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FARMERS' ADAPTATION TO CLIMATE CHANGE IN KWARA STATE, NIGERIA

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ABSTRACT: The study examined farmers' adaptation to climate change in Kwara State. Primary data were collected with the aid of well structured questionnaire. Data were analyzed using descriptive statistics, principal component analysis and the multinomial logit analysis. Results show the mean age of sampled farmers is 52 years. The study shows that farmers' are largely aged and have no formal education. The planting of legumes, improved varieties and reduction in farm size were adopted by half of the farmers. Planting of leguminous crop and planting of improved variety. Irrigation and planting of canopy trees are the least used strategies. Education, economic and infrastructural factors are significant variables influencing the choice of adaptation options irrespective of the strategy. The use of farmer field schools is therefore important in improving adoption of adaptation strategies and provision of irrigation facilities is recommended.

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Key words: Adaptation, Climate change, Multinomial logit, Kwara State

INTRODUCTION

Agricultural production remains the main source of livelihoods for most rural communities in developing countries and sub-Saharan Africa in particular. The region has been severely affected by effects of climatic change, including floods and droughts due to predominant dependence on rain fed agricultural production (DFID, 2004). In Nigeria, agriculture provides a source of employment for more than 60 percent of the population and contributes about 30 percent to the country's Gross Domestic Product (World Bank, 2000; Sokona, 2001; CBN, 2002; Daramola 2004; CSD, 2008). Agricultural production is mainly rainfed with little irrigation practiced during the dry season.

Climate change is expected to have serious environmental, economic, and social impacts. In particular, rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse impacts. Changes in mean temperatures and rainfall, increasing weather variability and rising sea levels will affect the suitability of land for different types of crops and pasture, the health and productivity of forests, the incidence of pests and diseases, biodiversity and ecosystems. Loss of arable land is likely due to increased aridity, groundwater depletion and the rise in sea level (FAO, 2007).

The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change. Rural communities dependent on agriculture in a fragile environment will face an immediate risk of increased crop failure and loss of livestock. Climate change will have greater negative impacts on poorer households as they have the lowest capacity to adapt (Adger et al. 2003). Climate change will worsen the living conditions of farmers, fishers and forest-dependent people who are already vulnerable and food insecure. Hunger and malnutrition will increase.

The United Nations Framework Convention on Climate Change, refers to '*climate change'* as the change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. The Intergovernmental Panel on Climate Change (IPCC) has evolved its own usage of the term *climate change* as any change in climate over time whether due to natural variability or as a result of human activity (IPCC, 2001). The projections on surface air temperature and globally averaged sea level indicate that the warming would vary by region, and would be accompanied by increases and decreases in precipitation. In addition, there would be changes in the variability of climate, and changes in the frequency and intensity of some extreme climate events. These general features of climate change will have impacts on agro ecological systems. (Adejuwon, 2006)

In Nigeria, climatic variability, characterized by periodic droughts and floods affect those whose livelihoods depend on climatic variables especially in rural households. For a greater part of the 20th Century, there was a general trend towards aridity in Nigeria and the rest of West Africa (Adejuwon et al. 1990, Nicholson, 2001, Hulme, et al. 2001). In addition, poverty is still high especially in rural areas predisposing farming households to negative impacts of climate change. The impact of this environmental change on the livelihood of the rural populace who depend mostly on agriculture and agricultural related activities is a cause for concern. Consequently, if not mitigated, these households will fall or get locked in poverty. How vulnerable are these farmers to climate change? There is a dearth of literature on degree of vulnerability of farming households in the different agro-ecological zones in Nigeria. This study seeks to contribute to the assessment of the vulnerability profile of crop farmers and identify their adaptation strategies. This will help policy makers identify areas of intervention.

Objectives

- Identify households adaptation strategies
- Isolate the determinants of the choice of adaptation methods adopted by farmers

METHODOLOGY

Study Area

This study was carried out in Kwara state, Nigeria. Kwara state is in the North Central region of Nigeria. It has a land area of about 32,500sq.km and a population of about 2.6 million as at 2005 (NPC, 2006). The state has sixteen local governments and three agro-ecological zones namely the Derived savannah, Guinea Savannah and Rainforest. The local government areas and their agroecological zones are in Appendix 1. There are two main seasons; the rain season is from April to October while the dry season starts from November to March. The natural vegetation consists broadly of rain forest and wooded savannah. The annual rainfall ranges from 1,000-1,500mm, while maximum average temperatures range between 30℃ and 35℃. With this climatic pattern and sizeable expanse of arable and rich fertile soils, the vegetation is well suited for the cultivation of a wide variety of food crops like; yams, cassava, maize, beans, rice, sugarcane e.t.c.

Source and Type of Data

Primary data was employed for this study with the aid of well structured questionnaire. Data was obtained from rural farming households which include their socioeconomic characteristics and adaptation strategies adopted sampled farmers.

Sampling technique

A multi stage sampling technique was employed to select respondent for the adaptation study. The state has sixteen local government areas are stratified into four zones (A, B, C, D) by the state's Agricultural Development Project (KWADP). The four zones formed the sample frame. The second stage involved the selection of 5 villages from each of the four zones to represent the different agro-ecological zones in the state. The last stage was the random sampling of six (6) food crop farmers based on the probability proportional to size in the 20 villages selected. Thus, a total sample of 120 respondents was selected.

Analysis of the Determinants of Farmers' Choice of Adaptation Methods

In determining factors influencing farmers' choice of adaptation methods, this study adopts the methodology used by Deressa et al (2008). The methodology follows a similar consideration to that of technology adoption. The decision on whether or not to adopt a new technology (an adaptation method) is considered under the general framework of utility or profit maximization (Norris and Batie, 1987; Pryanishnikov and Katarina, 2003). It is assumed that smallholder subsistence farmers use adaptation methods only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Although utility is not directly observed, the actions of the farmer are observed through the choices they make.

Suppose that Y_j and Y_k represent a household's utility for two choices, which are denoted by U_j, and U_k, respectively. The linear random utility model could then be specified as:

$$U_j = \beta_j X_i + \varepsilon_j \text{ and } U_k = \beta_k X_i + \varepsilon_k \quad (1)$$

where U_j and U_k are perceived utilities of adaptation methods j and *k*, respectively, X_i is the vector of explanatory variables that influence the perceived desirability of the method, β_j and β_k are parameters to be estimated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Green, 2000). In the case of climate change adaptation methods, if a household decides to use option j, it follows that the perceived utility or benefit from option j is greater than the utility from other options (say *k)* depicted as:

$$U_{ij} = (\beta_j X_i + \varepsilon_j) > (U_{ik} (\beta_k X_i + \varepsilon_k), k \neq j \quad (2)$$

The probability that a household will use method j among the set of climate change adaptation options could then be defined as :

$$P(Y=1|X) = P(U_{ij} > U_{ik}) \quad (3)$$
$$P(\beta_j X_i + \varepsilon_j - \beta_k X_i - \varepsilon_k > 0 | X)$$
$$P(\beta_j X_i - \beta_k X_i + \varepsilon_j - \varepsilon_k > 0 | X)$$
$$P(X^* X_i + \varepsilon^* > 0 | X = F(\beta^* X_i)$$

where P is a probability function, U_{ij} U_{ik} and X_i are as previously defined . $\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term, $\beta^* = (\beta_j - \beta_k)$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing adaptation, and $F(\beta^* X_i)$ is a cumulative distribution function of ε^* evaluated at $B^* X_i$. The exact distribution of F depends on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Green 2000).

Empirical Model

The multinomial logit (MNL) model was used to analyze adaptation choices following Kurukulasuriya and Mendelsohn, 2006. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Madalla 1983; Wooldridge 2002). Koch (2007) also emphasizes the ease of interpreting estimates from this model.

In the MNL model, let y denote a random variable taking on the values {1, 2...J) for j ,a positive integer, and for this study it represents the adaptation options., Let x denote a set of explanatory variables. How do cetris paribus changes in x affect the response probabilities P(y= j/x), j= 1, 2… J. Since the probabilities must sum to one, P(y = j/x) is determined once we know the probabilities for j =2 …….J.

Let X be an l x K vector with first variable one, the MNL model has response probabilities as follows:

$$P(y = j \mid x) = \exp(x\beta_j) / \left[1 + \sum_{j=1}^{j} \exp(x\beta j), \; j = 1.......J\right] \quad (4)$$

Where B_j is K x 1, j =1………J.

The adaptation methods most commonly cited in literature include the use of new crop varieties more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, change of planting dates, diversification from farm to nonfarm activities, irrigation and soil conservation techniques, changed use of capital and labor, and trees planted for shade and shelter (Bradshaw et al 2004; Kurukulasuriya and Mendelsohn, 2006a; Maddison, 2006; Nhemachena and Hassan, 2007). The adaptation options that will be used for this study will be based on asking farmers about their perceptions of climate change and the actions they take to counteract the negative impacts of climate change

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change nor probabilities. Differentiating equation (4) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial P_j}{\partial x_k} = P_j(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}) \quad (5)$$

The marginal effect or marginal probabilities are functions of the probability itself and measures the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green 2000; Koch 2007).

The explanatory variables hypothesized to affect the adoption of an adaptation option are:

a. Socio economic factors

- Gender (Male=1, 0= female);- Age (years);-Education in years; -Household size; -Farmers' experience in years

b. Wealth/ Financial

-Farm income (Naira); -Livestock ownership (1= own livestock and 0 otherwise);

c. Institutional factors

-Information on climate change (1= Yes and 0 = No); -Access to credit (1= Yes and 0 = No)

-Distance to market (km)

d. Social Capital

-Belong to farmers association (1= Yes and 0 = No)

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Farm Households

As typical in African farm households, males constitute 77% of the household heads representing about three quarters of all. About sixty percent of the farmers are 50 years and above. The mean age is 52 years. It is evident that more than half of the farmers are aged with almost 38% above 60 years. This implies that they will not be willing to take risky innovative options to adapt to climate change. Seventy seven percent of the farmers have no formal education and this reveals the poor literacy level of the farmers in the area. Nonetheless, their household sizes are not large with a mean of about four. About 90 percent have household sizes that are not more than six. This implies that the farmers are mostly aged, illiterate with relatively small household size. The primary occupations of these farmers are distributed between agriculture, non-agriculture and services. Although 38.2% are primarily farmers, others are into farming as a secondary activity. With other sources of livelihoods, most of the farmers will be able to mitigate the effect of climate change from other sources of income. The farmers are mostly from the guinea and derived savannah while only 5% are from the rainforest.

Table 1: Socio-Economic Characteristics of Farmers

Category	Frequency	Percentage (%)
Gender		
Male	220	77.2
Female	65	22.8
Age		
0-19	1	0.4
20-39	56	19.6
40-49	55	19.3
50-59	65	22.8
>=60	108	37.9
Household Size		
1-3	132	46.3
4-6	126	44.2
7-9	22	7.7
>9	5	1.8
Educational Attainment		
No formal education	218	76.5
Primary education	25	8.8
Secondary education	25	8.8
Tertiary education	17	6.0
Primary Occupation		
Agriculture	109	38.2
Non- agriculture	99	34.7
Services	77	27.0
Agro-ecological Zone		
Guinea savannah	134	47.0
Rainforest	15	5.3
Derived savannah	136	47.7

N= 285 Mean age: 52.02±14.634 Mean household size: 3.82±2.148

Adaptation to Climate Change

About three quarters of the farmers have adopted at least one adaptation strategy. Only 22.5 percent did not adopt any at all. The planting of legumes, improved varieties and reduction in farm size were adopted by half of the farmers. Other common strategies are crop diversification, diversification to non-farm activities and planting of improved varieties. Some others are not common and include mixed farming, irrigation and planting of canopy trees. Irrigation and planting of canopy trees are the least used strategies in the area.

Table 2: Adaptation Strategies

Adaptation Options	Frequency	Percentage (%)
Use of cover crop	38	31.7
Planting of leguminous crop	65	54.2
Mulching	47	39.2
Planting of canopy trees	16	13.3
Planting of improved varieties	62	51.7
Irrigation	30	25.0
Crop diversification	55	45.8
Mixed farming	33	27.5
Changing planting date	50	41.7
Diversification to non-farm activities	58	48.3
Water and Soil conservation	30	25.0
Reduction in farm size	70	58.3
No adaptation	27	22.5

N= 120

Determinants of adaptation options

Based on the information about adaptation choices, the choice sets considered in the adaptation model having the highest percentage which are: Planting of leguminous crop, planting of improved variety, crop diversification, changing planting date, diversification to nonfarm activity, reduction in the use of farm size and use of cover crop. The multinomial regression estimate shows that education is a significant variable influencing the choice of adaptation options irrespective of the strategy. This shows that farmer's education is important in addressing the challenges of climate change. The use of farmer field schools is recommended in view of the fact that most that the mean age is 52 years. The distance to the market is also significant followed by ownership of livestock and the farm income. These factors will increase the probability of adopting strategies to mitigate climate change negative impacts. Farmers' experience affected the adoption of change in planting date and the planting of improved varieties. These are conventional methods that farmers have known over the years and with experience, they will like to continue the practice. However the gender, age and household size of the farmers were not significant variables in their adaptation strategy choices. This shows that socio-demographic variables are not significant in the state as education, economic and infrastructural factors. The government therefore should enhance these factors.

Table 7: Marginal Effects of the Determinants of Adaptation Options

Variables	**Planting of improved varieties**	**Crop diversification**	**Changing Planting date**	**Diversification to non-farm activities**	**Reduction in the use of farm size**	**Use of cover crop**	**Mulching**
Gender	0.1451 (0.1788)	0.17608 (0.1542)	0.0925 (0.1675)	0.0257 (0.1854)	-0.0719 (0.1916)	0.0041 (0.1542)	-0.2226 (0.1709)
Age	-0.0139 (0.0098)	-0.0032 (0.0092)	-0.0156 (0.0102)	0.0007 (0.0099)	-0.0051 (0.0110)	0.0095 (0.0085)	-0.0172* (0.0094)
Household size	0.3260* (0.1874)	0.3128* (0.1845)	-0.1104 (0.1821)	-0.0185 (0.1850)	0.2404 (0.2188)	-0.0876 (0.1454)	0.1876 (0.1647)
Education in years	0.0373*** (0.0112)	0.0006 (0.0099)	0.0374*** (0.0111)	0.0390*** (0.0111)	0.0509*** (0.0125)	0.0067 (0.0088)	0.0299*** (0.0100)
Farmer's experience in years	0.0268* (0.0160)	-0.01552 (0.0146)	0.0314** (0.0153)	0.0174 (0.0144)	-0.0113 (0.0147)	-0.0041 (0.0119)	0.0158 (0.0131)
Income	0.0242 (0.0000)	0.3240 (0.0000)	0.4690 (0.0000)	0.972 (0.0000)	0.106** (0.000)	0.352 (0.0000)	0.36 (0.0000)
Livestock ownership	-0.1766 (0.1155)	-0.2187* (0.1144)	-0.0639 (0.1206)	-0.2267** (0.1166)	-0.3144*** (0.1039)	-0.2042* (0.1112)	0.0371 (0.1109)
Credit access	-0.1514 (0.3096)	-0.0533 (0.3244)	0.0000	-0.1509 (0.3202)	0.0000	0.0532 (0.2440)	0.1133 (0.2730)
Belong to farmer's association	0.1307 (0.1408)	-0.0495 (0.1389)	-0.2310 (0.1425)	-0.1636 (0.1382)	-0.0075 (0.1500)	0.0446 (0.1197)	-0.0441 (0.1365)
Information on climate change	-0.0248 (0.1390)	-0.1568 (0.1293)	-0.0690 (0.1460)	-0.1067 (0.1389)	-0.2458** (0.1104)	0.1539 (0.1003)	0.0957 (0.1264)
Distance to market	-0.0063 (0.0514)	0.0792 (0.0500)	0.0665 (0.0537)	-0.0134 (0.0516)	-0.1127** (0.0563)	-0.1165*** (0.0473)	0.0320 (0.0481)

***, **, * represent 1%, 5% and 10% significant level respectively.

Conclusion and recommendation

The study shows that farmers' are largely aged and have no formal education. Two third of the farmers are found to be vulnerable to climate change with more in the Guinea savannah and derived savannah. The planting of legumes, improved varieties and reduction in farm size were adopted by half of the farmers. Planting of leguminous crop, planting of improved variety, crop diversification, changing planting date, diversification to nonfarm activity, reduction in the use of farm size and use of cover crop are common adaptation strategies. Irrigation and planting of canopy trees are the least used strategies. Education is a significant variable influencing the choice of adaptation options irrespective of the strategy. This shows that farmers' education is important in addressing the challenges of climate change. The use of farmer field schools is therefore important in improving adoption of adaptation strategies.

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Appendix 1:

Table A1 showing Local government Areas and Agro-ecological zones

Agro-ecological Zones	Local Government Areas
Guinea Savannah	Asa, Edu, Baruten, Moro, Kaiama, Pategi
Rainforest	Oyun, Offa, Ekiti
Derived Savannah	Ilorin East, Ilorin South, Ilorin west, Irrepodun, Ifelodun, Oke-ero

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