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PERCEPTION AND ADAPTATION OF CROP FARMERS TO CLIMATE CHANGE TO IN NIGER STATE, NIGERIA

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ABSTRACT

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This paper analysed farmers' perception and examined the vulnerability and adaptation of crop farmers to climate change in Niger State, Nigeria. Primary data were used in the study obtained through a cross sectional survey. Questionnaire was used to elicit relevant information from the respondents. Data collection lasted for two months: that is from September 2014 to November 2014. Multi-stage sampling technique was used to elicit data from 280 respondents. Data analysis was done using descriptive statistics, Ordered Probit and Multinomial Regression logit models. Results showed that all the respondents were aware of climate change phenomenon. 49.7% of the sampled population were vulnerable at high and very high levels of vulnerability while 50.3% were vulnerable at low and very low levels of vulnerability. Adaptation measures used include early planting, weeding, tillage operation, changing timing of land preparation and harvesting dates, conservation, migration and wind breaks. The results show that access to credit, household size, membership of association, farm size, number of hazards and topography were significant factors affecting vulnerability to climate change. Moreover, increased use of agrochemicals, household size, hired labour education and extension visits were factor that significantly influenced the choice of adaptation measures. The study concluded that farmers in the study area were employing one or more adaptation techniques to mitigate the adverse effects of climate change. They were vulnerable to climate change because they were lacking socio-economic attributes that could make them less vulnerable to climate change. The study recommends making available credit facilities to farmers in order to enhance their farm incomes to enable them employ adaptive measures that could be effective in alleviating negative impacts of climate so as to reduce their vulnerability to climate change. The need also for the farmers to belong to organized farmer groups to increase their chances of access to agricultural credit is imminent.

Keywords: *Perception, Adaptation, Crop farmers, Climate change*

INTRODUCTION

The term "climate change" often refers to changes in climate which according to the Intergovernmental Panel on Climate Change IPCC (2007), are 90-95% likely to have been in part caused by human action. It describes changes in the variability of average state of the atmosphere over time scales, ranging from a decade to millions of years (Adejuwon, 2004). Swings in the global climate pattern have aroused attention at local, national and international levels (Onyeneke, 2010). Moreover, climate change is expected to increase with increased frequency and intensity of extreme weather conditions in Nigeria's coastal and rainforest regions (Babatunde *et al.*, 2011). The implications for the region are that it would generally experience wetter than average climate, more extreme weather conditions, particularly erosion, sea level rise and floods (Onyeneke *et al.*, 2012).

It is accepted today that the temperature of the earth's surface has increased by an average of about 0.3 to 0.6oC since the end of the 19th century. The 1990s had seven of the ten hottest years of the 20th century. The sea level also rose by an average of 10 to 25 cm during the past one hundred years, and this is, to a large extent, due to the increase in the average world temperature (ECA, 2008). Agriculture places heavy burden on the environment in the process of proving humanity with food and fiber, while climate is primary determinant of agricultural productivity. Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity. Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade (Lobel *et al*, 2008; Wolfe *et al*, 2005; Fischer *et al*, 2002).

Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain. It is evidence that climate change will have a strong impact on Nigeria-particularly in the area of agriculture; land use, energy, biodiversity, health and water resources. Nigeria, like all other countries of sub-saharan Africa, is highly vulnerable to the impacts of climate change (IPCC 2007; NEST, 2004). It was also noted that Nigeria specifically ought to be concerned about climate change because of country's high vulnerability due to its long (800 km) coastline that is prone to sea-level rise and the risk of fierce storm. Many parts of the country now experience warmer conditions compared to the period thirty years ago. Evidence of climate variability and climate change in Nigeria are indicated by increasing surface air temperature; increasing heat waves which enhances disease vectors, communicable diseases and epidemics; sea level rise and associated coastal erosion, flooding, saltwater intrusion and mangrove degradation.(NEST, 2004). The objective of the study were to ; determine the level of awareness and perception of crop farmers to climate change;

determine the level of vulnerability of the farmers to the effect of climate change and to analyse the determinants of vulnerability of crop farmers to the effect of climate change in the study area.

METHODOLOGY

The study was conducted in Niger State, Nigeria. The State was named after the River Niger with its capital at Minna, and it is located in the North central zone of Nigeria. It was created out of the defunct North western State. The State lies in the Guinea savanna vegetation belt of the country with favourable climatic condition for crop and livestock production. The location of the State is between Latitudes 8° 20' and 11° 30' N and between Longitudes 3° 30' and 7° 20' E. The provisional result of the 2006 National Population Census showed that the State had a population of 3,950,249 (NPC, 2006). Going by the population growth rate in Nigeria of 2.5% (World Bank, 2013).

Multi-stage sampling method was used in the selection of respondents for this study. The first stage involved the random selection of one Niger State Agricultural Mechanization and Development Authority (NAMDA) zone out of the three zones. In the second stage, three (3) Local Government Areas (LGAS) were purposively selected out of the total number of eight (8) LGAs in the Zone. They are Agaie, Bida, and Mokwa LGAs in Zone I. The purposive selection was based on the dominant cropping enterprises in each of the LGAs. The samples were drawn from the frame. The third stage involved a random selection of three (3) villages from each of the LGAs giving a total of nine (9) villages. The fourth and final stage involved a selection of crop farming households from each village. Data were obtained through a cross-sectional survey. Primary data was collected through questionnaire dissemination on the socioeconomic characteristics of respondents such as age, household size, marital status, gender, level of education and years of experience in crop production. Others are their level of awareness about climate change phenomenon, their perceptions of adaptation measures to mitigate climate change and factors responsible for the choice of adaptation method. The study employed Ordered probit as a generalization of the popular probit analysis to the case of more than two outcomes of an ordinal dependent variable. The model cannot be consistently estimated using ordinary least squares. It is usually estimated using maximum likelihood estimation procedure.

The model is built around a latent variable following Greene (2003) given as:

$$Y^* = \beta 1 \; x \; i + \mu i, \; (i = 1,2,3 \ldots\ldots n) \ldots\ldots\ldots(1)$$

Where, Y^* is unobserved latent variable for level of land degradation which is ordered,

$\beta 1$ is a vector of coefficients of explanatory variables (X_1) to be estimated.

The parameter estimate $\beta 1$ represents the effect of explanatory variables on the underlying order of status/severity and μi is the disturbance term.

The dependent variable Y is categorized into very high = 4, High = 3, Low = 2 and Very low = 1.

The explanatory variables are:

X1 = Age of crop farmer (Years)
X2 = Household size (Number of persons).
X3 = Level of education (Number of years spent in school).
X4 = Gender of the household Head (Male = 1, Female =2).
X5 = Access to credit (Amount in Naira).
X6 = Membership of association (Member = 1, Non-member = 0).
X7 = Level of income (Farm and Non-farm) (N)
X8 = value of assets (N).
X9 =Farming experience (Number).
X10 = Access to warning information (Access = 1, otherwise = 0).
X11 = Farm size (Hectares).
X12 = Frequency of hazards (Number of hazards faced).
X13 = Topography of Farm Land (highland = 3, midland = 2, lowland = 1).

The first stage of analysis was the descriptive analysis of the socioeconomic and environmental characteristics that describe the adaptive capacity, sensitivity and exposure of crop farmers and the use of Principal Component Analysis (PCA) to obtain the component so as to avoid uncertainty of equal weighting given the diversity of indicators to be used (Deressa *et al.*, 2008).

Multinomial logit model was used to analyze the factors responsible for the choice of climate change adaptation measure.

Following Yusuf (2013), the farmers were categorized based on the type of adaptation measures adapted into five (5) categories. The adaptation measures include:

Use of a weather-resistance varieties.
Changing planting and harvesting dates.
Changing tillage operations.

Planting tree crops
Increased use of agrochemicals (insecticides)
The multinomial logit model is specified as:

$$\Pr(Y_i = j) = \frac{\exp(\beta_j X_i)}{\left[1 - \sum_{j=1} \exp(\beta_j X_i)\right]} \quad \ldots\ldots\ldots\ldots (6)$$

Where, Yi = observed outcome of the individual, Xi = a vector of explanatory variables,
β = unknown parameters to be estimated
j = adaptation measure and
□ = summation sign
The probability of adapting each of the measures
(Pij¬) is given as :

$$P_{ij} = \frac{\exp(\gamma_j X_i)}{\left[1 + \sum_{j=1}^{8} \exp(\gamma_j X_i)\right]} \quad \text{For } j = 1,2,3,\ldots\ldots\ldots.(3)$$

$$P_{ao} = \frac{1}{\left[1 + \sum_{j=1}^{8} \exp(\gamma_j X)\right]} \quad \text{For } j = 1, 2, 3,\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The probability of being in group 10 (reference group) is given as

$$P_{ao} = \frac{1}{\left[1 + \sum_{j=1}^{9} \exp(\gamma_j X)\right]} \quad \text{for } j = 9\ldots\ldots\ldots\ldots.(4)$$

Rahji and Fakayode (2009) and Yusuf (2013) affirmed that the coefficients of the reference group have to be normalized to zero because the probability for all choices must sum up to unity. Therefore, for 10 choices, only (10-1) distinct set of parameters can be identified and estimated.
The multinomial logit model is built on the assumptions of Independence Irrelevant Alternatives (IIA). Significant X^2 values indicate the violation of the IIA assumptions.
The empirical Multinomial Logit model is specified implicitly as:
Yi = f (X1, X2, X3, X4, X5, X6, X7, X8, X9, X10, X11, X12, X13, X14,)
Where,
Yi = dependent variables (adaptation categories which are ten (10), as earlier defined.)
X = array of explanatory variables (regressors) for the jth individual.
Where,
X1 = sex of farmers (1 = male. 0 = female),
X2 = age of the farmers (years),
X3 = household size (no. of persons),
X4 = farming experience (years),
X5 = educational level (years),
X6 = access to extension facility (no. of times visited),
X7 = amount of credit facility (amount in Naira),
X8 = annual farm income (N),
X9 = farm size (hectares)
β0 = constant term
β1- β14 = respective parameters to be estimated.
The estimated regression coefficient for each choice represents the effects of Xi's on the likelihood of the farmer choosing that alternative Green (1993).

RESULTS AND DISCUSSIONS

Factors responsible for the choice of adaptation measures by respondents

The results of the Multinomial Logit analysis showing the factors responsible for the choice of adaptation measures among respondents in the study are presented in Table 1. The estimation proceeded with respondents who adopted increased use of agrochemicals as the reference group. This is because, majority (41.4%) of the respondents used increased agrochemicals as adaptation measure. Thus, the inference from the estimated coefficients for each group was made with reference to group 5. A likelihood ratio value of -329.886 was obtained and significant at 0.01 probability level. This result confirms that all the slope coefficients are significantly different from zero. The Pseudo R^2 value of 0.2131 further confirms that all the slope coefficients are not equal to zero. The implication of this is that, the explanatory variables collectively are significant in explaining the choice of adaptation in the study area. The results of the analysis are explained in terms of significance and signs of the parameters. The results in Table 1 indicated that the set of significant explanatory variables varied across the classified groups in terms of the signs and levels of significance. Thus, the household size, and education with estimated coefficients of 0.1893, 0.2846 and -0.2227 are positive and significantly associated with the classification of the other groups relative to the reference group. On the contrary, the negative coefficients for education under changing tillage operations, hired labour under use of weather resistant varieties and extension visits, implies that the probability of the farmers adapting these measures decreased with farmers' education, use of hired labour and the number of extension visits.

Table 1: Estimated Multinomial Logit Model for factors responsible for the choice of Adaptation Measures among Respondents

Variables	Use of Weather Resistant Varieties (Group 1)	Changing Planting and Harvesting Dates (Group 2)	Changing Tillage Operations (Group 3)	Planting Tree Crops (Group 4)	Increased use of Agrochemicals (Reference Group 5)
Sex	0.6619 (0.87)	0.5333 (0.71)	-17.1017 (-0.00)	-14.9997 (-0.00)	30.9062
Age (years)	0.0152 (0.50)	0.0129 (0.43)	0.0070 (0.12)	0.0735 (0.78)	-0.1086
Household Size (number)	0.0264 (0.69)	0.0441 (1.25)	0.1008 (1.70)	0.1893 (2.71)***	-0.3606
Experience (years)	0.0136 (0.49)	0.0437 (1.64)	0.0593 (1.21)	-0.0054 (-0.07)	-0.1112
Education (years)	0.10962 (1.90)*	0.0069 (0.12)	-0.2227 (-1.95)*	-0.0086 (- 0.05)***	0.11478
Extension visits (number)	0.0301 (0.31)	-0.3912 (-3.05)***	-12.819 (-0.02)	-0.6104 (-1.13)	13.7905
Amount of credit (Naira)	0.0000 (0.31)	0.0000 (0.50)	-0.0003 (-0.00)	-0.0003 (-0.00)	0.0006
Ave. Monthly income (Naira)	0.0000 (0.21)	-0.0001 (-0.47)	-0.0001 (-1.52)	0.0000 (0.25)	0.0000
Farm Size (Ha)	-0.2395 (-1.69)	-0.065 (-0.47)	0.2143 (0.71)	-0.0700 (-0.18)	0.1602
Constant	-1.1899 (0.58)	-1.5953 (-0.78)	11.9927 (0.00)	20.6338 (0.00)	-29.8613

Diagnostic Statistics
Number of Observations =280; Log Likelihood = -329.886; LR Chi-square = 84.12; Prob > = 0.0003; Pseudo R Squared = 0.213;
Source: field survey, 2015
***, ** and * Represents statistical significance at 0.01; 0.05 and 0.10 probability levels respectively.
Number in parenthesis are z-values

Table 2: Marginal effects and the quasi-elasticity estimates

Variables	Use of Weather Resistant Varieties (Group 1)	Changing Planting & Harvesting Dates (Group 2)	Changing Tillage Operations (Group 3)	Planting Tree (Group 4)	Increased Use of Agrochemicals (Reference Group)
Education (Years)	0.0195 (-0.2894)	0.0025 (0.0368)	-0.0103 (-0.4740)	-0.0012 (-0.1926)	-0.0144 (-0.1487)
Extension Visits (Nos.)	0.0343 (0.1251)	-0.0572 (-0.2611)	0.0000 (0.0001)	-0.0111 (-0.4611)	0.0431 (0.0888)
Hired Labour (Man-days)	-0.0110 (-0.0734)	0.0069 (0.0416)	0.0179 (0.2250)	-0.0001 (-0.0052)	0.0010 (0.0037)
Household Size (Nos.)	0.0031 (0.1313)	-0.0013 (-0.0523)	0.0027 (0.3046)	0.0043 (-1.7797)	-0.0075 (-0.2002)

Source: Field Data, 2015
Marginal effects are indicated above while partial elasticity's are in parentheses

Marginal effects and quasi-elasticity

The marginal effects and the quasi-elasticities were also computed and the results are presented in Table 2. The computations were done for the significant variables only. The significant variables affect the probability of choosing an adaptation measure by the respondents in their decision making process. Ojo (2012) used the quasi-elasticities rather than the marginal effects given that they are easier to interpret and made inferences. Thus, the partial elasticities of farmers' educational status, extension visits, hired labour and household size were inelastic being less than one, implying that a 1% change in these explanatory variables yielded a less than proportionate change in the probability of classification into the four other groups relative to the reference group. Given that these variables were inelastic for the reference group, it thus implies that the probability of classifying the farmers into any particular adaptation group is not hugely affected by the marginal changes in these variables, as 1% change in these variables led to a less than proportionate change in the probability of categorization of the farmers into any of the adaptation groups.

Table 3: Distribution of Respondents' According to Awareness of Climate Change

Variable	Frequency	Percentage
Awareness of Climate Change		
Yes	280	100
No		
Total	280	100
Awareness of Change in Rainfall Pattern		
Yes	280	100
No		
Total	280	100
Pattern of Rainfall Change		
Increase	230	82.1
Decrease	43	17.9
No Change		
Awareness of Temperature Change		
Yes	280	100
No		
Total	280	100.0
Pattern of Temperature Change		
Increase	191	68.2
Decrease	33	11.8
No Change	56	20.0
Total	280	100.0

Source: Field Survey, 2015

Climate change awareness

The respondents' distribution according to awareness of climate change is presented in Table 3. The awareness dimensions were categorized into awareness of climate change, awareness of change in rainfall pattern, pattern of rainfall and temperature change. Results indicated that all the respondents (i.e. 100%) were aware of climate change phenomenon. In the aspects of pattern of rainfall change, 82.1% of the respondents agreed rainfall increased, 17.9% agreed it decreased. Also, all the respondents (i.e. 100%) in the study area were aware of temperature change and in the aspect of temperature pattern, 68.2% of the respondents agreed it increased, 11.8% agreed it decreased and 20.0% of the respondents agreed there was no change. This implies that majority of the sampled respondents were aware of climate change. Therefore, it was easier for the sampled respondents to adapt climate change sustainable strategies. This is in line with the results of a study by Deressa *et al.* (2008) that education increases climate change awareness and the likelihood of soil conservation and changing planting dates as an adaptation method.

Perception of respondents on the effects of climate change

Respondents indicated varying levels of perceptions with regards the effects of climate change on their socio-economic activities, covering farm production, input cost, high commodity prices, food insecurity and livestock mortality, amongst others. Results in Table 4, revealed that respondents perceived climate change as contributing to low productivity of their crop enterprises, having ranked first with a mean of (3.35). High cost of production inputs ranked second with a mean of (3.25), while increased production cost ranked fourth with a mean of (3.05). It is possible that negative climatic outcomes may have hindered farmers' production enterprise, particularly, output and yield, thus, causing farmers to incur additional costs on basic inputs like seeds and hiring of additional labour with a view to redressing the negative occurrences .This is in line with the findings of Ifeanyi *et al.* (2012) who noted that adverse climate effects can influence farming outputs at any stage from cultivation through the final harvest.

Table 4: Perception on effects of climate change by respondents

Perception on Effect of climate change	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	%	Total Sum	Weighted Mean	Decision
Low Productivity	42 (15.0)	112 (40.0)	28 (10.0)	98 (35.0)	0 (0.0)	100	938	3.35	Agree
Increased Production Cost	14 (5.0)	98 (35.0)	56 (20.0)	112 (40.0)	0 (0.0)	100	98	3.05	Agree
High Cost of Inputs	28 (100.0)	112 (40.0)	42 (15.0)	98 (35.0)	0 (0.0)	100	910	3.25	Agree
Food insecurity & Food shortage	42 (15.0)	28 (10.0)	28 (10.0)	182 (65.5)	0 (0.0)	100	770	2.75	Disagree
Poor Standard of Living	14 (5.0)	112 (40.0)	14 (5.0)	126 (45.0)	14 (5.0)	100	826	2.95	Disagree
Death of Livestock	0 (0.0)	56 (20.0)	42 (15.0)	126 (45.0)	56 (20.0)	100	658	2.35	Disagree
Increase in Food Prices	0 (0.0)	84 (30.0)	56 (20.0)	70 (25.0)	70 (25.0)	100	714	2.55	Disagree

Source: Extracted from Survey Data, 2015
Values in parentheses are the respective percentages

Table 5: Respondents level of awareness vulnerability to climate change

Level of awareness	Frequency	Percentage
Very low	55	19.6
Low	86	30.7
High	108	38.6
Very High	31	11.1
Total	280	100.0

Source: Field Survey, 2015

Level of vulnerability to climate change

Using the Principal Component Analysis (PCA), vulnerability categorization was done for respondents. Vulnerability to climate change was profiled across farmers' socio-economic characteristics, climatic variables, perception of climate change and perception on adaptation. The first stage of the analysis was the descriptive analysis of the socio economic and environmental factors that describe the adaptive capacity, sensitivity and exposure and the use of PCA to obtain the components so as to avoid the uncertainty of equal weighting given the diversity of indicators used. Variables used to measure vulnerability are adaptive capacity, sensitivity, and exposure. The second stage of the analysis involved categorizing the respondents according to five different levels of vulnerability. The vulnerability levels of respondents are presented in Table 5. The levels of vulnerability of respondents were categorized into very low, low, high, and very high levels. Results in Table 5, revealed that 19.6% of the respondents experienced very low level of vulnerability, 30.7% had low, 38% had high level while 11.1% had very high levels of vulnerability in the study area. This is in line with the findings of Madu (2012) who found that respondents were generally vulnerable to climate change. This study also corroborate with the findings of Freeman et al., (2014) who found that farmers with no formal education were more vulnerable than those with formal education, and revealed that older farmers tended to be less vulnerable to climate change.

Ordered probit regression result on determinants of vulnerability to climate change

The determinants of vulnerability were analysed using Ordered Probit regression analysis. The results of the regression analysis are presented in Table 6. The results showed that access to credit, household size, membership of association, farm size, number of hazards, and topography were the significant factors affecting respondents' vulnerability to climate change. Household size was significant at 10% with a regression coefficient of 0.267. This implies that if household size was increased by 1% holding other variables constant, there is the likelihood that vulnerability will increase by 0.267%.

Access to credit had an estimated coefficient of 9.870e-06 and was significant at 10%. This implies that farmers having access to credit are more likely empowered to acquire the needed technologies and chemicals in order to effectively and profitably adapt to climate change. One percent increase in credit results in increase in farmer's adaptation to climate change. Farmers that had access to credit tended to adapt measures that could be effective in alleviating the impacts of climate change and this will lead to the reduction of their vulnerability. These results corroborate with the findings of Ozor *et al*. (2010). That higher income earning farmers and those that have access to credit have preference for increased use of agrochemicals as adaptation measures compared to diversion to other crops. Membership of association had a coefficient of 1.535 and was significant at %1. This study reveals that respondents that belong to cooperative or farmers association tends to be less vulnerable to climate change. This is because, they have access to borrow fund from the association for farming activities compared to respondents that does not belong to any association. Membership of respondents in different farmers' organization is assumed to have influence on climate change.

Table 6: Maximum likelihood estimates of the determinants of vulnerability

Variables	Coefficient	Z	P>/Z/
Age	0.160	1.260	0.207
Household Size	0.267	1.700*	0.090
Education	0.233	0.970	0.331
Gender	3.901	1.160	0.245
Credit	9.87e-06	1.860*	0.063
Membership of coop	1.535	6.740***	0.000
Income	0.127	1.620	0.106
Value of assets	1.16e-07	0.940	0.345
Experience	0.186	1.530	0.126
Warning information	8.988	1.060	0.287
Farm Size	1.330	2.210**	0.027
No of Hazards	7.970	6.180***	0.000
Topography	2.549	1.950*	0.052
N	280		
LR chi^2 (14)	116.29		
Prob.> chi2	0.0000		
Pseudo R^2	0.158		

Source: Field Survey, 2015
***, ** and * Implies statistical significance at the 0.01, 0.05 and 0.10 probability levels respectively.

CONCLUSION AND RECOMMENDATIONS

The study concluded that farmers in the study area were vulnerable to effect of climate change as most of them were lacking in resource endowment that could make them withstand the challenges so as to become less vulnerable to climate change. Farmers also preferred early planting and use of agrochemicals, increased frequency of weeding in the farm, and they also employ different adaptation techniques to mitigate the adverse effect of climate change. The study therefore recommends that Government at all levels need to increase awareness of climate change among crop farmers through extension officers and appropriate communication media such as radio and television. Government should provide current early warning information about climate and weather condition for farmers.

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