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Determinants of Use of Climate Change Adaptation Practices by Rice Farmers in Kebbi State, North-West Nigeria

Abstract. Rice productivity and sustainability are threatened by both biotic and abiotic stresses, the effects of which can be further aggravated by dramatic changes in global climate. The most viable option for rice farmers is to use climate change adaptation practices. This study therefore investigated the determinants of use of climate change adaptation practices among rice farmers in Kebbi State, North-West, Nigeria. Data were collected from a sample of 279 farmers selected using a multistage sampling procedure. The results of the data analysis revealed that the farmers used improved rice varieties, intercropping, recommended rates of fertilizers and other chemicals as climate change adaptation practices among others. Education, climate change awareness, and extension contact significantly influenced the use of climate change adaptation practices among the farmers. Other determinants of use of climate change adaptation practices among the farmers were years of cooperative membership, affordability, farming experience, weather information and farm size. It was concluded that use of climate change adaptation practices was determined by socioeconomic, institutional and technological characteristics. It is recommended among others that government policy should be geared towards encouraging the farmers especially the younger ones to acquire more formal education, larger farmlands and more climate change awareness.

Key words: climate change, smallholder farmers, Nigeria, climate adaptation, adoption, livelihoods

JEL Classification: Q16, Q10, Q19

Introduction

Rice farming is highly dependent on environmental factors which are the most important among several factors that influence agricultural production (Onyegbula and Oladeji, 2017). Rice production depends on optimum combination of factors of production in order to achieve remarkable yield. These factors are not limited to the familiar production inputs but include the various environmental factors provided by nature. Rainfall characteristics (intensity and duration), relative humidity and temperature constitute these weather-related and environmental factors that affect rice yield and its variability (Edeh *et al.* 2011). Rice production which is one of the world's most important crops for ensuring food security and addressing poverty will be thwarted as temperatures in rice-growing areas, increase with continued change in climate (Gumm, 2010).

One of the most serious long-term challenges to achieve sustainable growth in rice production is climate change (Wassmann *et al.,* 2007). Rice productivity and sustainability are threatened by biotic and abiotic stresses, and the effects of these stresses can be further

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aggravated by dramatic changes in global climate. Drought and flood already cause widespread rice yield losses across the globe and the expected increase in drought and flood occurrence due to climate change would further add to rice production losses in the future. Thus the major challenge is the potential adverse effect of changing climate on rice production and being the factor limiting increase in annual yield (Ayinde *et al.,* 2013). Climate change has brought uncertainty to weather conditions in Nigeria most especially in the northern part of the country which accounts for the major food crops produced inclding rice. Hence, the most viable option for the rice farmers is to use the climate change adaptation practices.

Farmers have a long history of responding to climate variability. Traditional and newly introduced adaptation practices can help farmers to cope with both current climate variability and future climate change. However, the debate about the adaptation of small-scale farmers to climate change has occurred in the absence of knowledge about existing and potential adaptation practices; because prevailing ideas about adaptation are vague, conducting focused research on potential adaptation practices and formulating appropriate advice for implementing new practices is difficult (Below *et al.,* 2010).

The evident fallout of climate change according to IPCC (2007); Kurukulasuriya and Mendelsohn (2006) can be reduced through adaptation. Although, African farmers have a low capacity to adapt to changes owing to low technological development, poverty and illiteracy, they have survived and coped in various ways. A better understanding of how they have done this is essential for designing incentives to enhance adaptation **(**Mohammed *et al.,* 2014). Supporting the adaptation strategies of local farmers through appropriate public policy and investment and collective actions can help increase the adaptation measures that will reduce the negative consequences of predicted changes in future climate with great benefits to vulnerable rural communities in Africa and Nigeria in particular (Hassan and Nhemachena, 2008).

There seems to exist, a gap between the rate at which climate is changing and the response to reduce its impact through employment of adaptation strategies that ensure sustainable food security (Mudzonga, 2012). In spite of this, determinants of farmers' decisions to adapt to climate change in North-West, Nigeria in general and Kebbi State in particular are not well known. This study seeks to investigate the determinants of farmers' decision to adapt to climate change in order to inform policy formulation that enhances farmers' capacity to adapt to climate change. It investigates the determinants of use of climate change adaptation practices among rice farmers in Kebbi State, North-West, Nigeria.

The broad objective of the study was to assess the determinants of use of climate change adaptation practices among rice farmers in Kebbi State, North-West Nigeria. The specific objectives were to:

i. describe the socioeconomic characteristics of rice farmers in the study area;
ii. identify the climate change adaptation practices employed by rice farmers;
iii. to determine the relationship between the farmers' socioeconomic, institutional and technological characteristics and use of climate change adaptation practices in the area.

Hypothesis of the Study

There is no significant relationship between the farmers' socioeconomic, institutional and technological characteristics and use of climate change adaptation practices.

Methodology

The Study Area

The study was conducted in Kebbi State, which was curved out of the old Sokoto State, and located within latitude $10^0 05^1$N and $13^0 27^1$N and Longitudes $3^0 35^1$E and $6^0 03^1$E. It shares international borders with Niger Republic in the West and Benin Republic in the South. It also shares a common boundary with Sokoto State in the western and southern parts. It is located in the Semi-arid Sudano-Sahelian ecological zone and experiences serious moisture deficiency for greater part of the year (Singh, 1995). However, the Southern portion of the State falls within Northern Guinea Savannah Ecological Zone.

Generally, the State is characterized by high temperatures especially in the months of March, April and May. The annual temperature varies from 21ºC – 38ºC. The soil type found in the state ranges from heavy clay in the *fadama* areas to sandy loam and sandy soil in the upland areas [Kebbi Agricultural and Rural Development Authority (KARDA), 1992]. Rainfall in Kebbi State begins around April and ends in October with highest rain in July and August. The annual rainfall ranges from 500 to 850mm increasing both in quantity and intensity within the State from the north to the south (Singh, 1995).

Kebbi State has a projected population of 4,279,777 people (NPC, 2015). Among the major ethnic groups found in the area are Hausa, Fulani, Dakarkari, and Zabarmawa. Others include Gungawa, Dandawa and Kambari. Majority of the inhabitants of the State are peasant farmers who reside in rural settlements, particularly along the bank of the existing rivers. Upland crops produced include millet, sorghum, rice, cowpea and maize, while the vegetable crops include tomato, pepper, onions, okra, lettuce and carrots. Other occupations in the area include fishing and livestock rearing (Kebbi State Diary, 2008).

Sampling Procedure and Sample Size

This study targeted Kebbi State, North-West, Nigeria. It is one of the major rice producing States in the country. A multistage sampling procedure was used to obtain the sample. In the first stage, four out of the 20 major rice producing LGAs were purposively selected in Kebbi State (based on high population of the rice farmers). The LGAs chosen included Augie, Dandi, Birnin Kebbi and Suru.

The second stage was a purposive selection of 16 villages out of 191(5%), also based on high population of the rice farmers, from the villages. In the third stage 279 farmers (2.873%) out of 9693 (sampling frame) were randomly chosen from the selected villages to give the study sample.

Method of Data Collection

Primary data for this study were obtained with the aid of an interview schedule. The data, involving information on 2015 farming season, were collected from August, 2016 to January, 2017.

The data consist of information on the farmers' socioeconomic characteristics including age, sex, household size, level of education, farm size, farming experience, off-farm employment, level of rice income and weather information. Information on institutional factors such as access to credit, extension contact and membership of associations were obtained. Similarly, factors related to attributes of technologies namely; affordability, complexity and relative advantage were also obtained. They also contained information on climate change adaptation practices employed by the farmers.

Analytical Techniques

Data for this study were analyzed using both descriptive and inferential statistics. Descriptive statistics such as frequency counts, percentages, ranges and means were used to achieve objectives: (i) and (ii), which described the socioeconomic characteristics of rice farmers and identified and described the climate change adaptation practices employed by rice farmers in the area.

Tobit regression model was used to establish the relationship between the farmers' socioeconomic, institutional and technological characteristics and use of climate change adaptation practices. The major strength of Tobit model over other econometric models, such as Ordinary Least Square (OLS) for estimation of adoption, is its inclusion of observations with non-use of adaptation practices. The Tobit model is a statistical model proposed by James Tobin in 1958, used in order to "explain the relationship between a non-negative dependent variable and an independent one assuming that there is a latent variable which linearly depends on the independent one through a parameter (beta) that determines the relationship between the independent and latent variables". In this paper, applying the Tobit model estimates.

$$y_i^* = \beta^t x_i + e_i \qquad i = 1,2,\dots,n$$

$$y_i = y_i^* = \begin{cases} y_i = y_i^* \; if \; y_i^* > 0 \\ y_i = 0 \; if \; y_i^* \le 0 \end{cases} \tag{1}$$

Where:

e_i Random error, the set represents all the variables is non observed influencing in the dependent variable y_i^* distributed $y^* \sim N(0,\sigma^2)$ which *i.i.d*

y_i^*: Represents (Latent variable) It is generated through traditional linear regression model according to the formula $(I_i = \beta^t x_i)$ it is non observer when $y_i^* < 0$.

y_i, x_i : Is the independent variable and the dependent variable known each $i = 1,2,\dots,n$. Generally, it can be defined as follows:

$$y_i = \begin{cases} \beta^t x_i + e_i \; if \; RHS > 0 \\ 0 \; o.w \end{cases} \tag{2}$$

While (Herman and Bierens, 2004) knew (Tobit Regression Model) and supposed the dependent variable observer y_i for observers $i = 1,2,\dots,n$ is achieved as follows:

$$y_i = max(y_i^*, 0) \tag{3}$$

For the purposes of estimate suppose that:

$e_i \sim N[0, \sigma^2]$

$y_i^*/x_i \sim N[\beta^t x_i, \sigma_u^2]$

$D_i = 1 \; if \; y_i^* > \gamma$

$\quad = 0 \; if \; y_i^* \leq \gamma$

Then the Maximum Likelihood Function:

$$L = \prod_{i=0}^{n} \Pr\left(y_i^* < \gamma\right)^{(1-D_i)}$$
$$\prod_{i=0}^{n} \left\{\Pr\left(y_i^* > \gamma\right) f\left(y_i^* / y_i^* \geq \gamma\right)\right\}^{D_i} \tag{4}$$

The function (4) can be simplified as follows:

$$\begin{aligned} P(y_i^* < \gamma) &= Pr(\beta^t x_i + e_i < \gamma) \\ &= Pr\left(\frac{\beta^t x_i + e_i}{\sigma_u^2} < \frac{\gamma}{\sigma_u^2}\right) \\ &= Pr\left(\frac{e_i}{\sigma_u^2} < \frac{\gamma - \beta^t x_i}{\sigma_u^2}\right) = \Phi\left(\frac{\gamma - \beta^t e_i}{\sigma_u^2}\right) \end{aligned} \tag{5}$$

When $\gamma = 0$, that:

$$P(y_i^* < \gamma) = \Phi\left(\frac{-\beta^t x_i}{\sigma_u^2}\right) = 1 - \Phi\left(\frac{\beta^t x_i}{\sigma_u^2}\right) \tag{6}$$

$$P(y_i^* \geq \gamma) = 1 - \Phi\left(\frac{\gamma - \beta^t x_i}{\sigma_u^2}\right) \tag{7}$$

When $\gamma = 0$, that:

$$P(y_i^* > \gamma) = \Phi\left(\frac{\beta^t x_i}{\sigma_u^2}\right)$$

$$f(y_i^*/y_i^* > \gamma) = \frac{1/\sigma\ \phi((y_i^* - \beta^t x_i)/\sigma_u)}{P(y_i^* > \gamma)} = \frac{1/\sigma\ \phi((y_i^* - \beta^t x_i)/\sigma_u)}{1 - \Phi((y_i^* - \beta^t x_i)/\sigma_u)} \quad (8)$$

Therefore:

$$L = \prod_{i=0}^{n} \Phi\left(\frac{\gamma - \beta^t x_i}{\sigma_u}\right) \prod_{i=0}^{n} \left\{1 - \Phi\left[\frac{\gamma - \beta^t x_i}{\sigma_u}\right]\right\} \prod_{i=1}^{n} \frac{1/\sigma\ \phi((y_i^* - \beta^t x_i)/\sigma_u)}{1 - \Phi((\gamma - \beta^t x_i)/\sigma_u)}$$

$$L = \prod_{i=0}^{n} \Phi\left(\frac{\gamma - \beta^t x_i}{\sigma_u}\right) \prod_{i=1}^{n} \sigma^{-1} \phi\left(\frac{y_i^* - \beta^t x_i}{\sigma_u}\right) \quad (9)$$

When $\gamma = 0$ that:

$$L = \prod_{i=0}^{n} \left[1 - \Phi\left(\frac{\beta^t x_i}{\sigma_u}\right)\right] \prod_{i=1}^{n} \sigma^{-1} \phi\left(\frac{y_i^* - \beta^t x_i}{\sigma_u}\right) \quad (10)$$

Where $\Phi(.)$ & $\phi(.)$ represents the probability distribution function, the probability density function, respectively for normal distribution, the Tobit Regression Model, described in the above to know the limited regression model.

If y_i & x_i are not observed when $y_i^* \le 0$ then the model is known as truncated regression model, in other words the data y_i^* & x_i are observed only when $y_i^* \ge \gamma$. We used R packages ("censReg") Arne. H (2013) [2] for analysing data.

In its simplest form, the Tobit model is presented as follows:

$$Y_i = \beta_{Xi} + e \quad (11)$$

Algebraically expressed for the i^{th} farmer, the Tobit model is explicitly expressed as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_N X_N \quad i = 1 \ldots\ldots\ldots\ldots\ldots N \quad (12)$$

Where: Y_i is the observed dependent variable, that is adaptation to climate change;
β_0 is the intercept or the level of use of adaptation practices that will occur regardless of the level of independent variable;
β_1.......................β_N are the coefficients of the independent variables;
X_1....................................... X_N are the independent variables (i.e. age, sex, household size, years of formal education, faming experience, farm size, off-farm employment, rice

income, climate change awareness weather information, access to credit, extension contact and years of cooperative membership, affordability, complexity and relative advantage).

The empirical model is specified as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \beta_{16} X_{16} + e;$$

Where:

Y_i = Use of climate change adaptation practices. These practices are: portfolio diversification (use of improved rice varieties and intercropping), soil conservation (mulching, planting of cover crops, planting of trees, moderate use of fertilizers, moderate use of chemicals and use of organic manure), adjusting the planting calendar (early planting, late planting, late harvesting and early harvesting), use of minimum tillage (zero tillage and making mounds and digging ridges across slopes) and use of irrigation technologies (rainwater harvesting, use of rivers/streams, digging of well and sinking of bore-hole).

e = Error term

β_0 = Constant

X_1 = Age of the farmer (In years)

X_2 = sex of the farmer (Male = 1or Female = 0)

X_3 = Household size (Number of individuals)

X_4 = Educational level (Years of acquiring formal education)

X_5 = Farming experience (Years)

X_6 = Farm size (In hectares)

X_7 = Off-farm employment (Yes = 1 or no = 0)

X_8 = Income from rice production (₦)

X_9 = Climate change awareness (Aware =1, not aware = 0)

X_{10} = Weather information (Number of sources)

X_{11} = Credit access (₦)

X_{12} = Extension contact (Number of contacts in 2015 growing season)

X_{13} = Cooperative membership (In years)

X_{14} = Affordability (Not Affordable = 1, Undecided = 2 and Affordable = 3)

X_{15} = Complexity (Unusable = 1, Undecided = 2 and Usable = 3)

X_{16} = Relative advantage (Unfavourable =1, Undecided = 2 and Favourable = 3)

Whenever there is a blend of many practices, the measuring of use of these agricultural practices becomes a complex exercise. In this study, use of climate change adaptation practices has been measured by development of a composite index. Composite Index (CI) is an aggregation of use of different dimensions of agricultural practices.

The method used for computing the composite index was based on the traditional method of computing the index for each indicator or dimension. Conventionally, index for any dimension is computed using the formula (1):

$$Dimension\ Index = \frac{Actual\ Value - Minimum\ Value}{Maximum\ Value - Minimum\ Value} \tag{13}$$

Following this, a composite index was developed by computing the weighted average. It was presumed that D_{ij} represented the value of the dimension index for the j^{th} state of the i^{th} indicator, then one gets equation (13):

$$I_j = \sum_{i=1}^{n} W_i D_{ij} \tag{14}$$

where, I_j is the composite index for the j^{th} state, and W_i is the weight assigned to the i^{th} indicator (For equal weights, $w_i = 1/n$) and

$$D_{ij} = \frac{X_{ij} - Min(X_i)}{Max(X_i) - Min(X_i)} \quad (15)$$

Composite Index for this study was thus obtained for the climate change adaptation practices.

Results and Discussion

Socioeconomic Characteristics of the Respondents

Socioeconomic characteristics discussed include age, sex, marital status, household size, occupation, educational qualification, farming experience and rice income of the respondents.

Age of the respondents

Age is an important factor not only for the knowledge of changes in the climate over time by the farmer, but in making decision in the use of climate change adaptation practices. Majority (about 60%) of the respondents fell within the range of 41–60 years with a mean 45.77 years (Table 1). This result indicates that the rice farmers were still in their economically active age since the average age is less than 50 years.

Table 1. Distribution of respondents according to their socio-economic characteristics (n=279)

Variable	Frequency	Percentage
Age (years)		
21-40	103	36.92
41-60	167	59.88
Above 60	9	3.20
Mean age	**45.77**	
Sex		
Male	260	93.19
Female	19	6.81
Marital status		
Married	237	84.95
Single	15	5.38
Widow	18	6.45
Widower	9	3.23
Household size		
Below 5	45	16.13
5-9	77	27.60
10-14	125	44.80
15-19	32	11.47
Above 19	0	0.00
Mean household size	**11.14**	

Major occupations		
Farming	244	87.46
Trading	24	8.60
Fishing	2	0.72
Civil Service	6	2.15
Transporting	3	1.00
Highest educational qualification		
Non formal	109	39.01
Primary	31	11.11
Secondary	93	33.33
Tertiary	46	16.49
Farming experience (years)		
5-9	15	5.38
10-14	26	9.32
15-19	17	6.09
20-24	90	32.26
25-29	83	29.75
Above 29	48	17.20
Mean farming experience	**24.64**	
Income from rice production ($)		
Below 166	6	2.15
166- 1655	225	80.65
1656-3146	30	10.75
More than 3146	18	6.45
Mean rice income	**1228**	

1USD = ₦ 302.

Source: own Authors' calculations.

This finding agrees with Adebayo *et al.* (2012) who reported, in a study to determine farmers' awareness, vulnerability and adaptation to climate change in Adamawa State, Nigeria, that about 51% of the farmers were between 31-50 years and about 26% of the farmers were up to 30 years of age, while farmers that were over 50 years of age constituted only about 23%, which implied that most of the famers were relatively young and physically active. Adebayo *et al.* (2012) stressed that the finding had a direct bearing on the availability of able bodied manpower for agricultural production and also on the ease of use of climate change adaptation strategies. Also, age influenced the ability to seek and obtain off-farm jobs and income, which could increase farmers' income and could help cope with adverse change in climate.

Sex of the respondents

Majority (about 93%) of the respondents were males (Table 1). This indicates that rice farming in the State is dominated by males. It is typical of the male dominance on the issue of gender parity or disparity. It also agrees with Ishaya and Abaje (2008); Abraham *et al.*

(2012) that the agricultural sector and the tedious activities related to climate change adaptation strategies are dominated by males.

Marital status

Majority (about 85%) of the respondents were married (Table 1). Marriage is an important aspect of the life of the farmers, hence, only about 5% of the respondents were found single. It indicates that majority of the respondents were saddled with the responsibility of catering for their family. This can create the need for portfolio diversification as a climate change adaptation strategy, in order to meet the various needs of the family members.

Household size

Table 1 shows that about 45% of the respondents had a family size of 10-14 individuals with a mean of about 11. This indicates that majority of the respondents had at least 10 individual members in their households. This is on the high side due to the polygamous lifestyle of the farmers and for the fact that unmarried sons often remain in the family.

Household size is the function of spouses, children and dependents staying and feeding under the same household head (Fatuase *et al.,* 2015). Ordinarily, this will make the farming households to accomplish various agricultural tasks as a result of higher labour endowments as reported by Deressa *et al*. (2011). Abaje *et al.* (2014) observed that large household size is believed to provide cheap labour that will assist in practices that will mitigate the impacts of climate variability and change by the respondents. This is because some of the resources and items that could be used in combating the impacts of climate variability and change cannot be afforded as the average annual income of the farmers is too meagre.

Major occupations

Major occupations for this study refer to the occupations that the farmer considers more important for his livelihood. Most (88%) of the respondents took farming as their major occupation, hence, majority of them were primarily farmers. Farming is the major source of livelihood, however, few of the farmers considered had secondary occupations such as trading (9%), fishing (1%), civil service (2%) and transporting (1%) as their major occupations (Table 1). This implies that the farmers considered farming as more important than any other occupation they may have.

Highest educational qualification

The results of the study reveal that over 60% of the respondents had either primary, secondary or tertiary education (Table 1). This implies that majority of the respondents had one form of formal education or another, while the minority had only Qur'anic education which is a non-formal education.

Formal education among farmers can favour the use of climate change adaptation practices through their literacy level. This agrees with Adebayo *et al.* (2012) who reported that, about 70% of the farmers in Adamawa State, Nigeria had some form of formal education and concluded that the literacy level among the farmers was high and could have implication for agricultural production and also for adaptation to changes in the climate. They observed that adoption of measures that could result in climate change adaptation is also easier and faster among the educated farmers than the uneducated ones. Maddison (2006) argues that education diminishes the probability that no adaptation is taken. In other words, it has a positive impact on adoption of climate change adaptation practices.

Farming experience

About 32% had a farming experience of 20-24 years (Table 1). The fact that none of the respondents had an experience of less than 5 years indicates that they were not new into farming. The mean farming experience was 24.64.

The more experienced the farmers are, the more they are better informed about the changes in climate and the more they employ adaptation measures that reduce the impact of climate change on their agricultural activities (Mudzonga, 2012). It is farming experience that matters more than merely the age of the farmer when it comes to adaptation to climate change (Hassan and Nhemachena, 2008). Studies by Maddison (2006) and Hassan and Nhemachena (2007) indicated that long years of farming experience increases the probability of a farmer adapting to climate change.

Income from rice production

Rice income refers to the earnings, returns or proceeds of cash or cash-equivalents received by the farmers from rice production. Results of the study show that majority (81%) of the respondents had an income from rice production, within the range of $166 to $1656 with a mean of $1228 (Table 1). Income is a major determinant in the adoption of agricultural technologies as available income enhances the acquisition of associated inputs and services for the adoption.

Use of Climate Change Adaptation Practices

In this study, climate change adaptation practices adoption was examined and not the effectiveness of adaptation measures to climate change effects. This is due to the fact that rice plots are used for multiple cropping and crop rotation in order to maximize the use of resources per plot.

Portfolio diversification

Portfolio diversification includes the use of improved rice varieties and intercropping. The result of this study shows that majority (89%) of the respondents used improved rice varieties. Similarly, majority (about 78%) of the respondents used intercropping (Table 2).

Table 2. Distribution of respondents according to use of CCAP (n=279)

Variable	Frequency	Percentage
Portfolio diversification:		
Use of improved rice varieties	247	88.53
Intercropping	217	77.78
Soil conservation:		
Mulching	125	44.80
Planting of cover crops	91	32.62
Planting of trees	138	49.46
Moderate use of fertilizers	256	91.76
Moderate use of chemicals	250	89.61
Use of organic manure	279	100.00
Adjusting the planting calendar:		
Early planting	270	96.77
Late planting	10	3.58
Early harvesting	265	94.98
Late harvesting	15	5.38
Use of minimum tillage:		
Zero tillage	12	4.30
Making mounds and digging ridges across slopes	260	93.19
Use of irrigation technologies:		
Rainwater harvesting	0	0.00
Use of rivers/streams	271	97.13
Digging of well	245	87.81
Sinking of bore-hole	14	5.02

*Multiple responses.

Source: own Authors' calculations.

This indicates that the respondents do not depend mainly on rice production; they also produce other crops to prevent a total failure of rice as a result of changes in climate. Not only are different crops grown, the respondents also carefully select the varieties that are better in terms of yield, early maturity, drought tolerance and resistance to pests and diseases. These are put into practice to adapt to climate change.

Soil conservation

Soil conservation for this study involves mulching, planting of cover crops, planting of trees, moderate use of fertilizers, moderate use of chemicals and use of organic manure. Mulching was used by about 45% of the respondents. Planting of cover crops was used by 34% while about 50% planted trees to minimize the adverse effects of climate change.

Majority (about 92%) of the respondents applied the moderate use of fertilizers and other chemicals (93%). In the same vein, the entire respondents (100%) practiced the use of organic manure (Table 2). This implies that the only aspects of soil conservation largely used by the farmers were moderate use of fertilizers and other chemicals as well as use of organic manure.

Adjusting the planting calendar

The adjustment of planting calendar involves early planting, late planting, early harvesting and late harvesting. Majority (about 97%) of the respondents used early planting. Similarly, about 95% of the respondents used early harvesting. Late planting was used by only about 5% of the respondents (Table 2). This indicates that early planting and early harvesting were the main components of adjusting planting calendar used widely by the rice farmers.

Use of minimum tillage

Minimum tillage involves zero tillage and making mounds and digging ridges across slopes. Majority (about 93%) of the respondents used the practice of making mounds and ridges across slopes. However, zero tillage was used by only about 4% of the respondents (Table 2). This indicates that making mounds and digging ridges across slopes was well used by the respondents in their efforts to adapt to climate change.

Use of irrigation technologies

This involves the use of rainwater harvesting, rivers/streams, digging of well and sinking of bore-hole to supply water to farmlands through supplementary irrigation. The use of rivers/streams as sources of water was used by majority (about 97%) of the respondents. Digging of wells for water supply was similarly used by majority (about 89%) of the respondents. There was a very minimal use of rainwater harvesting and sinking of bore-holes among the farmers (Table 2). This implies that the farmers mainly used rivers/streams and dug wells for irrigation. This is contrary to the finding of Abaje *et al.* (2014) who reported that the most significant climate change adaptation strategies used by farmers were water harvesting, use of fertilizer/animals dung to improve soil moisture and prayers for God to intervene.

Ayanwuyi *et al.* (2010) reported that adaptation strategies actually adopted by the farmers in Ogbomosho Agricultural Zone of Oyo State, Nigeria were increase water conservation, shading and shelter/mulching, soil conservation and moving to different site. Other farmers implemented water conservation techniques, increased irrigation and increased or reduction in land size cultivated.

Determinants of use of Climate Change Adaptation Practices by Rice Farmers

The likelihood ratio statistic as indicated by chi-square statistic was highly significant ($P < 0.00$), suggesting that the Tobit regression model has a strong explanatory power (Table 3). The result shows that years of formal education was statistically significant ($p < 0.00$) in determining the use of climate change adaptation practices by rice farmers (Table 3). The positive coefficient implies that education had a strong influence on the use of climate change adaptation practices. An increase in the level of education would increase the probability of the farmer to use climate change adaptation practices. This implies that as rice farmers acquire more education, their probability of adapting to climate change increases. These results are in support of the findings of Deressa *et al.* (2009) who found a positive relationship between education and adaptation to climate change in Ethiopia.

De Jonge (2010) also found that farmers who have university education are more likely to respond to climate change than farmers who have primary education. Education increases the probability of utilizing adaptation measures because higher level of education is often hypothesized to increase the probability of using new technologies (Daberkow and McBride 2003; Gbetibouo, 2009), greater access to information on climate change and agricultural productivity (Deressa *et al*., 2011).

Farm size was also statistically significant ($p < 0.10$) with a positive coefficient which implies that farm size had a strong influence on use of climate change adaptation practices (Table 3). An increase in farm size would increase the probability of the farmer using climate change adaptation practices. This implies that as rice farmers acquire more farm land, their probability of adapting to climate change increases. Larger farm has higher chance of utilizing adaptation measures (Fatuase *et al.,* 2015). This connotes with several studies in the literature (Gbetibouo, 2009; Deressa *et al.,* 2011; Fatuase and Ajibefun, 2014).

The probable reason was in line with the report of Daberkow and McBride (2003) cited in Gbetibouo (2009) who opined that given the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from using several adaptations. As these costs increase, the critical size also increases. It follows that innovations with large fixed transaction and/or information costs are less likely to be used by smaller farms (Gbetibouo, 2009).

Climate change awareness was significant ($p < 0.00$) indicating that it had a strong influence on use of climate change adaptation practices (Table 3). If a farmer is exposed to information on climate change then his/her probability of using the climate change adaptation practices increases. This implies that more climate change information dissemination will increase the likelihood of farmers to use the climate change adaptation practices. Rice farmers who have access to information on climate change have a higher predicted probability of adapting to climate change than those without access. The results are consistent with findings of Deressa *et al.* (2009) and Hassan and Nhemachena (2008) who found information on climate change as significant in influencing farmers' adaptation choice.

Extension contact was found to be statistically and positively significant ($p < 0.01$), which implies a strong influence on use of climate change adaptation practices (Table 3). An increase in extension contact would increase the probability of the farmer using climate change adaptation practices. This implies that as rice farmers obtain more contacts with the extension agents, their probability of adapting to climate change increases.

Fatuase *et al.* (2015) found that access to extension agent was significant in influencing the rate of utilizing adaptation measures. They added that the more the farmer has access to extension services, the more the chance of utilizing many adaptation measures. This is because extension agents assist the farmers to make decisions that would guide them against the consequences of climate change and by exposing them to latest information and technical skills that will boost their productivity in spite of changes in climate.

Years of cooperative membership was statistically significant ($p < 0.01$) with a positive coefficient (Table 3) which indicates a strong positive influence on use of climate change adaptation practices. An increase in the years of cooperative membership would increase the probability of the farmer using climate change adaptation practices. This implies that as rice farmers acquire more years in the cooperative societies, their probability of adapting to climate change increases. This is due to the role cooperative societies play in not only increasing the capital base of the farmers, but as an avenue to enlighten the farmers on the importance of using the climate change adaptation practices.

Affordability of using climate change adaptation practices was also found to be statistically an positively significant ($p < 0.01$) which implies a strong influence on use of climate change adaptation practices (Table 3). An increase in affordability would increase the probability of the farmer using climate change adaptation practices. This implies that as the affordability of the rice farmers increases, their probability of adapting to climate change would also increase. All the climate change adaptation practices have cost implications which limit the farmers' ability to use them. Farmers with higher capital base are more likely to employ the use of the adaptation practices.

Among the socioeconomic factors, sex, faming experience, years of formal education, farm size, weather information and climate change awareness were found to significantly influence the use of climate change adaptation practices among the rice farmers. Extension contact and years of cooperative membership were the institutional factors found to significantly influence the use of climate change adaptation practices among the rice farmers. Similarly, among the technology related attributes, affordability was found to significantly influence the use of climate change adaptation practices among the rice farmers. Hence, the null hypothesis is rejected.

Table 3. Factors influencing the use of CCAP in by the respondents

Variable	Coefficient	Standard error	t-ratio	P[|T|>t]
Constant	.2138744	.1678039	1.27	0.204
Age	-.0003699	-.0006583	-0.56	0.575
Sex	-.0254857	.0177675	-1.43	0.153
Household size	.0003793	.0007066	0.54	0.592
Years of formal Education	.0080802	.0008904	9.07	0.000***
Faming experience	-.0016371	.0006665	-2.46	0.015**
Farm size	.0148466	.0084005	1.77	0.078*
Income from rice production	-1.78e-08	2.42e-08	-0.74	0.463
Off-farm employment	.0123223	.0126979	0.97	0.333
Weather information	-.0123071	.005015	-2.45	0.015
Climate change awareness	.0768354	.0154901	4.96	0.000***
Credit accessed	-8.60e-08	7.83e-08	-1.10	0.273
Extension contact	.009482	.0028878	3.28	0.001***
Years of cooperatives membership	.0037079	.0006734	5.51	0.000***
Affordability of using CCAP	.0069117	.001617	4.27	0.000***
Complexity of using CCAP	.0015872	.0019944	0.80	0.427
Relative advantage of using CCAP	-.0021455	.0023761	-0.90	0.367
LR $chi^2(18) = 496.30$				
Prob > $chi^2 = 0.00000$				
Log likelihood = 444.13685				
Pseudo $R^2 = -1.2661$				

***Significant at 1% level **Significant at 5% level *Significant at 10% level.

Source: own Authors' calculations.

Conclusion and Recommendations

This study concludes that use of climate change adaptation practices among rice farmers in Kebbi State, North-West, Nigeria was determined by their socioeconomic, institutional and technological characteristics. Rice farmers in the State, were in their productive ages, which has a direct bearing on the availability of able bodied manpower for agricultural production and also on the ease of use of climate change adaptation strategies. They were married with large household size which is believed to provide cheap labour that would assist in practices capable of mitigating the impacts of climate variability and change.

The acquisition of one form of formal education or the other by the farmers had impact on adaptation to changes in the climate since use of adaptation practices that could result in climate change adaptation is easier and faster among educated farmers than the uneducated ones. Their membership of cooperative societies gave them access to credit which enhanced their possibility of adapting practices that reduce the negative impact of climate change.

Portfolio diversification (use of improved rice varieties and intercropping), soil conservation (moderate use of fertilizers, moderate use of chemicals and use of organic manure), adjusting the planting calendar (early planting and early harvesting), minimum tillage (making mounds and digging ridges across slopes) and use of irrigation technologies (use of rivers/streams and digging of well) by the farmers could lower the adverse effect of climate change on rice production.

Having a positive and significant influence on use of climate change adaptation practices among the rice farmers, government policy should be geared towards encouraging the farmers especially the younger ones to acquire more formal education, larger farmlands and more climate change awareness. Improving the State extension service and encouraging the farmers for more cooperative membership can increase their capacity to use the climate change adaptation practices. Cooperative membership can also increase the farmers' affordability to acquire the needed technology for adapting to the changes in climate.

Findings for this study showed a comparatively low use of mulching, planting of cover crops and planting of trees by the farmers, as adaptation measures to climate change effects. Hence, there should be an awareness creation campaign by both government and non-governmental organizations concerned with agricultural development to educate the farmers on climate change adaptation strategies and the implications of the adaptation strategies on yield and climate change.

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