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A MULTIVARIATE ANALYSIS OF FARM – LEVEL DETERMINANTS OF FOOD CROP FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN SOUTHWESTERN NIGERIA

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ABSTRACT

This study centered on the perception of climate change and the determinants of choice of climate change adaptation strategies used by food farmers in the study area. The study used multistage sampling procedure to select 180 respondents in the rainforest agro-ecological zone of Southwestern Nigeria. Primary data were collected to achieve this. Data analysis was done using descriptive statistics and multinomial logit model. The results indicated that household size negatively influences the use of multiple crop types or varieties, land fragmentation, multiple planting dates and crop diversification. Years of education attained by the respondents had a negative effect on the choice of multiple planting dates, crop diversification and off-farm employment as climate change adaptation strategies as opposed to cover cropping (the base category). Sex (male-headed household) had positive influence on the choice of multiple crop varieties, land fragmentation, multiple planting dates, crop diversification and off-farm employment. Extension contact positively influenced multiple crop varieties, land fragmentation and crop diversification while average distance had a positive relationship with the choice of land fragmentation and multiple planting dates in the study area. Access to credit was negatively related with multiple crop varieties, land fragmentation, multiple planting dates and crop diversification in the study area. Policy initiatives should focus more on credit access and agricultural education that is skill-oriented than the common general education to enhance farmers level of use and choice of adaptation measures. Also, agricultural extension programmes that are demand-driven especially with major focus on climate change adaptation and mitigation should be put in place to help reduce the negative effects of climate change.

INTRODUCTION

Climate change is already affecting people, their livelihoods and ecosystems and presents a great development challenge for the global community in general and for the poor people in developing countries in particular (Khanal, 2009). This also presents major challenges to scientists, policy makers and other stakeholders. Clear impacts from climate change are being witnessed in agriculture. There have been noticeable impacts on plant production, insect, disease and weed dynamics, soil properties and microbial compositions in farming systems (Khanal, 2009; Rosegrant *et al*., 2008).

Nigerian agriculture is already under pressure to meet the demand of rising population using finite, often degraded soil and water resources, which are now further stressed by the impact of climate change (Awotoye and Mathew, 2010). As a result, it is of interest to stakeholders in the agricultural sector to understand the kind of impact climate change will have on food and crop production. There have undoubtedly been shifts in agro-ecological conditions that will warrant changes in processes and practices in order to meet daily food requirements. In addition, climate change could become a significant constraint on economic development in developing countries that rely on agriculture for a substantial share of gross domestic production and employment (Rosegrant *et al*., 2008).

The agro-ecological zones across the Southwestern Nigeria are guinea savanna, derived savanna, freshwater swamp forest, lowland rainforest, and mangrove forest and coastal land (Fasola, 2007). Some changes in agricultural practices might also be taking place across the agro-ecologies of the zone, in order to ensure food security in southwestern Nigeria, a region that feeds about 45 per cent of the nation's population (Awotoye and Mathew, 2010). Steps must be taken to reduce the negative effects of climate change on Nigeria agriculture, especially food crop production in Southwestern Nigeria.

There are two central ideas for dealing with climate change, namely, mitigation and adaptation. Adaptation to climate change is an adjustment made to human, ecological or physical system in response to vulnerability (Adger *et al*., 2007). Climate change adaptation through the modification or improvement of agricultural practices will be imperative to continue meeting the growing food demands of modern society (Rosegrant *et al*., 2008). Adaptation reduces the negative impact of climate change (Adger *et al*., 2003; Kurukulasuriya and Mendelson, 2006). Adaptation of agronomic techniques and farm strategies is already happening (CEC, 2009). The modification of agricultural practices and production in order to cope with climate change will be imperative in order to meet and continue meeting the growing food demands of Nigerians. Evidence shows that farming systems and farming technologies within the region have been changing in response to the effects of climate change (Adebayo *et al*., 2011). But it will be imperative to examine the factors influencing farmers choice of climate change adaptation strategies in the study area because this will help in knowing areas to address difficulties associated with formulation of policies focusing climate change *vis-à-vis* food security in the region. Hence the need for this study, multivariate analysis of factors that influence food crop farmers' adaptation strategies to climate change at farm-level in the rainforest agro-ecological zone of Southwestern Nigeria.

METHODOLOGY

Method of data collection:

Multistage sampling technique was used in the selection of respondents (food crop farmers). Ondo state was randomly selected from three south-western states (Ondo, Ogun and Osun) mainly dominated by rainforest agro-ecology. In addition, 3 extension blocks were randomly selected from each of the 2 agricultural zones in the state, making 6 extension blocks in all. Two (2) farming communities were then randomly selected from each extension block, making a total of 12 communities. In each community, with the assistance of the local extension personnel, a list of food crop farm households was compiled and then 15 farmers were randomly selected, making a sample size of 180 food crop farmers for the study.

Estimation procedure:

Data were analyzed using the multinomial logit (MNL) model. MNL was employed in the estimation of the determinants of the choice of climate change adaptation strategies by food crop farmers because it is widely used in adoption decision studies involving multiple choices and is easier to compute than its alternative, the multinomial probit (MNP) model. It specifies the following relationship between the probability of choosing option A_i and the set of explanatory variables X as (Greene, 2003):

$$\Pr(Y_i = j) = \frac{e\beta_j' x_{ij}}{1 + \sum_{m=0}^{6} e^{\beta_m x_{ij}}},\ j = 0,1,2,3,....\ 6$$

Where β_j is a vector of parameters that relates the socio-economic, farm and institutional characteristics x_i to the probability that $Y_i = j$. Because the probabilities of the six (6) main climate change adaptation strategies must sum to one, a convenient normalization rule is to set one of the parameter vectors, say β_0, equal to zero ($\beta_0=0$). The probabilities for the six (6) alternatives then become (Greene, 2000):

$$P_j = \Pr(Y_i = j) = \frac{e^{\beta_j' x_{ij}}}{1 + \sum_{m=0}^{6} e^{\beta_m \bar{x}_{ij}}},\ j = 1,2,3,....\ 6$$

The estimated parameters of a multinomial logit system are more difficult to interpret than those of a bivariate (or binomial) choice model. Insight into the effect that the explanatory variables have on the climate change adaptation strategies choice can be captured by examining the derivative of the probabilities with respect to the k^{th} element of the vector of explanatory variables. These derivatives are defined as (Greene, 2000):

$$\frac{\partial \Pr(Y_i = j)}{\partial x_{ik}} = P_j \left[\beta_{jk} - \sum_{m=0}^{6} \Pr(Y_i = m)\beta_{jk} \right] j = 0,1,....,\ 6; k = 1,...,\ k$$

Clearly, neither the sign nor the magnitude of the marginal effects need bear any relationship with the sign of coefficients. The Y_i is the probability of choosing a climate change adaptation strategy. The following are the main climate change adaptation strategies used among the food crop farmers with their assigned values; 1 for using different or multiple crop varieties; 2 for change in location of food crop farmlands/plots (i.e. land fragmentation/ land use planning); 3 for change in timing of operations/ change in planting dates (i.e. multiple planting dates); 4 for crop diversification (i.e. changes in crop mix); 5 for diversification of source of household income to unrelated off-farm employment (off-farm employment opportunities) and 6 for planting of cover crops (cover cropping).

RESULTS AND DISCUSSION

Factors that influence food crop farmers' adaptation strategies to climate change:

The estimation of the multinomial logit (MNL) model for this study was undertaken by normalizing one category, which is referred to as the "reference state," or the "base category." In this analysis, the base category is cover cropping. The result of the multinomial logit (MNL) model indicates that different socio economic factors (household size, age of the household head, years of education of household head, sex of the household head, and years of climate change awareness) farm-specific variables (farm size and average distance) and institutional variables (extension contact, tenure security, social capital and access to credit) affect the farmers' choice of the main farm-level climate change adaptation strategies in food crop production in the study area. Results of the

parameter estimates (the estimated coefficients along with the robust standard errors) from the multinomial logit (MNL) models are presented in Table 2.
The likelihood ratio statistic (as indicated by χ^2 statistic) is highly significant ($P < 0.0000$), suggesting that the model has a strong explanatory power. As indicated earlier, the parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable: estimates do not represent actual magnitude of change or probabilities. Thus, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases the estimated coefficients should be compared with the base category (cover cropping), this is only used as the reference point against which other climate change adaptation strategies are contrasted. Table 3 presents the marginal effects along with the z-ratios.

Household size

The result shows that there is a negative relationship between household size and the probability of choosing multiple crop types/varieties, land fragmentation, multiple planting dates and crop diversification as adaptation strategies as opposed to cover cropping among food crop farmers in the study area (Table 2). This implies that the smaller food crop families were able to choose these main climate change adaptation strategies except off-farm employment than the larger families in the rainforest agro-ecological zone. This shows that larger households chose cover cropping as climate change adaptation strategy probably because of the benefits that cover cropping provides to the soil. This result agrees with the finding of Birungi and Hassan (2010) which found out that household size is negatively related to adoption of fallow as land management technology in Uganda.

Education of the household head

Education is negatively and significantly related to the probability of choosing and using multiple planting dates, crop diversification and off-farm employment as compared to cover cropping (Table 2). The marginal effects in Table 3 indicates that a one-unit increase in education level (or years of education) would lead to 0.00550 (0.55%), 0.00281(0.28%) and 0.000161(0.16%) decrease in the probability of choosing and using multiple planting dates, crop diversification and off-farm employment respectively. It could be probably deduced that the education acquired by these farmers is not formal agricultural education; it is assumed that a farmer with formal agricultural education will be more likely to innovate due to the higher associated skill. Birungi and Hassan (2010) reported that education was negatively related to adoption of terracing and inorganic fertilizer as land management practices in Uganda and also the study of Bayard et al. (2006) found that education is inversely related to adoption of rock walls as soil conservation practice in Forte- Jacques.

Sex of the household head

Male-headed household had an inverse relationship with all the main climate change adaptation strategies (multiple crop varieties, land fragmentation, multiple planting dates, crop diversification and off-farm employment) as seen in Table 2. This means that female-headed households had a higher probability of choosing and using the main climate change adaptation strategies than the male-headed food crop farm households in the study area. This implies a unit increase in the male-headed would lead to a 4.67%, 4.24%, 2.16%, 5.83%, 0.26% and 0.76% respectively decrease in the probability of choosing and using multiple crop varieties, land fragmentation, multiple planting dates, crop diversification and off-farm employment (Table 3).

Average Distance

Average distance of the farms to the residents of the farmers' households is positively related to the probability of choosing and using land fragmentation and multiple planting dates in the study area (Table 2). It implies that long distance (i.e. remoteness of the food crop farmers' residents to their farms) permits the use of land fragmentation and multiple planting dates adaptation strategies to climate change in food crop production in the study area. This agrees with the study of Birungi and Hassan (2010) that found out that distance for plot to farmer's residence had positive relationship with adoption of fallow, inorganic fertilizer and terracing as land management practices in Uganda.

Extension contact

Extension contact/ services significantly and positively related with multiple crop varieties, land fragmentation (i.e. number of parcels of food crop farm) and crop diversification in the study area (Table 2). This result supports the innovation theory (Rogers, 1995) and also suggests that the food crop farmers in the Rainforest agro-ecological zone of Southwestern Nigeria have made use of these adaptation strategies (multiple crop varieties, multiple planting dates and land fragmentation) among other adaptation strategies probably because of their personal conviction as a result of advice received from extension personnel. Ogada *et al.* (2010) also found positive relationship between fertilizer intensity and extension contact in farm technology adoption in rain-fed semi-arid lands of Kenya; on adoption of adaptation measures in Southern Africa, Nhemachena and Hassan (2007) found a positive effect of free extension services on probability of adoption of different crops, different varieties, crop diversification, increase irrigation and increase water conservation and Ransom, *et al.* (2003) found that contact with extension significantly and positively affected adoption of improved varieties in hills of Nepal.

Access to credit

Access to credit had a negative effect on the probability of choosing and using multiple crop varieties, land fragmentation, multiple planting dates and crop diversification as climate change adaptation strategies (Table 2). This implies a marginal increase in access to credit would lead to a decrease in the probability of choosing and using multiple crop varieties, land fragmentation, multiple planting dates and crop diversification by 0.0164 (1.64%), 0.0675 (6.75%), 0.000475 (0.048%) and 0.0574 (5.74%) respectively (Table 3). But this contradicts innovation theory (Rogers, 1995).

Table 2: Factors that Influencing Climate Change Adaptation Strategies

Explanatory Variables	Coefficients				
	MLTCRPV	LANGFRAG	MLTPLNTDT	CRPDVER	OFFFMEMP -
Household Size	-0.297	-0.344	-0.536	-0.436	-0.0513
(number)	(0.132)**	(0.133)***	(0.169)**	(0.156)**	(0.184)
Age of Household	-0.0713	-0.109	-0.0709	-0.0626	-0.102
Head (years)	(-0.730)	(0.0731)	(0.0797)	(0.0780)	(0.781)
Years of Education	-0.279	-0.293	-0.367	-0.250	-0.337
	(0.121)	(0.123)	(0.144)**	(0.128)*	(0.178)*
Sex (Male)	-12.427	-12.469	-11.997	-11.201	-11.084
(1/0)	(1.294)***	(1.329)**	(1.833)***	(1.714)***	(1.617)***
Years of Climate	0.0120	0.0346	0.0569	0.333	-0.0458
Change Awareness	(0.0661)	(0.0685)	(0.070)	(0.0765)	(0.0951)
Farm Size (ha)	-0.109	0.197	0.187	0.282	0.0813
	(0.299)	(0.296)	(0.334)	(0.312)	(0.365)
Average Distance	0.502	0.599	0.664	0.408	-0.759
(km)	(0.201)	(0.193)**	(0.204)***	(0.263)	(0.666)
Extension Contact	0.119	0.157	0.115	0.152	0.116
(number)	(0.0702)*	(0.0701)**	(0.778)	(0.084)*	(0.112)
Tenure Security	-1.336	-1.104	-1.190	-0.613	-0.133
(1/0)	(1.357)	(1.365)	(1.469)	(1.631)	(1.661)
Social Capital	0.039	0.0411	0.0799	0.00364	-0.0945
(number)	(0.0432)	(0.0452)	(0.0537)	(0.0492)	(0.0987)
Access to Credit	-2.532	-2.292	-2.508	-3.305	-0.263
(1/0)	(1.141)**	(1.156)**	(1.294)*	(1.494)**	(1.991)
Constant	24.173	24.397	21.919	20.990	23.899
	(5.580)***	(5.580)***	(6.231)***	(6.118)***	(6.378)***
Number of Observations			**180**		
		Wald χ^2 (55) = 720.37			
		Prob > χ^2 = 0.0000			
		Pseudo R^2 = 0.1374			
		Log pseudo likelihood = -210.03154			

Note: MLTCRPV stands for multiple crop types/ varieties; LANDFRAG stands for land fragmentation; MLTPLNTDT stands for multiple planting dates; CRPDVER stands for crop diversification; OFFMEMP stands for off-farm employment; and CVRCRP stands for cover cropping.

Cover cropping (CVRCRP) is the base category. Figures in parentheses are the robust standard errors; *** denotes P ≤ 0.01, ** denotes 0.01<P≤0.05, while * denotes 0.05<P≤0.10

Source: Computed from field data.

CONCLUSION AND RECOMMENDATION

The study shows that the multinomial logit analysis revealed that household size negatively influences the use of multiple crop types or varieties, land fragmentation, multiple planting dates and crop diversification. Years of education attained by the respondents had a negative effect on the choice and use of multiple planting dates, crop diversification and off-farm employment as climate change adaptation strategies. Sex (male-headed household) had positive influence on the choice and use of multiple crop varieties, land fragmentation, multiple planting dates, crop diversification and off-farm employment among others. Policies initiatives should focus more on credit access to enhance farmers' input-procuring ability and agricultural education that is skill-oriented than the common general education to enhance farmers level of use and choice of adaptation measures. Also, agricultural extension programmes that are demand-driven especially with major focus on climate change adaptation and mitigation should be put in place to help reduce the negative effects of climate in the study area.

Table 3: Marginal Effects from Multinomial Logit (MNL) Analysis of Factors that Influence Climate Change Adaptation Strategies Used in Food Crop Production in the Rainforest Agro-ecological Zone of Southwestern Nigeria

Explanatory Variables	**Marginal Effects**					
	MLTCRPV	**LANGFRAG**	**MLTPLNTDT**	**CRPDVER**	**OFFFMEMP**	**CVRCRP**
Household Size (in number)	0.0216 (1.66)*	-0.00203 (-0.16)	-0.0136 (-2.34)**	-0.00750 (-1.23)	0.000914 (0.64)	0.000614 (1.73)*
Age of household head (years)	0.00599 (1.45)	-0.00838 (-2.15)**	0.000795 (0.37)	0.00151 (0.72)	-0.0000636 (-0.42)	0.000150 (1.20)
Years of Education	0.00429 (0.47)	-0.00196 (-0.22)	-0.00550 (-0.98)	0.00281 (0.74)	-0.000161 (-0.51)	0.000522 (1.44)
Sex[b] (male) (1/0)	-0.0467 (-0.31)	-0.0424 (-0.32)	0.02059 (0.30)	0.0583 (1.49)	0.00262 (0.54)	0.00761 (1.15)
Years of Climate Change Awareness	-0.00622 (-0.84)	0.00349 (0.53)	0.00227 (0.99)	0.000727 (0.22)	-0.000222 (-0.67)	-0.0000431 (-0.46)
Farm Size (ha)	-0.0790 (-2.17)**	0.0504 (1.74)*	0.0101 (0.90)	0.0184 (1.69)*	0.000134 (0.14)	-0.0000715 (-0.13)
Average Distance (km)	-0.0162 (-0.76)	0.0216 (1.26)	0.00903 (1.42)	-0.00940 (-0.81)	-0.00412 (-0.67)	-0.000969 (-1.27)
Extension Contact (number)	-0.00760 (-0.88)	0.00769 (1.29)	-0.00124 (-0.47)	0.00146 (0.40)	-0.0000553 (-0.15)	-0.000242 (-1.08)
Tenure Security[b] (1/0)	-0.0752 (-0.88)	0.0292 (0.39)	0.000455 (0.01)	0.407 (0.86)	0.00299 (0.40)	0.00189 (1.20)
Social Capital (number)	-0.000152 (-0.04)	0.000574 (0.15)	0.00278 (1.30)	-0.00270 (-1.30)	-0.000427 (-0.78)	-0.00715 (-0.72)
Access to Credit[b] (1/0)	-0.0164 (-0.18)	0.0675 (0.79)	-0.000475 (-0.01)	-0.0574 (-1.13)	-0.000536 (-0.12)	0.00733 (1.48)
Number of Observations			**180**			

(*b*) dy/dx is for discreet change of dummy variable from 0 to 1

Note: MLTCRPV stands for multiple crop types/ varieties; LANDFRAG stands for land fragmentation; MLTPLNTDT stands for multiple planting dates; CRPDVER stands for crop diversification; OFFMEMP stands for off-farm employment; and CVRCRP stands for cover cropping. Cover cropping (CVRCRP) is the base category. Figures in parentheses are z- ratios. *** denotes $P \leq 0.01$, ** denotes $0.01<P\leq0.05$, while * denotes $0.05<P\leq0.10$
Source: Computed from field data, 2011.

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