of farmer	Years	+/-
Edu	Farmer's years of Education	Years	+
Weather	Access to weather information	Dummy: 1=yes, 0= Otherwise	+
Exp	Farming experience of farmer	Years	+
FBO	Member of Farmer-based Organisation	Dummy: 1=yes, 0=Otherwise	+
Extension	Extension service contacts	Number of times p.a.	+
Farmsize	Farm size cultivated	Acres	+/-
Decision	Participation in decision making	Dummy: 1=yes, 0=Otherwise	+

Off-farm	Engagement in off-farm activities	Dummy: 1=yes, 0=Otherwise	+
Hlab	Use of hired labour	№ of mandays	+
Flab	Use of family labour	№ of mandays	+
Land	Ownership of land	Dummy: 1= yes, 0 = Otherwise	+
Tractor	Access to tractor services	Dummy: 1=yes, 0 = Otherwise	+
Location	Location of farmer	1= Central Gonja, 0 = Otherwise	+/-

Table 1: Description of variables for the GLS regression model

3. Results and discussions

Results of the VIF and the Breusch Pagan test showed that the GLS regression model was devoid of multicollinearity and heteroscedasticity respectively. The GLS regression results, presented in Table 2 revealed that access to tractors, membership of farmer-based organisation, participation in decision making, engagement in off-farm income generating activities, ownership of land and formal extension contacts have significant positive influence on women farmers' adaptive capacity to climate change and variability while age of farmer and use of hired labour have significant negative influence on the adaptive capacity of women farmers to climate change and variability. The study further revealed that education, farming experience, location of farmer, farm size and weather information do not significantly influence women farmers' adaptive capacity to climate change. This is congruent with the findings of [25] who revealed that education and farm size were insignificant predictors of female headed farming households' adaptive ability to climate change in Eastern Uganda. This study discusses only the factors which significantly determine women farmers' adaptive capacity to climate change and variability.

Age has a significant negative effect on the adaptive capacity of women farmers to climate change and variability. This implies that younger women farmers have high adaptive capacity than elder women farmers. The younger farmers are capable of adopting labour intensive strategies to adapt to climate change and variability because they are still energetic. According to [6], younger farmers in Haiti easily adapted to climate change than older farmers due to difference in physical strength.

Variable	Coefficient.	Std. Error	Z	P – Value
Constant	0.515***	0.108	47.82	0.000
Age	-0.001***	0.002	-2.91	0.004
Education	0.001	0.000	1.10	0.273
Tractor	0.007*	0.004	1.77	0.076
Experience	0.002	0.001	1.47	0.140
Farmer-based Organisation	0.022***	0.004	5.07	0.000
Location	0.002	0.001	1.48	0.139

Farm size	-0.001	0.001	-0.86	0.392
Decision	0.013***	0.004	3.91	0.000
Off-farm activities	0.001***	0.000	4.76	0.000
Hired labour	-0.001***	0.000	-4.86	0.000
Weather information	0.009	0.007	1.33	0.183
Family labour	0.004	0.006	0.58	0.562
Land ownership	0.003***	0.000	3.02	0.003
Extension service	0.030***	0.005	6.37	0.000
№ of respondents = 210	Residual df = 195		AIC = -4.0192	
Deviance = 0.2437	Scale Parameter = 0.0010		BIC = -1362.123	
Pearson = 0.2437	Log Pseudo likelihood = 537.496			

Note: * and *** denote statistically significant at 10% and 1% respectively.

Table 2: Results of GLS regression on determinants of adaptive capacity to climate change and variability

The regression results also revealed that access to tractor services has a significant positive effect on farmers' adaptive capacity. Thus, women farmers with access to tractor services have high adaptive capacity than women farmers without access to tractor services. Also, being a member of a farmer-based organisation significantly and positively influences women farmers' adaptive capacity to climate change and variability. Apart from sharing ideas among each other, women farmers get the opportunity to learn new adaptation measures from other agricultural-based NGOs. This finding confirms [12] who attributed the low adaptive capacity of farming communities in the Protected Coastal Savanna and Transitional Zones in Ghana to minimal association with farmer-based institutions where they could learn new knowledge and skills to improve upon their adaptive capacity.

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The GLS regression results showed that women farmers' adaptive capacity to climate change and variability is significantly and positively influenced by their participation in decisions at the household and community levels. Women participation in vital decisions affords them the opportunity for their adaptation challenges to be heard and addressed by relevant institutions and persons.

Off-farm activities have significant positive influence on the adaptive capacity of women farmers to climate change and variability. This suggests that women farmers who engage in off-farm income generation activities such as shea nut processing, fishing, char coal burning and food vending as supplementary sources of livelihood are more capable of adapting to the impact of climate change and variability. This contradicts [12] who found that full-time farmers without off-farm engagement were more capable of adopting modern productivity enhancing technologies in Coastal Savanna and Transitional zones in Ghana than farmers who engaged in other off-farm activities. The reason could be due to difference in locations of both study areas. Thus, the contribution of off-farm activities to livelihood could be insignificant in the coastal savanna and transitional areas where bi-modal rainfall pattern exist, therefore have very shorter periods to engage in off-farm activities. However, in the Guinea Savannah where the dry season is longer than the rainy season, female farmers have longer periods to engage in off-farm activities which makes significant contribution to their livelihood.

Meanwhile, the reliance on hired labour as source of labour for farming activities by women has a significant negative effect on their adaptive capacity as revealed by the GLS regression results. Hired labour is not a reliable source of labour as most hired labour may not be available at a time women farmers need them for their farming activities. This result is contrary to [23] who found that households that employed hired labour to assist on their farming activities recorded high yield and effectively adapted to climate change. The possible explanation for the negative influence of hired labour on farmers' adaptive capacity as found by this study could be that wages paid to hire labour is high and farmers who employ more hire labour on their farms rather incurred more cost in production, thus reducing their profit margin.

Women ownership of farmland has a significant positive effect on farmers' adaptive capacities. This implies that women farmers who own their farmlands increase their adaptive capability to climate change and variability. The empirical results are contrary to [25] who reported negative effect of land ownership on farmers' adaptive capacity in Eastern Uganda.

Extension service also had a significant positive influence on farmers' adaptive capability. Therefore, the higher the extension contacts with women farmers, the higher their capability to adapt to the effect of climate change and variability. This is not different from the finding of [12] who attributed the low adaptive capacity of farmers in the Protected Coastal Savanna and Transitional Zones of Ghana to low agricultural extension agent – farmer ratio and contacts.

4. Conclusion

The study investigated the determinants of women farmers' adaptive capacity to climate change and variability in Northern region of Ghana. The empirical findings revealed that women farmers' adaptive capacity is positively influenced when they have access to tractor services for their farming activities, allowed to participate in decisions at the household and community levels, join farmer-based organisation or associations, engage in off-farm activities, have ownership over their farm lands, and have contact with agricultural extension agents. On the other hand, age of farmer and hire labour negatively contribute to women farmers adaptive capacity.

Based on these findings, the study recommends that smallholder women farmers should form farm-based associations to share farming experiences and through the Ministry of Food and Agriculture, be linked to the appropriate markets for the sales of their products. Also, agricultural extension agents should intensify contacts with women farmers in particular to stimulate their capacity to adapt to the adverse effects of climate change and variability by educating them on modern agronomic practices and recommended periods for agricultural activities such as when to start clearing the farm, when to plough, when to sow and when to harvest. Finally, women farmers should be given priority in terms of income generation projects of government and NGOs in the region to increase their resilience to climate variability.

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