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Analysis of Maize-Based Farmers' Choice of Adaptation Strategies to Climate Change in Nigeria

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ABSTRACT

Climate Change is a trending issue affecting agricultural production, drastically reducing crop yield and threatening food and nutrition security.This study aimed to investigate the factors that influenced the choice of farmers' adaptation strategies to climate change in three agro-ecological zones of Nigeria using data from cross sectional survey of 346 maize –based farming households. Data were analysed using descriptive statistics and multinomial logit model at $\alpha_{0.05}$. 90.8% of the maize farmers were male, with 54.6% between the productive age of 41-60 years and mean age of 45 years. About 47.4% of the farmers had no formal education while the average years of formal education was 6.5 years. The mean years of farming experience was 25.6 years. The analysis of adaptation to climate change made by maize farmers across the three agro-ecological zones showed that the common adaptation methods were changing the planting dates of maize, changing land-use practices, and uses of improved seed variety. The determinants of farmers' choice of adaptation strategies were age, education, farm size, farming experience, access to extension agents, access to credit, farm income, land ownership, agro-ecological zone, rainfall and temperature. Majority of the maize farmers were being constraint by inadequate credit or saving, inadequate knowledge of appropriate adaptation strategies and inadequate information on climate change. The study recommends government interventions through adult literacy programme, improved extension services, adequate credit facilities and adaptation policies should be based on the constraints and potentials of each agro-ecological zone.

1.0 Introduction

Climate change is primarily caused by the developed countries [1]. However, it is the bitter irony of destiny that Africa contributes least (920,000t of CO_2 each year, less than 4% of the global production) of all the continents to the climate change, but will probably suffer most from its consequences. Economists refer to this as a typical case of negative external effects, an externalisation of costs: A non-involved party bears the costs of a third party's actions [2]. Africa's vulnerability to climate change limits the effectiveness of development interventions and calls for greater efforts in reducing the rate of global warming. It is therefore important that the industrialized countries should now rapidly speed up their efforts to cut down greenhouse gas emissions to avoid dangerous climate change. Meteorological data have shown that rainfall pattern in Nigeria has changed in the past decades. It is recorded that rainfall measurement in Nigeria dates back to the last 70-80 years, and the later part of the last century is widely reported to have experienced low rainfall and drought conditions [3]. Nigerian agriculture is almost entirely rain-fed hence inherently susceptible to the vagaries of weather. Only about a million hectare is currently irrigated in Nigeria out of the total 30.5millions arable hectares of land [4]. Agriculture in Nigeria is therefore particularly vulnerable to the impacts of climate change [5], [2] and [6]. The consequences are that the increasing frequency and severity of droughts are likely to cause: crop failure; high and rising food prices; distress sale of animals; de-capitalization, impoverishment, hunger, and eventually famine.

Many people and most households in Nigeria depend on cereals (most especially, maize) as a contributing, if not principal, source of food and nutrition [7]. Maize is one of the important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Despite the great potential of Nigeria in cereal production, the frequent occurrence of drought occasioned by erratic rainfall distribution and/or cessation of rain during the growing season is the greatest hindrance to increased production. Traditionally, maize has been grown in forest ecology in Nigeria but large scale production has moved to the savannah zone, especially the Northern guinea savannah, where yield potential is much larger than in the forest. The environmental conditions required for maize cultivation are therefore superior in the savannah zone with high solar radiation, less incidence of biotic stresses and natural dryness at time of harvest [8].Maize grown in Nigeria and many other countries in sub-Sahara Africa are usually rainfed. Rainfall, and to a lesser extent, temperature are the most important climatic factors that determine crops' growth and timing of agronomic practices in different ecological zones of Nigeria. Although, Agricultural drought occurs when the levels of precipitation are sufficiently low to cause serious decrease in crop yield through its effects on the physiological process whereas, maize is essentially sensitive to moisture stress around the time of tasseling and cob formation. It also needs optimum moisture condition at the time of planting. Drought may occur at any stage of maize growth but when it coincides with flowering and grain filling periods yield loss could be between 40 to 90% [9]. Drought stress at flowering disrupts the synchrony between pollen shed and silking, which is the major cause of yield reduction [10]. In spite of great potential of Nigeria in maize production (African largest producer with nearly 8 million tons, two factors, one climactic and the other edaphic, were identified as limiting maize crop production [11]. First, frequent occurrence of drought occasioned by erratic rainfall distribution and/or cessation of rain during the growing season is the greatest hindrance to increased production. In order to reduce yield loss due to drought, drought resistant varieties are being developed. Secondly, it has been reported that low soil fertility is among the major constraints limiting the production of maize in the guinea savannah of West Africa [12].

The overall effect is possible rapid decline in productivity, food production in the face of rapid population growth in Nigeria. It is however suffice to note that farmers are quite conscious of these challenges and are rationally expected to put up diverse coping strategies. Such copping strategies are derivable from long years of experience amounting to indigenous knowledge or the output of their interactions with the research and extension system over the years.The effectiveness of these strategies goes a long way in determining the diversities and level of impact of climate change or variability on production of notable strategic crop like maize. These will in turn determine the potential impact on food security. Militating against the climate change thus requires understanding the impact of the change, the diversity and effectiveness of the coping strategies of the farmers towards fashioning out appropriate intervention strategies against climate change as it affects maize production in Nigeria.

Adaptation and mitigation can both be used to reduce the negative impacts of climate change. Responding to climate change through mitigation will take time and therefore adaptation becomes critical particularly where the ability to adapt is low. Adaptation is an important component of climatic change impact and vulnerability assessment and is one of the policy options in response to climatic change impacts [13], [14]. The awareness of climate problems and the potential benefits of taking action is important determinant of adoption of agricultural technologies [15]. [16] argue that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. The literature on adaptations has made it clear that adaptation are dependent on customs, institutions and policies; thus one might expect to see differences in the extent of adaption between agro-ecological zones within the same country. Addressing long-term climate change should entail a comprehensive long-term response strategy at the national or local level and requires a dynamic approach [17]. However, in the absence of directed policy responses, farmers choose their own adaptation measures depending on their household and farm characteristics. Probit and logit models are the most commonly used models in the analysis of agricultural technology adoption research. Binary probit or logit models are employed when the number of choices available is two (whether to adopt or not). The extensions of these models, most often referred to as multivariate models, are employed when the number of choices available is more than two. The most commonly cited multivariate choice models in unordered choices are multinomial logit (MNL) and multinomial probit (MNP) models. Multinomial logit model have been used by different studies [18], [15], [19] regarding farmers' choices of adaptation options and their determinants. However, most of the studies were undertaken at a macro level and the results are highly aggregated hence have little relevance for addressing country-specific adaptations to climate change. This study intends to bridge the gap in literature by considered micro-level analysis of adaptation strategies, using farmer behavioural models to study how farmers make decisions when choosing among various adaptation options. Examining these socio-economic, institutional and environmental factors will help in guiding strategies for adaptation in the future. An important policy message of this study is that it would afford the policy makers the opportunity to plan for effective adaptation policies based on the constraints and potentials of each agro-ecological zone.

2.0 Material and Methods

2.1 Study area

The study area is Nigeria. Nigeria is one of the sub-Saharan African nations in the western part of the Africa and shares land border with the republic of Benin to the west, Chad and Cameroon to the east, Niger republic to the north, and its coast lies on the gulf of Guinea [20]. The total land area of Nigeria (923,766km2) is divided into seven broad ecological or land resource zones namely mangrove swampy forest, Rainforest, Montane forest/grassland, Derived savannah, Guinea savannah, Sudan savannah, and Sahel savannah [21]. The categorization is based on the similarity of climate and vegetation cover as well as the type of crops that are adapted to each land area. With the exception of the montane region, the length of wet season (days) and temperature increase from the coast to the hitherland. In this categorization no state of the federation can boast of one ecological zone. A state may have up to three ecological zones. All these zones support maize production.

2.2 Type and sources of data

The study employed both primary and secondary data. Primary data were collected with the aid of structured questionnaire. Data were collected on different household and farm characteristics, infrastructure, and institutional factors that influence the use of adaptation methods by farmers. Finally, data were collected on farmers' perceptions of short- and long-term climate change, their adaptation strategies in response to these and the barriers to effective adaptation strategies. Secondary data on climate variables that is temperature and rainfall for 41 years (1970-2011) was employed in the study. Rainfall is the most important form of precipitation in terms of meeting water requirement of agricultural crops. The data was obtained from the Nigerian Metrological Agency in Oshodi, Lagos State. Averages of temperature and rainfall for the 41 years were pooled to allow enough variation in the data set. Their averages for the two predominant seasons (Dry and Rainy season) in the country were estimated for the 41 years period.

2.3 Sampling procedure

A multistage sampling technique was employed for this study. In the first stage, three major maize producing states were purposively selected to represent agro-ecological zones (Niger: Guinea Savannah; Taraba: Montane Savannah and Oyo: Derived Savannah). The second stage was the selection of four Local Government Areas with record of highest maize production in each of the states. Thirdly, 5 villages were randomly selected from each LGA and lastly 346 maize-based farming households were randomly selected from the list of maize producing farmers obtained from the ADP of each zones in a proportionate sampling method.

2.4 Analytical tools

This study made use of descriptive and inferential statistics. The descriptive statistics include frequency distribution, mean, percentages and standard deviation. This was used to profile socioeconomic variables, production practices, and information on climate change, perception indicators, adaptation methods and constraints to adaptation.

2.5 Multinomial Logit Model

The multinomial logit (MNL) model was employed to analyze the determinants of farmers' choice of adaptation methods. This method can be used to analyze choices of crop [22] and livestock [23] choices as methods to adapt to the negative impacts of climate change. 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 [24]. Moreover, Koch [25] emphasizes the usefulness of this model by describing the ease of interpreting estimates from this model. The great advantage of multinomial logit is its computational ease and also it is relatively robust, as measured by goodness of fit or prediction accuracy [26], [27], and [28].

To describe the MNL model, let y denote a random variable taking on the values {1,2….j} for choices j, a positive integer, and let ***x*** denote a set of conditioning variables. In this case, y representing the adaptation measure chosen by any farming household in the study area. We assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures (that means that a person chooses exactly one of the options, not more and not less) and these measures are assumed to depend on factors of x. Therefore, x represents socioeconomic characteristics of households, institutional characteristics, climate attributes, environmental, and other factors. The question is how, *ceteris paribus*, changes in the elements of ***x*** affect the response probabilities p(y=j/x), j = 0, 1, 2…. J. Since the probabilities must sum to unity, p (y=j/x) is determined once we know the probabilities for j = 1, 2…j. Let ***x*** be a 1x K vector with first element unity. The MNL model has response probabilities:

$$P(y = j/x = \frac{exp^{(\beta_j x_i)}}{1+\sum_{k=0}^{j} exp^{(\beta_j x_i)}} \; j = 0,1 \dots j \;\ldots\ldots\ldots\ldots 1$$

Where β_j is a vector of coefficients on each independent variables X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that β_0 =0 and the probabilities can be estimated as:

$$P(y = j/x = \frac{exp^{(\beta_j x_i)}}{1+\sum_{k=0}^{j} exp^{(\beta_j x_i)}} \; j = 0,1 \dots j, \beta = 0 \;\ldots\ldots\ldots\ldots 2$$

Equation (2) yields the J log-odds ratios

$$In\left(\frac{P_{ij}}{P_{ik}}\right) = X_i'(\beta_j - \beta_k) = X_i' \; \beta_j, if\ , k = 0 \ldots\ldots\ldots\ldots 3$$

The dependent variable is therefore the log of one alternative relative to the base alternative. The MNL coefficients are difficult to interpret, and associating with β_j the outcome is tempting and misleading. The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change nor probabilities [29]. To interpret the effects of explanatory variables on the probabilities, marginal effects are hence computed. Differentiating equation (3) partially with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial P_j}{\partial X_i} = P_j(\beta_j - \sum_{k=0}^{j} P_k \beta_k) = P_j(\beta_j - \beta') \ldots\ldots\ldots\ldots 4$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in the probability of a particular choice being made with respect to a unit change in an independent variable from the mean.
The MNL model is however operationalized empirically in this study with the following equations:

$$Y_{ot} = \alpha_0 + \beta_{10}X_1 + \beta_{20}X_2 + \ldots\ldots\ldots \beta_n X_n + \varepsilon_i \ldots\ldots\ldots 5$$

$$Y_{1t} = \alpha_0 + \beta_{11}X_1 + \beta_{21}X_2 + \ldots\ldots\ldots \beta_n X_n + \varepsilon_i \ldots\ldots\ldots 6$$

$$Y_{2t} = \alpha_0 + \beta_{12}X_1 + \beta_{22}X_2 + \ldots\ldots\ldots \beta_n X_n + \varepsilon_i \ldots\ldots\ldots 7$$

$$Y_{3t} = \alpha_0 + \beta_{13}X_1 + \beta_{23}X_2 + \ldots\ldots\ldots \beta_n X_n + \varepsilon_i \ldots\ldots\ldots 8$$

The adaptation methods considered in this study are based on farmers' perceptions on climate change and the actions taken to counteract its negative impact. The following three adaptation strategies are commonly practiced across the three agro-ecological zones in the study areas

Y_0 = No adaptation (base category)
Y_1 =Changing land-use practices
Y_2 = Improved seed variety
Y_3 = Changing planting dates

Explanatory variables
The explanatory variables followed [16], [18], and [30]
X_1 = Gender of household head (1= male, 0 otherwise)
X_2 = Age of household head (years)
X_3= Household Size (number)
X_4 = Education of household head (years)
X_5 = Farm Size (ha)
X_6 = Farming experience (years)
X_7 = Distance to output market (km)
X_8 = Distance to input market (km)
X_9 = livestock ownership (1=yes, 0 otherwise)
X_{10} = Access to extension agents (1= yes, 0 otherwise)
X_{11} = Access to other source of climate information (1= yes, 0 otherwise)
X_{12}= Access to credit (1=yes, 0 otherwise)
X_{13} = Farm income (Naira)
X_{14} = Non-farm income (Naira)
X_{15} = Land tenure (1= land ownership, 0 borrowed land)
Agro-ecological zones dummies
X_{16}=Derived savanna (1 = yes, 0 otherwise)
X_{17}=Guinea savanna (1= yes, 0 otherwise)
X_{18}=Montane savanna (1= yes, 0 otherwise)
Climate variables
X_{19}= Mean monthly temperature (^{0}C)
X_{20}= Mean monthly rainfall (mm)

3.0 Results and Discussion

3.1 Socioeconomic charcateristics of Farm households

Result (Table 1) showed an overall male dominance of 90.8%. Male dominance has severally been attributed to the laborious nature of peasant farming due to high dependence on manual labour. Also limited access of women to production incentives has also made men the major actor. The average age of the maize farmer was estimated at 45 years. This depicts an active and productive population of maize crop farmers in the study area with greater possibility for the supply of physical strength and mental alertness which is capable of increasing the potential for improved productivity. The mean years of farming experience was estimated at 25.56 ± 12.69. This indicates that most of the farming households have been practicing farming for long. This implies that with the level of experience of the sampled farmers they are expected to have more knowledge and information about climate change and other agronomic practices that they can use in response to climate change. The year of educational attainment was found to be low with mean years of schooling of 6.5 years. The low level of education depicts a scenario which is capable of undermining the potential for improved productivity. Sampled household has an average household size of 8 persons and farm size of 3.31 hectares. The average quantity of maize yield was estimated at 3.01t/ha which is lower than the expected yield of 5.5t/h-7.5t/h depending on the maize hybrid.

Table 1: Socio-economic characteristics of Maize-based Farmers.

Aggregate measure (proportions)	**%**	
Gender (male headed)	90.8	
	mean	Standard deviation
Age of household head (years)	45.14	10.45
Farming experience (years)	25.56	12.69
Education of household head (year)	6.46	6.47
Household size (number)	8.33	4.28
Farm size (ha)	3.31	3.52
Maize yield (t/ha)	3.01	3.64

Source: Computed from Field Data 2012

3.2 Adaptation strategies to climate change

Households reported that they have used more than one type of adaptation strategies. This implies that a single strategy may not be adequate in adapting to the impact of climate change as combination of several strategies is likely to be more effective than a single strategy. Table 2 reveals the analysis of adaptation made by respondents across the agro-ecological zones. Results showed that the major adaptation methods adopted by maize farmers across the three agro-ecological zones are changing the planting dates of maize, changing land-use practices and uses of improved maize seed.

Analysis by agro-ecological zone potentials showed that in the Derived savannah, mixed cropping or multi cropping is commonly adopted to mitigate the adverse effect of climate change on maize production. This zone is a transition zone between rainforest and guinea savannah hence supports growing of different types of food crops and tree crops. Multiple cropping ensures that farmers are able to get some positive net returns from their farming activities: when some crops fail others will produce some positive returns, particularly drought resistant crops such as cassava. However, in Guinea and Montane savannah the most common adaptation strategy is mixed farming i.e planting crops and rearing livestock. The availability of vast expanse of grassland in these zones supports increasing livestock production. In the advent of adverse climatic conditions farmers in these zones embark on livestock rearing to complement losses from crop failure. Though the use of irrigation recorded low percentage, this may be due to cash constraints that limit the farmers' investment in irrigation facilities and scarcity of resources including water for irrigation.

Table 2: Adaptation to climate change by agro-ecological zones (% of respondents)

Adaptations	Derived	Guinea	Montane
Mixed/multi cropping	78.7	35.8	19.0
Changed land-use practices	75.5	65.3	58.1
Use of irrigation	2.6	20.6	35.3
Mixed farming	27.7	57.6	69.2
Changing time of planting	77.7	83.8	69.5
Use of improved seed varieties	52.8	51.1	50.7
Change from farming to non-farming	4.3	25.6	30.2
Changing use of xcals and fertilizers	26.6	36.8	44.2
Prayer or ritual offering	11.4	42.2	38.3
No adaptation	10.6	4.6	7.6

Source: computed from field Data, 2012 Note: Multiple response

3.3 Determinants of Maize Farmers' Choice of Adaptation Strategies to Climate Change in Nigeria

The choice of farmers' adaptation strategies was estimated using multinomial logit (MNL) model. MNL was estimated by normalizing one category which is normally referred to as the base category. In this analysis, no adaptation option was used as the base category. The likelihood ratio statistics as indicated by chi-square statistics was found to be highly significant (Table 3), suggesting the model has a strong explanatory power. The estimated coefficient of the MNL and their level of significance are presented in Table 3. The parameter estimates of the MNL model provide only the direction of the effect of the independent variables in the dependent variable; they do not represent the actual magnitude of change of probabilities. Thus, the marginal effects of the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independents variable, are reported and discussed. In all cases, the estimated coefficients were compared with the base category of no adaptation. Table 4 presents the marginal effects along with the levels of significance.
The model was checked for the problem of multicollinearity among the independent variables. All the twenty variables included in the model were checked for Multicollinearity using Variance Inflation Factors (VIF). VIF value greater than 10 may need further investigation. A tolerance (I/VIF) value lower than 0.1 is comparable to a VIF of 10 which means that the variable could be considered as a linear combination of other independent variables. Result shows that VIF for all variables were less than 10 (1.12 – 8.27) and tolerance values were higher than 0.1. This indicates that Multicollinearity is not a serious problem in the model estimation.The model was also tested for the presence of heteroscedasticity using white's test and Breusch- Pagan test . Both test the null hypothesis that the variance of the residuals is homogenous. Result shows that p- value on both test are higher. Thus the null hypothesis of homogeineity of variance is rejected. These tests are very sensitive to model assumption, such as assumption of normality. (These result can be provided on request)

3.3.1 Changing Land-Use Practices Adaptation Strategy

Table 4 shows that age, farm size, farming experience, other sources of climate change information, farm income, land ownership and agro-ecological zone are important factors affecting the choice of changing land –use practices as adaptation strategy relative to the base category.

Age of the household head is negatively and significantly (p<0.05) related to the adoption of changing land-use practices. This implies that older farmers were less likely to be flexible than younger farmers and thus have a lower likelihood of adopting changing land-use practices as an adaptation strategy. According to [31] there is no agreement in the adoption literature on the effect of age. The effect of age is generally location- or technology specific.

Farm size has a positive and significant impact on the likelihood of adapting to changing climatic conditions by changing land-use practices. A unit increase in farm size increases the probability of adapting to climate change by changing land-use practices (0.016;P<0.01). Farmers with vast hectares of land will be able to rotate the cropping patterns all year round and avoid using the same land for continuous maize production. This has the advantages of replenishing soil nutrient, reducepests and diseases, and improve maize yield.Large-scale farmers are more likely to adapt because they have more capital and resources [30]. [15] suggest that capital, land and labor are important factors for coping with and adapting to climate change.

Farming experience has positive and significant impact on the probability of changing land-use practices. The marginal effect indicates that increase in the year of farming experience by a unit increases the probability of choosing changing land-use practices by 0.007 unit (p<0.1). This implies that a farmer with great deal of farming experience would employ different land –use methods to mitigate the adverse effect of changing climate. This result is in agreement with the findings of [15] that experienced farmers have high skills in farming techniques and increased likelihood of using portfolio diversification as well as spread risk among activities.

Access to other sources of climate change information increases the probability of maize farmers' adaptation to climate change. The marginal effect indicate that increase in the access to other sources of information on climate change i.e media, neigbouring farmers, NGOs etc increases the probability of adapting to climate change by changing the land-use practices (0.017; P<0.05). The result is consistent with findings of [19] and [15] who found information on climate change as significant in influencing farmers' adaptation choice.

Farm income has positive and significant impact on the likelihood of choosing changing land-use practices to adapt to climate change relative to the base category. A unit increase in farm income increases the probability of changing land–use practices by 0.104unit (p<0.05). This implies that a farmer with reasonable amount of farm income can increase the uses of land under cultivation. This findings agreed with [32] that the adoption of agricultural technologies requires sufficient financial well-being. When the main source of income in farming increases, farmers tend to invest on productivity smoothing options such as improved seed varieties, soil and water conservation and crop diversification options[33]

It was observed that ownership of land has positive and significant impact on the likelihood of adopting changing land-use practices as adaptation strategy relative to the base category. Ownership of land increases the predicted probability of changing land –use practices by 0.107(p<0.1). This implies that farmland owner who are currently using this strategy to cope with climate change have higher probability of keeping on using the strategy compared to sampled households who borrowed land for maize cultivation. This result is consistent with the findings by [30] who argue that farmers with proper property rights may be able to change their amount of land under cultivation to adjust to new climatic conditions.

Farming in montane savannah agro-ecological zone has negative and significant relationship with changing land-use practices. This indicates that farming in montane savannah decreases the probability of using changing land-use practices as adaptation strategy by 0.251 ($p<0.05$) relative to farming in derived savannah.

3.3.2 Improved Seed Variety Adaptation Strategy

The significant variables that determine the choice of improved maize seed variety includes: years of schooling, farming experience, extension agents, access to credit, farm income, Non-farm income, land ownership, agro-ecological zones and temperature.

The coefficient of years of schooling is positive and significant implying that education seems to have a strong influence in adapting to climate change. A unit increase in the years of schooling of the household head increases the probability of using improved seed variety by 0.112 ($p<0.05$). This is because higher level of education is believed to be associated with access to information on improved farming methods and productivity consequences. This result is in agreement with the findings by [19], [36] and [33] who reported that literate farmers were more likely to respond to climate change by making the best adaptation option based on his preference and individual decision to reduce risk aversion.

Farming experience has a positive and significant impact on the likelihood of using improved maize seed to reduce adverse effect of climatic changes. A year increase in the farming experience of maize farmer increases the probability of adapting to climate change using improved maize seed by 0.012 ($p<0.05$). The result is in line with [35] who found that the farmer'sexperience increases the probability of uptake of all adaptation options.

Access to extension agents has positive and significant impact on the likelihood of using improved seed variety as adaptation measure relative to the base category. The marginal effect indicates that a unit increase in the frequency of extension contact would increase the probability of using improved seed variety by 0.060 unit ($p<0.1$). This is because extension agent influences farmer to make informed decision and optimize farming practices. This result supports the findings by [36], [19] and [33] who reported in their various studies that extension contact is an important factor motivating increased intensity use of specific adaptation strategy.

Access to credit has positive and significant impact on the likelihood of selecting improved maize seed as adaptation strategy. Access to credit increases the probability of choosing improved seed variety by 0.054 ($p<0.05$) relative to the comparison group. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take [15]. This result supports the findings by [30], [33] and [37] who in their various studies emphasized the important role of credit institution support in promoting the use of adaptation options to reduce the negative impact of climate change.

Farm income and Non-farm income has a positive and significant impact on the likelihood of using improved maize seed to adapt to changing climate relative to the base category. A unit increase in the farm income and non- farm income increases the probabilities of adapting to climate change using improved seed variety by 0.032($p<0.01$) and 0.057

(p<0.1) respectively. This result is similar to that by [38] and [32] who noted that farmers' incomes (whether farm or off-farm income) have a positive relationship with the adoption of agricultural technologies since the latter requires sufficient financial wellbeing to be undertaken.

Being an owner of productive land has positive and significant impact on the likelihood of choosing improved seed variety as adaptation strategy relative to the comparison group. Ownership of land increases the probability of adopting improve seed variety by 0.140 (p<0.01). This implies that farmer who has a property right on the land which is associated with wealth can afford to buy improved seed varieties to adapt to changes in climate in his environment.

Farming in guinea and montane savannah agro-ecological zones respectively has a higher likelihood of adapting to adverse weather conditions using improved maize seed varieties that are drought tolerant relative to farming in derived savannah agro-ecological zone. Result shows that maize farmers living in guinea savannah agro-ecological zone were 0.231(p<0.05) more likely to adopt improved seed to adapt to changes in climate than farmers living in derived savannah. Similarly, maize farmers living in montane savannah were 0.173 (p<0.1) more likely to choose improved seed variety to adapt to changes in climate than farmers living in derived savannah This finding is similar to the study conducted by [39] who reported that farmers living in drier areas with more frequent drought are more likely to describe the climate change to be warmer and drier than farmers living in a relatively wetter climate with less frequent drought. [16] and [15] made the same observation that local agro-ecological conditions has a higher likelihood of influencing a farmer to perceive climate change and hence his decision to adapt or not.

The coefficient of temperature is positive and significant indicating that a unit increase in temperature increases the probability of using improved seed variety by 0.048 (p<0.1). This implies that during the hot weather farmers will make use of drought resistant varieties as an effective adaptation strategy to cope with increased temperature. Planting drought resistant maize varieties increases the chances of successful harvests and hence higher net farm revenues despite adverse climatic conditions.

3.3.3 Changing planting date Adaptation Strategy

The variables that determine the choice of changing the planting date of maize includes: age, farming experience, access to extension agent and rainfall.

The result indicates that a year increase in the age of the household head increases the probability of changing the planting date of maize by 0.009 (p<0.1). By implication, as the farmer is ageing, he/she acquired more experience in farming and weather forecasting and this helps in increasing the likelihood of predicting accurately the time to plant in order to mitigate the adverse effect of climate change. This result is in agreement with [30] and [33] who observed in their respective studies, that there was a positive relationship between age of the household head and the adoption of improved agricultural technologies.

Result showed that the more experienced farmers were more likely to adapt to climate change by changing the planting date of maize. Increase in farming experience by a year increases the predicted probability of changing the planting date adaptation by 0.003 (p<0.01). This findings is similar to those arrived at by [35] that farming experience enhances the probability of uptake of adaptations as experienced farmers have better knowledge and information on changes in climatic conditions, crop and livestock management practices.

Access to extension services has a higher likelihood of adopting changing the planting date of maize as adaptation strategy to mitigate the adverse effect of changing climate.Increase in maize farmers' access to extension agents increases the probability of changing the planting date of maize by 0.130 ($p<0.05$). This result agreed with the findings of [19[and [16], who reported that access to information on climate change through extension agents or other sources creates awareness and favourable condition for adoption of farming practices that are suitable under climate change. [30] argue that farmers who have access to extension services are more likely to be aware of changing climatic conditions and have knowledge of the various management practices that they can use to adapt to changes in climatic conditions.

Sample households with lower annual mean rainfall over the survey period were more likely to adapt to climate change by changing the planting date of maize. The result indicates that decreasing rainfall significantly ($p<0.1$) increases the likelihood of changing the planting date. During the period of low rainfall or cessation of rain, farmers will adapt by delaying the planting till later period when there is regular rains.

Table 3: Parameter Estimates from the Multinomial Logit for Climate Change Adaptation

	Changing land-use Practices	Improved seed variety	Changing date of planting
Gender	0.057(1.222)	1.431(0.964)	0.396(0.894)
Age	0.112(0.050)**	-0.061(0.045)	0.037(0.043)**
Household size	0.054(0.093)	0.015(0.094)	0.006(0.089)
Years of schooling	-0.005(0.056)	0.096(0.056)**	-0.043(0.052)
Farm size	0.065(0.069)**	-0.018(0.066)	-0.016(0.057)
Farming experience	0.103(0.048)*	0.046(0.044)**	0.047(0.043)***
Distance to Product market	-0.094(0.084)	-0.013(0.083)	-0.043(0.074)
Distance to input market	0.002(0.078)	-0.033(0.076)	-0.055(0.071)
Livestock ownership	1.243(0.827)	-0.045(0.767)	0.851(0.741)
Access to extension agents	1.300(1.472)**	0.335(1.404)**	1.225(1.408)**
Other source of CC Info.	-1.638(1.775)	-1.744(1.628)	1.031(1.610)
Access to credit	0.748(0.722)	0.624(0.718)**	1.416(0.679)
Farm income	0.127(1.014)*	0.721(0.918)**	-0.617(0.864)
Non- Farm income	0.484(0.725)	-0.082(0.656)*	-0.175(0.064)
Land Ownership	0.040(1.147)*	0.115(1.054)**	-1.826(0.925)
Guinea savannah	-1.052(1.981)	0.039(1.999)**	-1.563(1.935)
Montane savannah	-4.152(1.685)**	0.362(0.145)*	-1.037(1.297)
Rainfall	-0.023(0.27)	-0.032(0.028)	-0.014(0.026)**
Temperature	-1.120(0.753)	0.708(0.748)**	0.953(0.073)
Constant	40.832(26.983)	35.865(27.086)	40.820(26.483)

Number of observations = 314; LR Chi square (95) = 183.74; Pseudo R_ square = 0.1708; Log Likelihood = -445.88805; Prob. > Chi square = 0.0000; Base category: No adaptation strategy

Table 4: Marginal Effects from the Multinomial Logit for Climate Change Adaptation

	Changing land- use practices	Improved seed variety	Changing date of planting
Gender	-0.054(0.155)	0.078(0.064)	-0.202(0.151)
Age	-0.007(0.004)*	0.001(0.004)	0.009(0.005)**
Household size	0.006(0.006)	0.00005(0.008)	-0.003(0.009)
Years of schooling	0.004(0.004)	0.112(0.004)**	-0.003(0.006)
Farm size	0.016(0.006)***	0.001(0.006)	0.002(0.008)
Farming experience	0.007(0.004)*	0.012(0.004)**	0.003(0.005)***
Distance to Product market	-0.003(0.008)	-0.005(0.009)	0.011(0.011)
Distance to input market	0.007(0.007)	-0.002(0.008)	-0.011(0.010)
Livestock ownership	0.067(0.054)	-0.181(0.093)	0.039(0.090)
Access to extension agents	0.065(0.075)	0.094(0.139)*	0.130(0.127)**
Other source of CC Info.	0.017(0.111)**	0.002(0.097)	0.107(0.151)
Access to credit	-0.027(0.050)	0.054(0.058)**	0.165(0.071)
Farm income	0.104(0.087)**	0.032(0.081)***	-0.024(0.103)
Non- Farm income	0.039(0.057)	0.057(0.056)*	-0.020(0.074)
Land Ownership	0.107(0.055)*	0.140(0.049)***	-0.358(0.097)
Guinea savannah	-0.002(0.121)	0.231(0.198)**	-0.154(0.160)
Montane savannah	-0.251(0.053)***	0.173(0.145)*	0.049(0.143)
Rainfall	-0.0002(0.002)	-0.002(0.002)	-0.003(0.003)**
Temperature	-0.025(0.041)	0.046(0.054)**	0.002(0.068)

***Significant at 1%, **Significant at 5%, *Significant at 10%. Values in parenthesis are standard error
Source: Computed from Field data (2012)

3.4 Barriers to Adaptation to Climate Change

The analysis of barriers to adaptation in Nigeria maize agriculture by agro-ecological zones revealed some important differences in the extent and prevalence of different adaptation measures. The possibility of these differences may be due to differences in the perception of climate change across the agro-ecological zones or due to institutional differences between the agro-ecological zones. Six major constraints to adaptation were identified by maize farmers across the agro-ecological zones. These are inadequate information on climate change, inadequate knowledge of appropriate adaptation strategies, inadequate credit or saving, no access to water/river/stream, inadequate access to improved seed variety and land tenure problem.

Results (Table 5) showed that in all the agro-ecological zones, the most common barriers are inadequate knowledge of adaptation strategies, followed by inadequate credits or saving to invest in appropriate adaptation strategies and inadequate information on climate change. However there is a marked difference in the barriers to adaptation across the agro-ecological zones. In Derived savannah, inadequate credit or saving is the most common barrier among the maize farmers. Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties and irrigation facilities. This suggests the need to strengthening the credit institutions in this zone by making provision for adequate loan at low interest rate that will enable the farmers to embark on effective adaptation strategies to mitigate the adverse effect of climate change. In Guinea savannah, the most common barrier to climate change adaptation is inadequate knowledge of appropriate adaptation strategies to mitigate the negative effect of climate change. The government should encourage and motivate the extension agents in this zone by improving their welfare packages and transportation system. This will stimulate the extension agents to increase their number of visits and coverage areas with potential of increasing farmers' knowledge of indigenous adaptation strategies to combat the adverse effect of climatic conditions prevailing in their zone. In the Montane savannah, farmers were most impeded by inadequate credit or saving. This effectively hindered their productive investment in irrigation infrastructures, improved seed variety and others. The government through extension agents should encourage farmers to form cooperative societies so that they can attract large amount of loan from banks and other donor agencies. Government should also facilitate the provision of adequate credit to farmers by strengthening the credit institutions in this zone. In all the zones, lack of information on climate change was considered a major barrier to climate change adaptation. Government should upgrade and strengthening the meteorological agencies for effective service delivery by providing farmers with early warning signal through extension agents, media organisation and NGOs to enable them make informed decisions and allow them to better prepared for adverse weather conditions.

Table 5: Barriers to Adaptation by Agro-ecological Zones

	Derived	Guinea	Montane	Pooled
Inadequate information on CC	58 (61.7)	100 (57.8)	63 (79.7)	229(63.9)
Inadequate knowledge of appropriate adaptation strategies	58 (61.7)	130 (75.1)	47 (59.5)	235(67.9.0)
Inadequate credit or savings	59 (62.8)	96 (55.5)	67 (84.8)	222(64.2)
No access to water/river/stream	29 (30.9)	81 (46.8)	12 (15.2)	41(11.8)
No access to improve seed	9 (9.6)	9 (5.2)	47 (59.5)	65(18.8)
Land tenure problem	26 (27.7)	7 (4.0)	39 (49.4)	72(20.8)

Source: Computed from Field Data 2012. Note: Multiple responses

Conclusion

The analysis of adaptation to climate change made by maize farmers across the agro-ecological zones showed that the common adaptation methods across the three agro-ecological zones were changing the planting dates of maize, changing land-use practices, and uses of improved seed variety. The choice of adaptation strategies to climate change in the study area were significantly determined by age, years of schooling, farm size, farming experience, extension agents, credit, farm income, land ownership, agro-ecological zones, rainfall and temperature. However, majority of the maize farmers were being constraint in their adaptation practices by inadequate credit or saving, lack of knowledge of appropriate adaptation strategies and inadequate information on climate change, Based on the evidences from this study, it is recommended that adult literacy programme should be given priority as this will increase farmers' knowledge and help them appreciate the benefits of adapting to climate change; the government through extension services should encourage farmers' cooperative where farmers can exchange information about their farming experience; there is preference for specific adaptation strategies among farmers based on the prevailing climatic conditions in their respective zone thus adaptation policies by government should target different agro-ecological zones based on the constraints and potentials of each agro-ecological zone.

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