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Determinants of Choice of Indigenous Climate Related Strategies by Smallholder Farmers in Northern Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author RMA guided the research, developed the conceptual framework, and led the review of drafts of the paper. Author JKMK led the data analysis and also reviewed the paper; author PME drafted the survey instrument with supervision from authors RMA and JKMK. Author YOO assisted author RMA in preparing the proposal for funding of research on farmers strategies for adapting climate change. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

This study assessed the determinants of Choice of Indigenous Climate Related Strategies by Smallholder Farmers in Northern Ghana using primary data obtained through community focus group discussions and household survey, and subjected to the Multinomial Logit regression model. The empirical results reveal that presence of a market, informal credit from friends and relatives, location of farmer, farmer-to-farmer extension, noticing of a decrease in rainfall and noticing an increase in temperature influence the choice of indigenous climate related strategies. There is therefore the need to improve smallholder farmers' access to market, agricultural extension services and their awareness of changes in rainfall and temperature.

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1. INTRODUCTION

Three major physical impacts of climate change have been identified in Ghana, namely temperature change, change in rainfall and sea level rise [1]. Owusu *et al.,* [2] report that there has been a shift in the rainfall regime in Ghana towards a longer dry season and vanishing short dry spell. Based on climate models and depending on geographic location, it is projected that by the year 2100, mean daily temperatures will increase by 2.5º-3.2 ºC where as total annual rainfall will decrease by 9-27 percent [3]. Climate change has a direct impact on the livelihoods of smallholder farmers in northern Ghana since agriculture in the zone is mostly climate dependent.

In order to reduce the impacts of climate change, smallholder farmers have been modifying their practices. Adger *et al.,* [4] and Athula and Scarborough [5] opine that adaptation to climate change is already taking place at the household level. No study has been conducted to date to identify factors that influence the choice of indigenous climate related strategies by smallholder farmers in northern Ghana. This study seeks to fill this void and contribute knowledge to the general adaptation literature. The rest of the study is structured as follows: Section 2 provides the methodology; Section 3 provides the empirical application and results; while section 4 provides the conclusions and recommendations. This paper is a follow up to Etwire et al., [6] and Kuwornu et al., [7].

2. METHODOLOGY

2.1 Method of Analysis

In modeling the relationship between an endogenous variable with more than two outcomes and a set of exogenous variables, the multinomial logit is appropriate. Depending on whether the endogenous variable has an ordered structure or not, multinomial models can be grouped into two categories. For an unordered model, the endogenous variable is not specified in any order of importance or magnitude. The generalized and conditional logit models are two types of unordered models that can be used for modeling nominal data [8].

In order to determine the factors that influence the choice of indigenous climate related strategies by smallholder farmers in northern Ghana, this study employs the unordered multinomial choice model with logistic distribution. This is possible because the indigenous climate related strategies identified were not ordinal in nature.

The theoretical framework adopted for this study, is based on the random utility model as espoused by Greene [8]. Let y_a and y_b denote a smallholder farmer's utility of two choices, which can be represented as U^a and U^b. For example, U^a could be the utility derived from crop and livestock related strategies whiles U^b could represent the utility derived from soil related strategies. The choice by the smallholder farmer between the two indigenous strategies reveals which one provides a higher utility; the farmer's utility is however latent. Hence the observed indicator is equal to one if $U^a > U^b$ and zero if $U^a \leq U^b$. A common formulation is the linear random utility model,

$$U^a = X'\beta_a + e_a \text{, and } U^b = X'\beta_b + e_b \quad (1)$$

Following from Greene [8], the probability of smallholder farmer's choice of crop and livestock related strategies is assumed to be a function of a number of attributes; namely socioeconomic, institutional and environmental characteristics, X, as presented in equation (2); where B_j is a vector of coefficients on each of the exogenous variable X.

$$\Pr ob(Y_i = 1) = \frac{e^{B_j' X_i}}{\sum_{k=0}^{3} e^{B_k' X_j}}, \quad j = 0, 1, \ldots, 3 \quad (2)$$

Equation (2) is normalized to remove indeterminacy by assuming that $B_0 = 0$ and the probability is estimated as;

$$\text{Prob}(Y_i = 1 \mid x_i) = \frac{e^{\beta_j' X_i}}{1 + \sum_{k=1}^{3} e^{\beta_k' X_j}}, \; j = 0, 1, 2 \ldots J, \; B_0 = 0 \quad (3)$$

Maximum likelihood estimation of equation (3) yields the log-odd ratios presented in equation (4);

$$In\left(\frac{P_{ij}}{P_{ik}}\right) = x_i'\left(B_j - B_k\right) = x_i' B_j, \quad \text{if } k = 0 \quad (4)$$

The choice of crop and livestock related strategies are therefore the log-odds in relation to the soil related strategies which serves as the base alternative. According to Greene [8], the coefficients of the multinomial logit are difficult to interpret and associating B_j with the j^{th} outcome is tempting and misleading. The marginal effects are usually derived to explain the effects of the independent variables on the dependent variable in terms of probabilities as presented in equation (5).

$$\frac{\partial P_j}{\partial x_i} = P_j\left[B_j - \sum_{k=0}^{J} P_k B_j\right] = P_j\left(B_j - \overline{B}\right) \quad (5)$$

The marginal effects measure the expected change in the likelihood of choice of a particular climate related strategy with respect to a unit change in an exogenous variable [8].

2.1.1 Variables considered for the model

The exogenous variables that were considered to have an effect on the choice of an indigenous adaptation strategy by a smallholder farmer in northern Ghana are discussed below under three main headings namely agro ecology, institutional and environmental factors.

2.1.2 Location

Morris *et al.,* [9] and Mensah-Bonsu et al*.,* [10] both reported a positive relationship between a farmer's location and technology adoption. Diffusion of any technology or practice over space and time usually start from a particular point and time. The location of a farmer may therefore be important in determining the type of indigenous climate related strategies available to them. This paper captures farmer location in terms of agro ecology.

2.1.3 Institutional Factors

2.1.3.1 Existence of market in the community

According to Nhemachena and Hassan [11], farmers with access to markets have higher chances of adapting to changing climatic conditions. Smallholder farmers who are far away from markets tends to adopt multiple cropping and mixing of livestock and crops, over specialized crop cultivation as adaptation strategies to climate change and variability [12].

2.1.3.2 Access to credit

Access to credit has been reported to have a positive effect on the probability of an individual adopting an adaptation strategy [12,13]. According to Nhemachena and Hassan [11], "farmers with access to credit have higher chances of adapting to changing climatic conditions. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options they might want to take. For instance, with financial resources and access to markets farmers are able to buy new crop varieties, new irrigation technologies, and other important inputs they may need to change their practices to suit the forecasted and prevailing climatic conditions". This paper considers access to credit from family and friends and not formal sources.

2.1.3.3 Agricultural extension visits

Several authors have noted that, access to agricultural extension services have a positive influence on the adoption of an adaptation strategy [12,13,14,15]. According to Nhemachena and Hassan [11], "access to extension services increases the probability of taking up adaptation options. Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have extension contacts have better chances to be aware of changing climatic conditions and also of the various management practices that they can use to adapt to changes in climatic conditions". This paper considers only farmer to farmer extension which has also been reported to have a positive influence on the adoption of climate related strategies by farmers [14].

2.1.4 Environmental factors

2.1.4.1 Temperature

The effect of temperature on adoption of climate related strategies is mixed. Whiles some authors have reported temperature to have a positive effect on adoption of climate related strategies [11,13,14], Mandleni and Anim [15] report a negative relationship between temperature and adoption of adaptation measures. This paper considers unpredictable temperature and increased temperature as two separate exogenous variables.

2.1.4.2 Rainfall

The influence of rainfall on the decision of smallholder farmers to adopt climate related strategies is not unambiguous. Nhemachena and Hassan [10] observes that, increases in rainfall increases the likelihood of smallholder farmers changing their management practices to take advantage of the increased rainfall and decreasing rainfall increases the probability of smallholder farmers to efficiently utilise water resources for food production. Similarly, Gbetibouo [13] also reports that a decrease in rainfall is likely to increase the probability of smallholder farmers adopting delay in planting as an adaptation option to climate change and variability. On the contrary, Deressa *et al.,* [14] reports that rainfall negatively influences the adoption of livestock sale and eating less, as an adaptation strategy to climate change and variability. Noticing of a decrease in rainfall by smallholder farmers is considered for this study.

A brief description of how the exogenous variables for the models are measured in this study is presented in Table 1.

Table 1. Exogenous variable description

Factor	Exogenous variable	Measurement
Institutional	Market	Dummy: 1=yes, 0=otherwise
	Borrowed from friends	Dummy: 1=yes, 0=otherwise
	Farmer-to-farmer extension service	Dummy: 1=yes, 0=otherwise
	Received formal extension service	Dummy: 1=yes, 0=otherwise
Environmental	Noticed unpredictable temperature	Dummy: 1=yes, 0=otherwise
	Noticed increased temperature	Dummy: 1=yes, 0=otherwise
	Noticed decreased rainfall	Dummy: 1=yes, 0=otherwise
	Notice climate change or variability	Dummy: 1=yes, 0=otherwise
	Location or Region	Dummy 1 = Guinea Savannah or Northern Region 0 = otherwise

2.1.5 Endogenous variable

The endogenous variable considered for this study are traditional climate related adaptation practices identified during community focus group discussion and broadly classified into four strategies namely, crop and livestock related strategies (CLAS); soil related strategies (SAS); cultural practice related strategies (CUPAS); and any other indigenous strategies (OAS). A crop and livestock related strategy is any combination of practices that seeks to stabilize food and livestock production and to a large extent income; for example, crop diversification and livestock diversification. Soil related strategy is any combination of practices that tend to enhance soil health directly and to a large extent yield, for example, mulching and organic matter enhancement. Cultural practice related strategy is any combination of practices that seek to improve upon farm management, for example, weed management. Any other indigenous strategy is any combination of practices that do not fall into any of the categories above, for example, timing the onset of the rainy season.

The soil related strategies is used as the base category. The parameters for the models are estimated using the maximum likelihood method. The likelihood ratio (LR) statistic is used to test the overall significance of the model [16]. The model was also tested for two major econometric problems associated with multinomial logits namely dependence on irrelevant

alternatives and multicollinearity. According to Greene [8], the assumption of Independence from Irrelevant Alternatives (IIA) follows from the assumption that disturbances are independent and homoscedastic. The IIA assumption suggests that the probability ratio of smallholder farmers choosing between four indigenous climate related strategies for example, does not depend on the availability of other alternatives. The Hausman test can be used to determine if the IIA assumption has been violated or not. The statistic has a limiting chi-squared distribution with K degrees of freedom and tests the null hypothesis that the odds are independent of irrelevant alternatives [8]. STATA SE 11 software was used for the estimation. During analysis of the results, the STATA software was enabled to detect variables that were correlated. Such variables were dropped and a new model was re-run in order to avoid the problems associated with multicollinearity.

2. 2 Sampling Procedure and Data

The data is based on a sample survey of farm households in Northern Ghana, collected in November 2011. A multi-stage sampling technique was employed to sample farmers. All the three northern regions of Ghana were purposively sampled since it represents the savannah zone of the country with Northern Region representing Guinea savannah and Upper East and Upper West Regions representing Sudan savannah.

Based on population, land size and ecology, four districts in Northern Region and two districts each in the Upper East and Upper West regions were selected through simple random sampling. Four communities were randomly sampled in each district except Kasena-Nankana East where only three communities were sampled. Finally, between eight to twelve households per community were randomly enumerated. A total of 296 households were interviewed and thirty one focus group discussions were also held.

3. RESULTS AND DISCUSSION

3.1 Institutional Factors

About 18 percent of the sample borrowed money from family and friends for agricultural investments. Financial constraint is a disincentive to putting more land under cultivation and acquiring farm inputs. Receiving informal credit from friends and relatives help complements a farmers' own savings in order to overcome cash constraints that are critical to production and productivity. Terms and conditions on borrowing from friends and family is normally less stringent (in terms of collateral, period for repayment, interest rate among others) as compared to borrowing from formal credit thereby making it a more convenient and comfortable system for smallholder farmers. Borrowing from friends and family is usually based on trust and the financial capacity of the lender and not necessarily on the amount requested.

About a third (33.4 percent) and 31 percent of the sample reported that they received formal agricultural and farmer-to-farmer extension services in 2011 respectively. Formal agricultural extension services together with farmer to farmer extension services are the main ways by which farmers become aware of a new technology which is a necessary condition for adoption to take place. The core mandate of agricultural extension agents is to serve as a link between agricultural researchers and farmers. They serve as change agents and mostly work through lead or contact farmers. It is not uncommon to find these contact farmers providing extension services to other farmers. Increasing use of participatory technology

generation methods such as on-farm research and participatory varietal selection enable researchers to work directly with farmers who also serve as change agents.

About 30 percent of the sample reported that they have a market in their community as presented in Table 2. The presence of a market in a community increases the households' access to input and outputs. Markets also serve as a place for social interactions and merry making in most communities in northern Ghana, with some markets actually coming alive when it is dark even in the absence of electricity.

Table 2. Relative frequencies of institutional factors

Institutional factors	Percentage of sample
Borrowed from friends	17.8
Farmer-to-farmer extension	30.6
Received agricultural extension service	33.4
Market in community	29.4

Source: Computations from field survey, 2011

3. 2 Environmental Factors

Majority of the sample (65%) reported noticing an increased in temperature. An increase in temperature could reduce soil moisture through increased evaporation, reduce soil microbial activity and facilitates wilting of field crops. Perceived increased in temperature is likely to result in the adoption of strategies that could help smallholder farmers better adapt. A decrease in rainfall has being noticed by about 74 % of the sample. Farmer's perception of a decrease in rainfall has a direct implication on all cropping decisions since crop production in northern Ghana is mostly rain fed.

3.3 Level of Adoption of Indigenous Climate Related Strategies

Seventeen indigenous practices and technologies were identified to be used by smallholder farmers in northern Ghana in adapting to the effects of climate change and variability. These indigenous practices and technologies are broadly classified into four categories namely crop and livestock related strategies, soil related strategies, cultural practice related strategies and other indigenous strategies as represented in Table 3 below.

Table 3. Indigenous adaptation strategies used by farmers

Crop and livestock related strategies	% of sample	Soil related strategies	% of sample	Cultural practice related strategies	% of sample	Other indigenous strategies	% of sample
Mixed cropping	12.8	Mounds	8.8	Mulching	13.2	Early or late planting	31.4
Crop rotation	3.0	Manure	5.7	Regular/early weeding	4.4		
Full season traditional varieties	2.7	Ridging	1.7	Fallow rotation	3.7		
Livestock production	1.4	Loosening the soil	1.4	Spacing of planting materials	1.7	Timing of rain	5.4
Short duration crops	0.7	Creating of bunds or drainage channels	1.7				
Mono cropping	0.3						
Percent of sample	20.9		19.3		23.0		36.8

Source: Computations from field survey, 2011

The crops and livestock related strategies comprise of six technologies or practices namely mixed cropping, crop rotation, cultivation of full season traditional varieties, livestock production, cultivation of short duration crops and mono cropping. Under this category, 12.8 percent of the sample reported mixed cropping as the most effective indigenous method of dealing with the effects of climate change and variability. Cultivating several types of crops on the same field reduces the likelihood of total crop failure as a result of variability in temperature and rainfall since different crops have different weather requirements. Crop rotation is the most preferred technology by some households (3 percent) in adapting to the effects of climate change and variability. Rotation is usually between cereals, legumes and in some cases root and tuber crops. Crop rotation is important because it helps to reduce the impacts of declining soil fertility and pest and diseases as a result of climate change and variability. Cultivation of full season traditional varieties in order to adapt to climate change and variability is reported by 2.7 percent of the sample. Full season traditional varieties were perceived to be more effective in withstanding harsh weather conditions as compared to some improved crop varieties. Some households (1.4 percent) engaged in livestock production in order to adapt to the effects of climate change and variability since crop production is perceived to be more sensitive to changes in the weather as compared to livestock production. Cultivation of short duration crops as the most effective indigenous strategy in adapting to the effects of climate change and variability is reported by less than 1 percent of the sample. Most traditional crop varieties have different gestation periods, cultivation of short duration crops instead of season full crops enable smallholder farmers to escape the effects of drought and sometimes floods. Mono cropping was also reported as being effective in adapting to the effects of climate change and variability. Cultivating a particular crop for a long time gives the smallholder farmer experience and knowledge which comes in handy in adapting to effects of climate change and variability.

Five identified indigenous technologies or practices used by smallholder farmers in adapting to climate change and variability namely making of mounds, manure application, ridging, loosening of soil and creation of bunds or drainage channels are categorised as soil related strategies. Most of the households (8.8 percent) under this category reported making mounds on their fields in order to adapt to the effects of climate change and variability. Mounds help to reduce the effects of droughts on field crops especially root and tuber crops by conserving soil moisture. Matured roots and tuber crops are also left in the mounds until it becomes favourable to harvest as a way of adapting to either drought or flood. Manure is also used by many households (5.7percent) in adapting to the effects of climate change and variability. Manure was found to be mainly in the form of crops residues usually from cereals. The use of animal droppings is also not uncommon even though the practice is not widespread. The use of manure by smallholder farmers is perceived to be effective and less costly in terms of improving soil fertility as a result of erosion emanating from floods and other extreme weather events. Ridging was also reported by some (1.7percent) household as being the most effective indigenous way of adapting to the effects of climate change and variability. Ridging enables the soil to conserve moisture during periods of intermittent drought or erratic rainfall. Ridging is usually done on a small scale through the use of simple farm implements such as hoe, and in some cases animal drawn implements are used especially in the Upper East Region. About 1 percent of the sample reported that they ploughed and harrowed their fields in order to loosen the soil before cultivation. This is done in order to improve soil aeration and drainage as an indigenous adaptation mechanism to flooding. About 2 percent of the sample also reported creating bunds or drainage channels on their field in order to either retain or drain rain water on their fields, this indigenous adaptation mechanism is used in dealing with the effects of erratic rainfall and flooding and is important for cereals especially rice.

Cultural practice related strategy is another categorization that consists of four identified indigenous agricultural practices namely mulching, regular or early weeding, land rotation and spacing of planting materials. About 13 percent of the sample reported that they adapted to the effects of climate change and variability by using mulch on their farms. Mulching enable field crops to withstand intermittent drought and is mostly used on tuber and vegetable fields. Early and regular weeding is being used by about 4 percent of the sample as the most effective way of dealing with the effects of climate change and variability. Early and regular weeding is perceived to be effective in dealing with the emergence of stubborn weeds which were not previously known. About 4 percent of the sample reported practicing fallow rotation as a means to adapting to the effects of climate change and variability. Under the fallow rotation system, farmers with large tracts of land usually partition their field into plots. At any point in time some plots are cultivated whiles other are left to fallow. Rotation includes lands that are both near and far away from the farm households. Yam production was found not to be sedentary. Therefore, smallholder farmers reported rotating their yam fields. Spacing of planting materials was reported by about 2% of the sample as being the most effective means in adapting to the effects of climate change and variability. Spacing enables crops to have access to adequate nutrients and water in the field.

Two distinct indigenous adaptation mechanisms that were reported by smallholder farmers in northern Ghana as being effective in dealing with the effects of climate change has been categorized as 'other indigenous strategies'. These are early or late planting, and timing of the onset of the rainy season. Majority (31.4 percent) of households reported that they timed their planting in order to escape pests, diseases, drought and flood. They either planted early or late as an indigenous adaptation mechanism to climate change and variability. About 5 percent of the sample reported that they adapted to the effects of climate change and variability by timing the onset of the rainy season. Some farmers said they had the capacity to 'smell' rain before it actually fell and are able to know if the rainy season has actually begun or not. They perceived the timing of the onset of the rainy season to be effective in avoiding total crop failure by not planting just because some rains have fallen.

3.4 Factors that Influence the Choice of Indigenous Climate Related Strategies by Smallholder Farmers in Northern Ghana

The result of the analysis indicates that the overall model with a log likelihood chi square ratio of 98.66 is statistically significant as shown in Table 4 below. Results of the Hausman Test as shown in Table 5 indicate that, the independence from irrelevant alternatives assumption has not been violated thereby justifying the application of the Multinomial Logit to the dataset. The marginal effects and not the estimated coefficients are discussed in this study. The marginal effects are superior to the estimated coefficients because they also provide the magnitude or probability of change response in the use of an adaptation strategy. Table 6 presents the marginal effects of the factors that influence the choice of indigenous climate related strategies by smallholder farmers in northern Ghana. The soil related strategy is used as the base strategy for this analysis.

Table 4. Factors that influence the choice of indigenous climate related strategies by smallholder farmers in Northern Ghana – multinomial logit results

Variable	Coefficients	Standard Error	P>|z|
Crop and livestock related strategies			
Borrowed from friends	0.6751	0.5726	0.238
Noticed increased temperature	2.3718***	0.4682	0.000
Noticed decreased rainfall	0.5201	0.5702	0.362
Farmer-to-farmer extension	0.6406	0.5108	0.210
Market in community	0.6721	0.4753	0.157
Location	1.0138**	0.4447	0.023
Constant	-2.4391***	0.6259	0.000
Cultural practice related strategies			
Borrowed from friends	-0.5772	0.6566	0.379
Noticed increased temperature	1.8856***	0.4428	0.000
Noticed decreased rainfall	-0.9247*	0.4747	0.051
Farmer-to-farmer extension	1.2559***	0.4788	0.009
Market in community	1.2549***	0.4538	0.006
Location	1.1496***	0.4305	0.008
Constant	-1.1518**	0.4970	0.020
Other indigenous strategies			
Borrowed from friends	0.3015	0.5488	0.583
Noticed increased temperature	2.3336***	0.4117	0.000
Noticed decreased rainfall	-0.4926	0.4543	0.278
Farmer-to-farmer extension	1.3279***	0.4507	0.003
Market in community	0.5843	0.4357	0.180
Location	0.7323*	0.4015	0.068
Constant	-0.9465**	0.4610	0.040
Base outcome: Soil related strategies			
Test statistics			
Number of observations	296		
LR Chi^2 (18)	98.66		
Prob > Chi^2	0.0000		
Pseudo R^2	0.1240		
Log likelihood	-348.3328		

, **, ** implies statistical significance at 10%, 5% and 1% respectively
Source: Computations from field survey, 2011

Table 5. Hausman tests of independence of irrelevant alternatives assumption Ho: Odds are independent of other alternatives

Omitted	Chi^2	df	P>Chi^2	Evidence
Soil Related Strategies	37.499	17	1.000	For Ho
Crop and Livestock Related Strategies	37.116	7	1.000	For Ho
Cultural Practice Related Strategies	35.405	7	1.000	For Ho
Other Indigenous Strategies	19.975	7	1.000	For Ho

Source: Computations from field survey, 2011

Table 6. Marginal effects of the factors that influence the choice of indigenous climate related strategies by smallholder farmers in Northern Ghana

Variable	Crop and Livestock Related Strategies	Cultural Practice Related Strategies	Other Indigenous Strategies
Borrowed from friends	0.1019*	-0.1479*	0.0610
Noticed increased temperature	0.0902*	0.0042	0.1551***
Noticed decreased rainfall	0.1585**	-0.1287**	-0.0714
Farmer-to-farmer extension	-0.0644	0.0614	0.1311**
Market in community	0.0020	0.1248***	-0.0359
Location	0.0463	0.0806*	-0.0223
Base outcome: Soil Related Strategies			
Number of Observations: 296			

, **, *** implies statistical significance at 10%, 5% and 1% respectively
Source: Computations from field survey, 2011

Informal credit from relatives and friends, noticing of decreased rainfall and increased temperature by smallholder farmers are the factors that influence the choice of a crop and livestock related strategy. Presence of a market in the community, and noticing of a decrease in rainfall, access to credit from family and friends and location are the factors that were found to have an effect on the choice of a cultural-practice related strategy as an adaption response to climate change and variability. Farmer-to-farmer extension and noticing an increase in temperature are the factors that positively influence the choice of 'other indigenous strategies' (early or late planting and timing of rainfall) vis-à-vis soil related strategies.

Noticing an increase in temperature increases the probability of choice of a crop and livestock related strategy as an adaptation option to climate change and variability by about 9%. The impact of an increase in temperature is likely to be more detrimental on a crop production system than a livestock production system, and on long a duration crop as compared to a short duration crop. Smallholder farmers in northern Ghana are therefore more likely to adopt crop and livestock related strategies such as livestock production and cultivation of short duration crops as compare to soil related strategies such as manure application and loosening of the soil as a means to improving aeration. The findings of this study is consistent with that of Nhemachena and Hassan [11]; Gbetibouo [13] and Deressa *et al.,* [3] who all reported a positive relationship between an increase in temperature and the adoption of climate related strategies.

The probability of choosing a crop and livestock related strategy instead of a soil related strategy as an adaptation response increases by 10 percent if a smallholder farmer in northern Ghana has access to credit from friends and relatives. Friends and relatives who are willing and able to lend out credit to other farmers are also normally interested in their welfare and would usually not hesitate to share proven indigenous crop and livestock strategies with such farmers. Soil related strategies (for example, making of mounds, manure, ridging, bunding and loosing of soils) are generally more expensive as compared to crop and livestock related strategies such as mixed cropping, crop rotation, use of short duration crops among others. Smallholder farmers who already need support are therefore less likely to use a soil related strategy which is more costly as compared to a crop and livestock related strategy that may not involve any cost at all. The findings of this study confirm the results of Hassan and Nhemachena [12] who contend that access to credit has a

positive effect on the probability of a farmer choosing a crop and livestock related strategy in both dry and irrigated lands. The results of this study also agree with the findings of Nhemachena and Hassan [11] and Gbetibouo [13].

Results of the study also show that smallholder farmers in northern Ghana who have noticed a decrease in rainfall have a 16 percent chance of choosing a crop and livestock related strategy instead of a soil related strategy as an adaptation option to climate change and variability. The use of crop and livestock technologies such as short duration crops enables smallholder farmers to stabilize their yield in spite of a reduction in rainfall. Diversification mechanisms such as mixed cropping and livestock production also ensure that smallholder farmers who use crop and livestock strategies do not suffer total farm losses in the event of reduced rainfall. Soil related strategies such as application of manure, ridging and loosening of soil are unable to conserve enough soil water therefore most smallholder farmers are unwillingly to adopt such technologies in response to a decline in rainfall. The findings of this study is supported by Nhemachena and Hassan [11] who observed that decreasing rainfall increases the probability of smallholder farmers to efficiently utilise water resources for food production.

Presence of a market in a farming community increases the likelihood of use of a cultural practice related strategy by about 12 percent. Smallholder farmers in northern Ghana are more likely to use a cultural practice related strategy instead of a soil related strategy in responding to climate change and variability if there is a market in their community. Markets in northern Ghana do not only serve as a place to buy and sell both agricultural inputs and outputs but also serve as a place for social interactions. Markets especially drinking bars serve as a place for exchange of ideas and farming technologies especially proven technologies (for example, land rotation and spacing of planting materials) that do not cost farmers with abundance of land a lot of money. According to Hassan and Nhemachena [12], Smallholder farmers who are near to markets tend to adopt specialized crop cultivation as adaptation strategies to climate change and variability.

As an adaptation strategy to climate change and variability, sourcing of credit from friends and relatives reduces the probability of choosing a cultural practice related strategies by 15 percent. Cultural practice related strategies are relatively less expensive as compared to soil related strategies such as making of mounds, manure, ridges and bunds. Access to credit is therefore not a major consideration for the choice of a cultural practice related strategy. Smallholder farmers who have access to farm credit from friends and relatives are therefore in a better position to adopt resource demanding strategies such as soil related strategies.

Noticing of a decrease in rainfall reduces the likelihood of choice of a cultural practice related strategy as an adaptation response to climate change and variability by about 13%. With the exception of mulching, none of the practices categorized as a cultural practice related strategy is able to conserve soil moisture hence faced with a decrease in rainfall, smallholder farmers in northern Ghana are more likely to respond by adopting soil related strategies such as making of bunds, ridges and mounds. Similarly, Gbetibouo [13] has also reported that a decrease in rainfall is likely to increase the probability of smallholder farmers adopting delay in planting as an adaptation strategy to climate change and variability.

Location significantly influences the decision by smallholder farmers to adopt an indigenous climate related strategy. A farmer in the Northern Region (Guinea Savannah) is about 8 times more likely to use a cultural practice related strategy to adapt to the effects of climate change as compared to a farmer in the Upper West and East regions (Sudan Savannah).

Northern region is the largest region in Ghana in terms of geographical area; the region therefore has more agricultural land than the Upper West and East regions. It is therefore not uncommon to find farmers in the Northern Region engage in cultural practices such as land rotation and spacing of planting material as a result of the relative abundance of agricultural land. Morris *et al.,* [9] and Mensah-Bonsu *et al.,* [10] both report a positive relationship between location and adoption of improved maize technologies in Ghana.

The probability of choice of an 'other indigenous strategy' as an adaptation response to climate change and variability increases by about 13 percent if the recommendation is coming from another farmer. Adoption of other indigenous strategies such as early or late planting has the potential to result in total crop failure or poor harvest if the timing is inappropriate. Smallholder farmers in northern Ghana with only one cropping season in a year are usually risk averse since they depend mostly on their farms for their livelihoods and are therefore less likely to adopt early or late planting unless such a recommendation is coming from a fellow resource poor farmer who is recommending based on example or experience. Adoption of soil related strategies such as loosening of soil and application of manure may not result in total crop failure even if the timing is inappropriate. The findings of this study conforms to that of Deressa *et al.,* [14] who noted that farmer-to-farmer extension has a positive influence on selling of livestock and borrowing from relatives as coping strategies to climate change and variability.

The probability of choice of other indigenous strategies increases by about 16% if smallholder farmers notice increases in temperature. Increases in temperature mostly have a negative effect on plant growth usually resulting in wilting of leaves. Planting early or late to escape the dry spell within the rainy season seems to be more effective as compared to using soil related strategies such as loosening of soil, creating of bunds or drainage and ridging. Smallholder farmers in northern Ghana are therefore less likely to use soil related strategies to adapt to the effects of climate change and variability as compared to 'other indigenous strategies'. The findings of this study is supported by Nhemachena and Hassan [11]; Gbetibouo [13] and Deressa *et al.,* [14] who all reports that an increase in temperature have a positive effect on the adoption of climate related strategies. However, Mandleni and Anim [15] report a negative relationship between temperature and adoption of climate related strategies.

4. CONCLUSION

This study assessed the determinants of Choice of Indigenous Climate Related Strategies by Smallholder Farmers in Northern Ghana using primary data was collected through community focus group discussions and household survey, and the Multinomial Logit regression model. The empirical results reveal that presence of a market, informal credit from friends and relatives, farmer-to-farmer extension, location of farmer, noticing of a decrease in rainfall and noticing an increase in temperature influence the choice of indigenous climate related strategies influence the choice of indigenous climate related strategies.

The study provides the following policy recommendations. There is the need to create more awareness about the phenomenon of climate change highlighting changes in rainfall and temperatures in order to facilitate the adoption of both indigenous and introduced climate related strategies. The capacities of change agents (such as self-motivated farmers and leaders of farmer based organisations) on the concept of climate change and available adaptation strategies could be built in order to enhance widespread adoption.

Farming communities in northern Ghana should be assisted to develop markets for both agricultural inputs and outputs. This has the potential of improving the adoption of cultural practice related strategies as well as soil and plant health related strategies.

There is the need to make agricultural extension services widely available to smallholder farmers in northern Ghana in order to boost the adoption of improve breeds and varieties. More agricultural extension agents could be employed and effective group dissemination techniques such as farmer field forums could be adopted.

Government should intensify efforts in engaging the youth in the 'youth in agriculture policy' initiative. Beneficiaries of the project should be introduced to good agricultural-practice related strategies as an adaptation mechanism to climate change and variability with females specifically targeted for maximum impact.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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