Factors Influencing Farmers' Awareness and Choice of Indigenous Practices in Adapting to Climate Change and Variability in Northern Ghana

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Abstract

Farmers in Northern Ghana adapt to the adverse effects of climate change using traditional practices. However, farmers' awareness of these practices is a spring-board to their choices of available indigenous climate related adaptation strategies. This study examined farmers' awareness and usage of indigenous adaptation strategies using the Heckman Two-Stage Sample Selection Model. Questionnaire was administered to 285 randomly selected households to determine the factors influencing farmers' awareness and choice of indigenous adaptation strategies. The empirical results showed that majority of farmers are aware of and employed soil related indigenous adaptation strategies. Education, membership of farmer-based organisation, farmer-farmer extension contacts and farming experience significantly determine farmers' awareness of indigenous adaptation strategies. Farmers' level of education, farming experience, farmer-farmer extension contacts, membership of farmer group, labour hours and age significantly influenced farmers' choice of indigenous climate related adaptation strategies. Based on these findings, it is recommended that farmers should endeavour to form groups to serve as a platform to share knowledge on indigenous farming practices for effective climate change adaptation.

Introduction

The growing conditions of crops and livestock are affected by the climatic condition of the agro-ecology of the area. Based on climate models, mean daily temperatures are expected to increase by 2.5°C - 3.2°C, whereas total annual rainfall is projected to decrease by 9 - 27 percent across various geographical locations by the year 2100 across the world. The outcome of increased temperature and erratic rainfall are floods and droughts with detrimental effects on water availability and food production (IPCC, 2014; Alhassan *et al*., 2018a).

Of concern is that Ghana's economy is basically agrarian and is dominated by small scale farmers with about 90 percent cultivating less than two hectares of farm lands (MoFA, 2010). In the northern Region of Ghana, described as the 'food basket of the nation', staple crops such as maize, sorghum, rice, soy beans, cowpea, groundnut, yam and millets are the main cultivars of smallholder farmers, who also rear domestic animals such as goats, sheep and poultry (Ministry of Food and Agriculture, MoFA, 2010). The production of these crops is under serious threat by the harsh climatic conditions of these semi-arid areas. Although smallholder farmers are aware of the effects of climate variability and employ traditional knowledge to cope, the intensities of long-term climatic stressors are usually unprecedented and persistent, and surpass the effectiveness of indigenous adaptation measures used by the smallholder farmers (Alhassan *et al*., 2017; Alhassan *et al*., 2018b; Pettengell, 2010).

Literature on adaptation indicates that most

studies have concentrated on innovative measures developed by research institutions with little attention on farmers' traditional response methods. The few studies available on the determinants of farmers' adaptive strategies have employed the multinomial logit or probit models without premising their awareness of adaptation options as a spring-board to adoption. Also, given that farmers can use two or more available strategies to adapt to climate change, the suitability of multinomial logit or probit becomes questionable since it is based on exclusive choice of strategies. Thus, the methodological gap and neglect of indigenous adaptation strategies in the literature are research gaps addressed by this paper. Indigenous strategies were identified and the factors influencing farmers' awareness and choice of the indigenous strategies were determined using the Heckman Sample Selection Model.

In the adaptation literature, indigenous strategies include all the measures and practices innovated by farmers themselves. These could be the creativity of recent or past generations (Al-Hassan *et al*., 2013). This study perceives indigenous adaptation strategies to mean all the traditional climate related adaptation practices emanating either from farmers of current generations, or those passed onto farmers from previous generations. These include the use of indigenous crop varieties, mixed cropping systems, soil loosening techniques, creation of bunds or drainage channels, use of manure, cultivation of short season crops, homestead gardening, migration, increase of planting space, change in timing of farm operations, crop diversification, and regular or early weeding (Al-Hassan *et al*., 2013; Boko *et al*., 2007; Etwire *et al*., 2013; FAO, 2006; Gbetibouo, 2009; Hassan and Nhemachema, 2008). This study classified the indigenous adaptation strategies into four main categories based on how they are related and practiced in the study area: crop related, soil related, cultural practices related and other indigenous related strategies (Alhassan *et al*., 2018c).

Gbetibouo (2009) investigated the factors determining farmers' choice of adaptation strategies to climate change and variability in the Limpopo Basin of South African. The findings revealed that whereas farming experience, farm size, soil fertility, temperature, off-farm income, perceiving increased temperature and access to extension services positively influenced farmers' choice of adaptation strategies; wealth was found to exert negative influence on such decisions of farmers. Perceived change in rainfall, education level of farmers and access to climate information were, however, not significant.

Whereas Nhemachema and Hassan (2007), Deressa et al. (2010) and Gbetibouo (2009) observed a positive relationship between farmers' perceived increase in temperature and their adoption of climate adaptation strategies leading to their lower vulnerabilities; Mandleni and Anim (2011) reported otherwise for livestock farmers in Eastern Cape of South Africa. Deressa et al., (2009) revealed that an experienced farmer who lived in the Nile Basin of Ethiopia over a period of ten years was more acquainted with the climatic conditions in the area and easily adapted to the changing environment by adopting one of the traditional adaptation practices compared to the less experienced farmer.

Materials and Methods

Study Area

The study was conducted in northern Ghana,

which comprises the three administrative regions of the north including Northern, Upper East and Upper West regions. Northern Ghana occupies about 41 percent of the land area of Ghana and has about 17.1 percent of the national population (GSS, 2012). Majority of the people of Northern Ghana, age 15 years and above, are illiterates. The agricultural sector employs over 70 percent of the labour force and is mainly rain-fed. The climate of the area is semi-arid which is conducive for rearing livestock such as cattle, sheep, goats and fowls. Majority of people in northern Ghana live in poverty (GSS, 2014).

Sampling Procedure and Data Collection Techniques

Farming households for this study were selected based on a well-designed sampling procedure. The three regions of northern Ghana were selected because of their location in a semi-arid climate region and significant role in food production in the country. Based on population and land size, the Northern region was allocated two districts (Sheini and Nakpal communities from Zabzugu communities; and Nyong and Kpataribogu communities from Karaga District), while the Upper East (Pungu and Janania communities from Kasena-Nankana East Municipality) and Upper West (Kunyebin and Gurumbelle communities from Wa East district) regions were allocated one district each. Within each district, two farming communities were randomly selected and the number of farming households ascertained through household listing. Random number tables were then used to select the required number of households to represent the community in the study, using proportionate simple random sampling. A total of 285 households were selected for the study, visited by the research team to explain the essence of the study, seek for consent for the interview and administer questionnaires with households at a time appropriate to the household head or his/her representative.

Theoretical Framework

A person goes through a series of decision making processes before adopting a novelty, as assumed by the diffusion adoption theory (Botha and Atkins, 2005). Before a person adopts a strategy to adapt to climate change, he/she must first be aware of the strategy before deciding to reject immediately or adopt the strategy. The adoption decision process may continue if the farmer sees the need for the adaptation strategy. The farmer may however, decline the decision to adopt the strategy after expressing initial interest, or continue with the adoption decision by comparing the strategy with other prevailing strategies. If the farmer observes that the strategy under consideration is more beneficial than the prevailing strategies, he/she may try the new strategy, but, more likely on a small scale to test its suitability or otherwise. If the farmer is satisfied with the new strategy, then, it is adopted; otherwise, it is rejected. The theory of consumer behaviour assumes that the expected benefits or utility (satisfaction) derived from a strategy is the basis of its assessment which leads to the decision on adopting the adaptation strategy. If farmers expect higher satisfaction or benefits from adopting the strategy to not adopting, he/she will adopt the strategy compared to when lower benefits are expected from adopting the innovation (Botha and Atkins, 2005). This study makes use of the diffusion and consumer behaviour theories in explaining farmers' choice of indigenous adaptation strategies. For this study, a farmer is either an adopter

or non-adopter of a given adaptation strategy. A farmer is considered an adopter if he/she is using at least one of the specific indigenous adaptation strategies within the main category in the last growing season.

Analytical Framework

The Heckman Sample Selection Model was employed to determine the factors influencing farmers' choice of indigenous adaptation. Farmers decide to adopt or not to adopt a strategy after their awareness of the specific strategy is created. This suggests that it will be inappropriate to use an entire dataset from respondents to determine the factors influencing the choice of adaptation strategies without first ascertaining respondents' awareness about the strategy (Greene, 2012). To avoid this sampling bias, this study employed the Heckman Sample Selection Model to determine the factors influencing farmers' choice of indigenous climate change adaptation strategies by first determining farmers' awareness of an adaptation strategy to be selected in determining the choice of such adaptation strategy. According to Heckman (1976), the maximum likelihood estimation of the Heckman Sample Selection model is suitable for a survey data. The general Heckman Sample Selection Model is given by equation (1). Regression equation:

$$Y_j = X_j\beta_i + \mu_{1j} \qquad (1)$$

Where Y_j is the dependent variable, X_j is an array of independent variables, β_i are parameters to be estimated from the regression model and μ_{1j} represents the error term.

$$Z_j\gamma + \mu_{2j} > 0$$

Selection model:

Where $\mu_1 \sim N(0, \sigma)$,

$\mu_2 \sim N(0, 1)$ and

$corr(\mu_1, \mu_2) = \rho$

The likelihood for observation j, $\ln Lj = lj$ is given by equation (2).

$$lj = \begin{cases} w_j \ln \Phi\left\{\dfrac{Z_j\gamma + (y_j - X_j\beta)\rho/\sigma}{\sqrt{1-\rho^2}}\right\} - \dfrac{w_j}{2}\left(\dfrac{y_j - X_j\beta}{\sigma}\right)^2 - w_j(\sqrt{2\pi\sigma}) & y_j \ \ observed \\ w_j \ln \Phi(-Z_j\gamma) & y_j \ \ not \ \ observed \end{cases} \qquad (2)$$

Where Φ is the standard cumulative normal and is an optional weight for observation *j*. According to Heckman (1976), σ and ρ are not estimated directly in the maximum likelihood method. Instead, $\ln\sigma$ and $a\tanh\ \rho$ are directly estimated using equation (3).

$$a\tanh \quad \rho = \frac{1}{2}\ln\left(\frac{1+\rho}{1-\rho}\right) \qquad (3)$$

The standard error of $\lambda = \rho\sigma$ is approximated through the propagation of error (delta) method. That is,

$$Var(\lambda) \approx D \quad Var\left\{\left(a\tanh \quad \rho \quad \ln\sigma\right)\right\}D'$$

Where *D* is the Jacobian of λ with respect to $a\tanh\ \rho$ and $\ln\sigma$.

The empirical model for the study is specified by equation (4).

$$Y_j = \beta_0 + \beta_1 Edu + \beta_2 Exp + \beta_3 Sex + \beta_4 Lab + \beta_5 Age + \beta_6 Extens + \beta_7 Group + \mu_1 \quad (4)$$

Where a farmer adopts adaptation strategy *j*, only if he/she is aware of it. Thus, we assume that Y_j (adoption) is observed if:

$$\gamma_0 + \gamma_1 Edu + \gamma_2 Exp + \gamma_3 Sex + \gamma_4 Extension + \gamma_5 Group + \mu_2 > 0$$

and μ_1 and μ_2 have correlation ρ.

For this study, a farmer is either an adopter or non-adopter of a given adaptation strategy. A farmer is considered an adopter if he/she is using at least one of the specific indigenous adaptation strategies within the main category in the last growing season. Given that is a dichotomous dependent variable (1 denotes adopt, 0 denotes otherwise), each of the main categories of indigenous adaptation strategies (Crop Related Strategies, Soil Related Strategies, Cultural Practice Related Strategies and Other related Strategies) were regressed on the explanatory variables as binary dependent variable. The marginal effects are superior to the estimated coefficient

because in addition to the direction of change, it provides the magnitude or probability of the change response with respect to the explanatory variable. Therefore, the marginal effects rather than the coefficients have been presented and discussed in this paper. addition to the direction of change, it provides the magnitude or probability of the change response with respect to the independent variable. Therefore, the marginal effects rather than the coefficients have been presented and discussed in this paper.

Data was entered and analysed using version 14 of STATA. Table 1 presents a description of variables in the regression and selection models.

TABLE 1
Description of Variable for the Heckman Sample Selection Model

Variable	Description	Measurement	A prior Expectation
Y_j	Adoption of strategy j	Dummy: 1= adopt, 0=Otherwise	+
Edu	Education level of household head	Years	+
Exp	Farming experience	Years	+
Sex	Sex of household head	Dummy: 1=male, 0= Otherwise	-/+
Extens	Farmer-farmer extension contacts	Number of contacts per annum	+
Group	Membership of farmer group	Dummy: 1= yes, 0= Otherwise	+
Lab	Use of labour hour	Number of hours per annum	-/+
Age	Age of household head	Years	-/+

Results

Socio-demographic Profile of Farmers

The socio-demographic characteristics of respondents used in the regression model are presented in Table 2. The educational attainment of respondents ranges from zero to 15 years of formal education with a mean of 2.23 years. Majority of households were headed by males (60%). The average age of household heads was 45.81 years - suggesting that respondents can provide informed and reliable responses on climate change. Averagely, respondents have been farming for 16.94 years and thus, acquainted with the traditional strategies of adapting to climate change. The mean labour hours spent on farming per annum by households was 269.15 with 122 hours and 924 hours as minimum and maximum labour hours, respectively. Majority of respondents (62.3 %) belong to a farmer group as indicated by an average of 0.62.

TABLE 2
Socio-demographic Profiles of the farmers

Socio-demographic profile	Mean	Std Dev.	Minimum	Maximum
Education (Years)	2.23	4.04	0	15
Sex of household head	0.60	0.49	0	1
Age (Years)	45.81	12.87	26	80
Farming experience (years)	16.94	13.61	2	42
Labour (Hours)	269.15	185.23	122	924
Extension contacts	1.83	1.99	0	10
Membership of farmer group	0.62	0.48	0	1

Farmers' awareness and adoption of indigenous climate related adaptation strategies

The results show that over 80 percent of farmers indicated being aware of at least one of the indigenous climate change adaptation

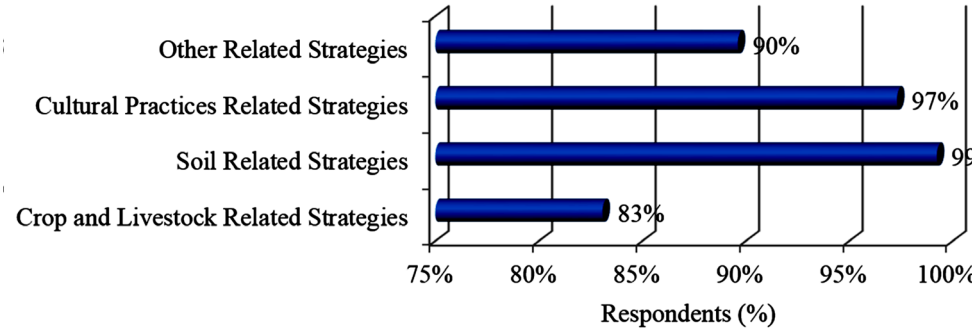

Figure 1: Farmers awareness of indigenous adaptation strategies

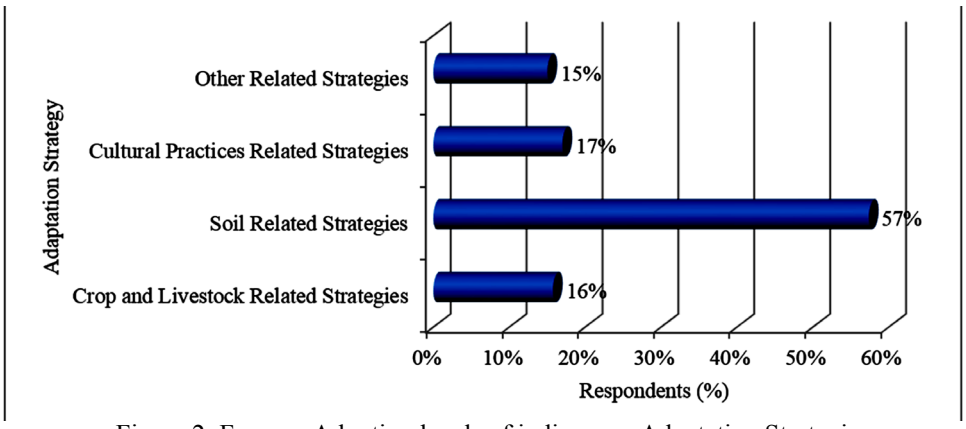

Figure 2: Farmers Adoption levels of indigenous Adaptation Strategies

strategies which were classified as crop related strategies, soil related strategies, cultural practice related strategies and other indigenous adaptation strategies. Even though farmers' awareness of indigenous climate change adaptation strategies is relatively high (Figure 1), its adoption tends to be low with the most adopted indigenous adaptation strategy being soil related (57%) (Figure 2). Table 3 presents the specific adaptation strategies under each of the four main indigenous strategies. The most popular crop related indigenous adaptation strategy is mixed farming with about 11.3 percent of the farmers reportedly adopting this strategy. The widely used soil related indigenous adaptation

TABLE 3
Specific Indigenous Climate Related Adaptation Strategies

Crops related strategies		Soil related strategies		Cultural practices related strategies		Other indigenous related strategies	
Specific strategy	% of sample	Specific strategy	% of sample	Specific strategy	% of sample	Specific strategy	% of sample
Mixed cropping	10.5	Mounds raising	32.2	Mulching	5.6	Early/late planting	5
Crop rotation	8.3	Manure	15.3	Regular/early weeding	9.7	Timing of rain	8.0
Traditional varieties	12.4	Ridging	10.2	Land fallowing	8.3	Migration	2.0
Short duration crops	8.2	Loosing of soil	5.5	Plant spacing	7.1		
Mono cropping	2.6	Creating bunds or drainage channels	24.7				
Mixed farming	11.3						

strategy among farming households was mounds raising and employed by 32.2 percent of sampled farming households. Early or late weeding appeared to be the dominant cultural practices related strategies with about 9.7 percent of farming households using the practice in adapting to climate change. Among the other indigenous climate related adaptation strategies identified, timing of rains appeared to be dominant with 8 percent of respondents relying on the strategy to adapt to climate related effects. These findings confirms the findings of Alhassan et al. (2018b).

Factors influencing farmers' awareness and adoption of indigenous climate change adaptation strategies

This section of the paper looks at the factors influencing farmers' awareness and adoption of indigenous climate change strategies using Heckman's Sample Selection Model. Before executing the regression, a correlation test was conducted on the independent variables to establish if there existed any significant relationships among the variables. The level of significance was established at 10 percent. The correlation results revealed that farm size, access to tractor services, perceived climate change and farm income significantly correlated with other independent variables and were not included in the regression (Table 4).

TABLE 4
Correlation of Independent Variables for the Heckman Sample Selection Model

	Education	Land Ownership	Farming Experience	Farm size	Sex of HHH	Labour	Age of HHH	Tractor access	Noticed Climate change	Extension	FBO	Farm income
Education	1.00											
Land ownership	-0.02	1.00										
Farming experience	-0.05	0.08	1.00									
Farm size	0.02	0.15	-0.10	1.00								
Sex of HHH	-0.01	0.12*	0.00	0.02	1.00							
Labour	0.01	-0.01	-0.06	0.21*	0.09	1.00						
Age of HHH	0.06	-0.01	-0.10	0.04	0.02	0.02	1.00					
Tractor access	-0.06	-0.03	0.02	0.01	-0.01	0.00	-0.21*	1.00				
Noticed climate change	0.09	-0.05	-0.02	0.07	-0.05	0.02	0.16	-0.12	1.00			
Extension	-0.12	0.05	0.10	-0.21*	-0.08	-0.03	-0.05	0.09	0.04	1.00		
FBO	-0.09	-0.01	0.12	-0.08	-0.02	-0.13	0.02	-0.02	0.06	0.30*	1.00	
Farm income	-0.02	0.13*	0.02	0.39*	0.08	0.10	-0.04	0.01	0.07	0.04	0.04	1.00

Note: * means significant at 10%.

Crop Related Adaptation Strategies

The Wald Chi square test for the crop related strategies model showed that the Chi square value of 3987.49 was significant at 1 percent. This justifies the use of the Heckman Sample Selection model for the data (Table 5). Education has a significant negative influence on farmers' awareness of crop related climate adaptation strategies. On the contrary, farmer-farmer extension contacts and being a member of a farmer-based organisation significantly and positively influences farmers' awareness of crop related climate adaptation strategies. Farmers' decision to choose crop and livestock related strategies are significantly and negatively influenced by their educational level and number of labour hours. On the other hand, farmer-farmer extension service

TABLE 5
Results of the Heckman Two-Stage Sample Selection Model of the factors influencing Farmers' Awareness and Choice of Crop Related Strategies

Determinant of Adoption	Selection model (awareness)		Adoption model	
	$\partial y/\partial x$	ρ - value	$\partial y/\partial x$	ρ - value
Education	-0.025**	0.038	-0.009**	0.045
Farming experience	-0.002	0.492	-0.008	0.495
Sex of household head	0.089	0.479	0.033	0.476
Farmer-farmer extension contact	0.085***	0.005	0.704**	0.043
Membership of Famer-based Organisation	0.287**	0.040	2.061	0.564
Labour hours			-0.031***	0.007
Household head's age			0.105**	0.037
Wald test of independent equations				
Total observation	285			
Censored	14			
Chi square	3987.49			
Prob > Chi Square	0.000			
/athrho	Coefficient = 17.987, P – value = 0.000			
/lnsigma	Coefficient = -1.007, P – value = 0.000			

Note: *, **, and *** means significant at 10%, 5% and 1% respectively

and household head's age significantly and positively influence these decisions.

Soil Related Adaptation Strategies

The soil related strategies model was tested for fitness using the Wald chi square test. The results indicated that the Chi square value of 27.05 was significant at 1 percent, implying that the Heckman Sample Selection model fits the soil related strategies data. Farmers' awareness of soil related climate adaptation strategies is significantly and positively influenced by the farming experience of the household head. Farming experience significantly but negatively influences the decision of farmers who are aware of soil related strategies to adopt the strategy in adapting to climate change. Being a member of a farmer-based organisation on the other hand exerts significant positive influence on

TABLE 6
Results of the Heckman Two-Stage Sample Selection Model of the factors influencing Farmers' Awareness and Choice of soil related Strategies

Determinant of Adoption	Selection model (awareness)		Adoption model	
	$\partial y/\partial x$	ρ - value	$\partial y/\partial x$	ρ - value
Education	0.012	0.427	-0.006	0.424
Farming experience	0.011**	0.022	-0.005**	0.017
Sex of household head	0.145	0.264	-0.074	0.260
Farmer-farmer extension contact	0.049	0.128	-3.831	0.737
Membership of Famer-based Organisation	0.000	0.856	5.591***	0.000
Labour hours			0.025	0.124
Household head's age			0.001	0.698
Wald test of independent equations				
Total observations	285			
Censor	26			
Chi square	27.05			
Prob > Chi Square	0.006			
/athrho	Coefficient = -16.728, P – value = 0.000			
/lnsigma	Coefficient = -0.676, P – value = 0.000			

*Note: *, **, and *** means significant at 10%, 5% and 1% respectively*

farmers' decisions to use soil related strategies. These results are presented in Table 6.

Cultural Practices Related Adaptation Strategies

The Heckman Sample Selection model is suitable for the cultural practices related strategies data given that the Chi square value of 57.05 was significant at 1 percent as revealed by the Wald Chi square test. The Heckman sample selection regression results indicated that farming awareness of cultural practices related strategies is significantly and positively influenced by farmers' experience. However farmer-farmer extension contact significantly and negatively influenced farmers' choice of cultural practices related strategies (Table 7).

Other Indigenous Adaptation Strategies

The Chi square value of 157.04 for the other indigenous strategies model was significant at 1 percent. This justifies the applicability

TABLE 7
Results of the Heckman Two-Stage Sample Selection Model of the factors influencing Farmers' Awareness and Choice of cultural practice related Strategies

Determinant of Adoption	Selection model (awareness)		Adoption model	
	$\partial y/\partial x$	ρ - value	$\partial y/\partial x$	ρ - value
Education	0.113	0.604	0.004	0.560
Farming experience	0.117*	0.072	0.005**	0.036
Sex of household head	0.089	0.545	-0.034	0.513
Farmer-farmer extension contact	0.002	0.845	-3.081*	0.083
Membership of Famer-based Organisation	0.057	0.758	1.151	0.176
Labour hours			0.008	0.643
Household head's age			-0.002	0.743
Wald test of independent equations				
Total observations	285			
Censor	12			
Chi square	57.05			
Prob > Chi Square	0.000			
/athrho	Coefficient = 16.840, P – value = 0.000			
/lnsigma	Coefficient = -0.955, P – value = 0.001			

TABLE 8
Results of the Heckman Two-Stage Sample Selection Model of the factors influencing Farmers' Awareness and Choice of other Indigenous Related Strategies

Determinant of Adoption	Selection model (awareness)		Adoption model	
	$\partial y/\partial x$	ρ - value	$\partial y/\partial x$	ρ - value
Education	0.058**	0.024	0.006	0.306
Farming experience	-0.001	0.820	-0.001	0.539
Sex of household head	0.003	0.886	0.056	0.266
Farmer-farmer extension contact	0.029	0.572	0.001	0.798
Membership of Famer-based Organisation	-0.157	0.424	-0.004**	0.033
Labour hours			0.002	0.876
Household head's age			0.043	0.433
Wald test of independent equations				
Total observations	285			
Censor	53			
Chi square	157.04			
Prob > Chi Square	0.000			
/athrho	Coefficient = -11.831, P – value = 0.000			
/lnsigma	Coefficient = -0.986, P – value = 0.000			

of the Heckman Sample Selection model on the dataset. The Heckman sample selection regression results revealed that only education of farmers significantly and positively influences their awareness of other indigenous climate related adaptation strategies. The results further showed that being a member of a farmer-based organisation significantly and positively influence farmers' decision on other indigenous climate related adaptation strategies. (Table 8)

Discussion

Farmers have high awareness levels of indigenous climate related adaptation strategies. This is attributable to their exposure to traditional practices which have been practiced within their locality over many years, to the extent that, even if a farmer does not employ such practices, he/she might have seen or heard other farmers practise or talk about it. While other studies have shown that indigenous climate related adaptation practices such as early/late planting and timing of rain were more popular strategies than soil and crop related practices in the northern regions of Ghana (Al-Hassan et al., 2013); the majority of farming households in this study rather relied on soil related indigenous climate adaptation strategies with fewer farming households reported to be using crop related, cultural practices related and other indigenous climate related adaptation strategies. Armah et al. (2013) also reported that farmers in northern Ghana employed indigenous land management practices such as mounds raising, ridging and manure application to adapt to agro-biodiversity loss and climate change. The different strategies observed could be the result of changes in the adaptation patterns of farmers over time and socio-economic differences in study communities.

The negative relationship between farmers' education and their awareness of crop and livestock related strategies can be attributed to the fact that educated farmers tend to show more interest and adopt modern crop related strategies such as hybrid seeds than indigenous varieties. Mabe et al. (2014) also observed that farmers' education negatively influenced their decision to change crop varieties in adapting to climate change in Northern Ghana. However, education positively influenced farmers' awareness of other indigenous climate related adaptation strategies such as migration, early/late planting and timing of the rain, but does not significantly influence the choice of such strategies. Educated farmers are acquainted with the weather patterns and may plant early or late, depending on the onset of the rain. The effect of education on farmers' choice of other indigenous adaptation strategies failed to meet the study's a priori expectation.

Experienced farmers are more knowledgeable about various methods for boosting the fertility of the soil as well as other traditional strategies practised in the area, than farmers with less farming experience. However, since farmers' awareness of an adaptation strategy do not warrant their adoption, more experienced farmers do not employ soil related adaptation strategies such as raising of mounds, manure application, ridging and loosing of soil as it requires more strength and labour. Instead, experienced farmers select cultural related practices such as land fallowing, plant spacing, mulching and early weeding to adapt to climate change. This is consistent with Mabe et al. (2014) that farmers in Northern Ghana who had more experience in farming employed mulching and fallowing as adaptation measures to climate change relative to other traditional climate related adaptation strategies.

When farmers have access to extension services from other farmers, it significantly raises their awareness and choice of crop related indigenous adaptation strategies but, may shy away from cultural related practices. Farmers share knowledge on the effectiveness of indigenous varieties, short duration crops and crops combination on the same field to maximize yield and even how to rotate crops on cultivated lands over time (Alhassan et al., 2018a). There is a higher likelihood of farmers' choice of crops related strategies via-a-vis soil related strategies if the recommendation is from another farmer as

well as a positive influence of farmer-farmer relationship on farmers' choice of cultural practices (Al-Hassan et al., 2013; Alhassan et al., 2018b).

Farmers who belong to farmer-based organisations are also more likely to be aware of crop related indigenous strategies but, this factor exerts no significant influence on their decision to use crop related strategies. However, for soil related strategies, farmer-based organisations have no significant effect on farmers' awareness but significantly influence farmers' choice of these set of strategies. Frequently, farmers share experiences during farmer groups' meetings and take advice from each other on which indigenous climate related strategies are more effective. The tendency to employ crop related indigenous climate adaptation strategies decreases as labour hours increased. This deviates from the a priori expectation of the study but, is consistent by Armah et al. (2013) who reported that farming households in Northern Ghana with large households who provide more labour do not use crop related indigenous strategies to adapt to agro-biodiversity and climate change. Elderly farmers are more likely to adopt crop and livestock related indigenous climate adaptation strategies than younger farmers. This opposes the negative effective of age on the choice of crop varieties among farmers in northern Ghana (Mabe et al., 2014), but, is in agreement with Apata (2011) who revealed that the choice of mixed farming and mixed cropping among farm households in Southwest Nigeria was positively influenced by age of farmers.

Conclusions and Recommendations

The study indicates that whereas farmers' awareness on indigenous climate related adaptation strategies is high, their uptake and use of these strategies is relatively lower. Education, farming experience, farmer-farmer extension services and membership of a farmer group are the important determinants of farmers' awareness of indigenous climate related adaptation strategies. Farmers' choice of indigenous climate related adaptation strategies are mainly influenced by their level of education, experience in farming, farmer-farmer extension contacts, membership of farmer groups, access to labour and age. Farmers are encouraged to self-organise into groups where more experienced farmers can share the traditional ways of adapting to climate change with younger farmers. Such groups can also be used as collateral for sourcing funds to support farming activities of members.

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