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Adaptation to Climate Change by Farmers in Makurdi, Nigeria

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Author's contributions

This work was conducted in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The increasing trend of climate change has led to growing concern on its impact on different sectors of the economy particularly on agriculture. Coping with the vulnerability and negative effects of climate change on agriculture requires mitigation at the policy level and adaptation at the farm level. However, the ability of farmers to adopt the various adaptation strategies may be constrained by a number of factors. Therefore, this study identified the climate adaptation strategies adopted by farmers in Makurdi, Nigeria and subsequently examined the determinants of farmers' adaptation strategies to climate change. The primary data used in this study were collected through structured questionnaires administered to 120 randomly selected farmers. Both descriptive and inferential statistics were used in analyzing the data. Results shows that about 58% of the farmers adopted at least one of the following climate change adaptation strategies: cultivating diff type of crop, shortening growing season, changing extent of land put in crop production, use of irrigation as water source, use of chemical fertilizer, mulching, planting of cover crops, planting of resistant crop varieties, changing of planting dates, adoption of new techniques

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and use of drainage system. Logit regression was used to identify factors that influence the strategies employed by famers for adaptation to climate change. The result of the logit model showed that annual farm income, farming experience, knowledge of climate information, education and extension access variables are significant determinants of climate change adaptation strategies.
The study recommends the promulgation of policies to ensure that farmers have access to physical, human and social capital will enhance farmers' ability to respond effectively to changing climate conditions.

Keywords: *Climate change; determinants; adaptation strategies; smallholder farmers.*

1. INTRODUCTION

Agriculture is an important source of food and fibre, employment and foreign exchange for most developing countries. For instance, agriculture contributes over 40% of Nigeria's GDP, employs about 70% of the population, and produces about 80% of the food needs [1]. Although, agriculture still accounts for about 88% of non-oil export earnings, its contribution has seriously declined over the decade falling from about 75% of total export earnings in the 1960s to less than 3% currently [2]. Increasing productivity in agriculture depends heavily on a number of factors including weather and climate conditions. Climate in a narrow sense is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system [3]. It is increasingly observed that the earth is warming and hence the climate is changing.

Climate change arises due to a number of factors but basically due to human activities, such as the emission of greenhouse gases and changing land uses [4,5]. Climate change has recently been defined by the Intergovernmental Panel on Climate Change as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or inland use" [6]. It is noted that this definition differs from that provided by the United Nations Framework Convention on Climate Change (UNFCCC), which states that climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" [6]. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

One of the continents of the world that has been acknowledged to be most vulnerable to vagaries of climate change is Africa in general but West Africa in particular [4]. The current food crisis in some countries such as Nigeria serves as a reiteration of the continuing vulnerability to the changes in the climatic conditions. This has been attributed to a number of factors which include weak institutional capability, a lack of authentication of local knowledge and inadequate involvement in environmental adaptation issues [7-10]. Nigeria in particular is highly vulnerable to the whims of climate change because of its long (800km) coastline which is prone to sea level rise and the risk of fierce storms [11].

The fact that agriculture plays a vital role in food security and hence human welfare which are critical to economic and sustainable development, has aroused concerns from all quarters as to the potential impacts of climate change on agriculture. These concerns have motivated a considerable number of researches on agriculture and climate change in recent times [12-14]. The potential impact of climate change on agriculture spans a number of areas including quantity and quality of agricultural (livestock and crop) production and hence food security and poverty, supply of inputs, land uses, biodiversity, hydrological balances, increased pest and

diseases and other components of agricultural systems [4]. For instance, projections show that crop yield in Africa would fall by 10-20% by 2050 or even up to 50% as a result of climate change [15]. This is mainly so because African agriculture is largely rain-fed and hence primarily dependent on weather and climate conditions.

According to [16], the nature and extent of environmental stresses such as climate change do not necessarily determine agriculture's vulnerability, rather what matters is the ability of the society to cope and/or recover from such environmental change. The coping capacity and the extent of exposure are related to both changes in the environmental and changes in the societal aspects like cultural practices and land use [17]. Early efforts to deal with the challenges of global warming focused mainly on mitigation, with the aim of reducing and possibly stabilizing the GHG concentrations in the atmosphere [18]. However, had this stabilization been achieved to some extent, global warming would continue to increase in different countries over time. Accordingly, adaptation is considered a feasible option in reducing vulnerability and associated negative climate change effects [19]. Adaptation is "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" [6]. In other words, adaptation is the process by which ecological, social or economic systems adjust to actual or expected stimulus and their effects or impacts [20]. Adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the impact of climate [19,21,22]. Such strategies include the adoption of drought resistant varieties, early maturing crops, mulching, and selective keeping of livestock in areas where rainfall declined, irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and changing planting date, among others [17,23,24,25].

Numerous studies [26-37] have been conducted on climate change impact on agriculture while also considering adaptation to climate change. These studies showed the importance of adaptation measures in substantially decreasing potentially adverse impacts of climate change and in strengthening the benefits associated with changes in climate. For instance, [28] showed that if adaptation is taken into account, there is great potential to increase food production under climate change in many regions of the world. [32] indicated that with adaptation, it is possible to reduce food deficits in Africa from 50 to 20 percent. Further, [33] showed that in Indian agriculture, the potential damages from climate change can be reduced from 25 to 15-23 percent under adaptation.

[34] used data from over 15000 operations in Canadian prairie agriculture for the period 1994-2002, reported that individual farms have become more specialized in their cropping patterns since 1994 and that this trend is unlikely to change in the immediate future, despite expected climate change and the known risk-reducing benefits of crop diversification. Based on this they recommended that there is a need to assess and understand the wider strengths and limitations of various 'suitable' and 'possible' adaptations to changes in climate. [35] used the Ricardian model to examine the role of irrigation as an adaptation measure against unfavourable climatic conditions and found that irrigation significantly reduces the negative impacts of climate change. [36] used multinomial logit models to analyse crop and livestock choice as adaptation options, respectively. They found that farmers switch crops as a measure of climate change adaptation while they choose goats and sheep as opposed to beef cattle and chicken for adaptation given that goats and sheep can do better in dry and harsher conditions (warmer temperatures) than beef and cattle. While these studies have shown the possibility of reducing the effect of climate change using the various adaptation strategies, it is equally noted that some socioeconomic, policy and institutional factors may constrain the farmers' ability to adopt these strategies [18,37,38,39,40]. Hence, the need to understand the constraining factors to climate change adaptation cannot be overstressed.

Against this background, the broad objective of this study is to analyse farmers' adaptation strategies and the determinants of adopting such strategies in Makurdi, Benue State, Nigeria. The specific objectives are to describe farmers' socioeconomic characteristics in the study area, identify the climate adaptation strategies adopted by the smallholder farmers and examine the factors that determine the climate adaptation strategies adopted by smallholder farmers. To the best of our knowledge there is no study on this in Benue State, Nigeria.

2. MATERIALS AND METHODS

This study was conducted in Makurdi, Benue State, Nigeria which is also the headquarters of the State. The study area has a population of 287,398 people [41] with a land area of 804 square kilometers. The city is located in central Nigeria and lies on the south bank of the Benue River. The latitude and longitude of Makurdi is 7°43'North and 8°35'East (See Fig. 1).

A multistage random technique was used to select the respondents. In the first step, six council wards out of eleven were selected using simple random technique. The six council wards that were sampled are Agan, Fidi, Bar, Ankpa/Wadata, North Bank 1 and North Bank II. In the second, twenty farm households from the six council wards were randomly selected. In the third stage, the household was purposively selected and served with the questionnaire. This makes a total of 120 sample farmers for the study. The data was analyzed using the Logit model.

The Logit model is estimated with maximum likelihood estimation (MLE) technique. The Logit model is specified as

$$\frac{P_i}{(1-P_i)} = \frac{1+\exp(Z_i)}{1+\exp(-Z_i)} \quad (1)$$

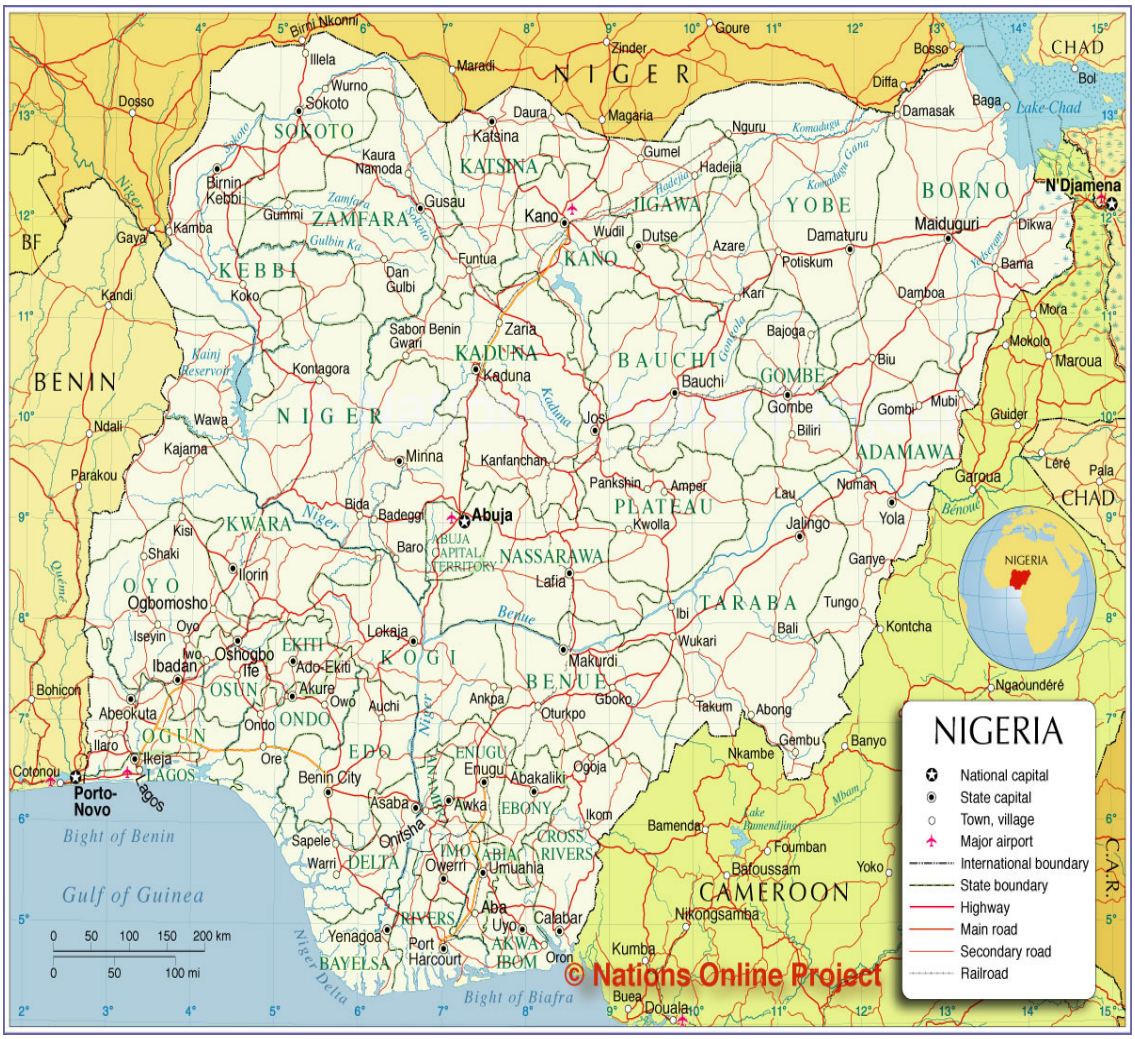

Fig. 1. Administrative and political Map of Nigeria showing Makurdi
Source: http://www.nationsonline.org/oneworld/map/nigeria_map2.htm

Where P_i is the dependent variable which in this study is the probability of adoption of at least one climate adaptation strategy. P_i ranges between 1 and 0 and is nonlinearly related to Z_i and is a linear function of the explanatory or independent variables, X_i, with values ranging from $-\infty$ to $+\infty$. Because equation (1) is nonlinear, one can linearize the model by taking the natural log. This gives the following linear Logit model:

$$Li = \ln\left[\frac{P_i}{(1-P_i)}\right] = Zi = \beta_0 + \beta_1 X_1 + ... + \beta_n X_n + e \qquad (2)$$

where $\frac{P_i}{(1-P_i)}$ = is the ratio of the probability that a farmer will use any of the listed climate change adaptation strategies (planting resistant crop varieties, cultivating different types of crops, shortening growing season, changing extent of land put into crop production, use of irrigation as water sources, use of chemical fertilizer, mulching, planting of cover crops, changing of planting dates, adoption of new techniques, use of drainage system, others (specify))presented to them to the probability that a farmer will use none of the strategies. Hence, the dependent variable is binary and its value is 1 for a farmer who used at least one of the listed strategies and 0 for a farmer who used none. β_0 to β_n are parameters to be estimated and e is the error term. X_1 to X_1 are the independent variables. The description of all the variables (dependent and independent) used for analysis is presented in Table 1.

3. RESULTS AND DISCUSSION

3.1 Socioeconomic and Demographic Characteristics of Respondents

The socioeconomic and demographic characteristics of the respondents are reported in Table 2. The result in Table 2 shows that majority (60.83%) of the farmers were males while 39.17% were females. This implies that males are more actively involved in farming in the study area. The dominance of the male counterparts may be attributed to the labourious nature of farming in the area whereby most of the farming operations are carried out manually using crude farm implements. In such situation, males may be more able to withstand the stressful and energy dissipating nature of farming. The result also indicates that 70.00% of the respondents were married, 17.50% were single, 8.30% widowed and 4.20% divorced. This implies that more married male are involved in farming in the study area and this is consistent with [42].

Table 2 reveals that majority of the respondents (35%) are between the ages of 33 – 45 years while only 2.50% of the respondents are aged 72 – 84 years. This implies that most farmers are still in their productive age. Majority of the farmers have been farming for the past 13 to 25 years with a mean farming experience of about 19 years. Again this indicates most farmers are relatively young.

Table 1. Description of variables in used for analysis

Variable	Description
Adoption	1 for adopting climate strategy, 0 otherwise
Primary education	1 for attending primary school, 0 otherwise
Secondary education	1 for attending secondary, 0 otherwise
Polytechnic education	1 for attending polytechnic, 0 otherwise
University education	1 for attending university, 0 otherwise
Annual farm Income	Annual income from farming in naira
Tenancy	1 for own farm, 0 for rented farm
Experience	Number of years involved in farming
Market	Distance from house to the nearest market in km
Extension	1 for visit from extension agents, 0 otherwise
Credit	1 for access to credit, 0 otherwise
Climate information	1 for received climate information, 0 otherwise
Gender	1 for male, 0 for female

According to [43], older farmers are more risk – averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting adaptation strategies. However, older farmers may also understand the complexities of farming more than younger farmers since they having been into the business longer and experiences may serve as a proxy for age.

Table 2 reports the educational status of the sampled farmers. The result shows that 20.00% of the farmers had no formal education, 16.67% had primary education, 28.33% had secondary education, 20.00% had polytechnic education while 15% had university education. This shows that the farmers have some level of education and would therefore be able to comprehend the complexities of farming and climate change better. Household size ranges from 1 -7 (55%), 8 – 14 (38.33%), 15–21 (4.17%), 22-28 (1.67%) and 29-35 (0.83%) with a mean size of 8 persons. Higher family size is an indication that there are enough hands to carry out the farming activities. Hence, household size as a proxy to labour availability reduces labour constraints. It should however be noted that large household size may increase the probability of poverty if majority of the members are not involved in income generating activities but are merely dependants.

Majority (58.33%) of the respondents have farm sizes of less than 3 hectares with a mean farm size of 2.4 hectares. This is an indication that these farmers are mainly small scale producers. Despite the smallness of the farms, majority (78.33%) of the farmers own the farms which they cultivate as against 21.67% who rented theirs. Tenancy would motivate farmers to invest more in practices and technologies that would improve their farm outputs including climate adaptation strategies.

Majority (42.51%) of the respondents had annual farm income between ₦200,000–₦399,000. The mean annual income is ₦300,534.6. This implies that the respondents in the study area had high income from their farming activities. It is expected that household with higher income will be in a better position to adopt new farming technologies [44] which could reduce the negative effects of climate change. Majority (52.50%) of the farmers live about 5-10 kilometres away from the nearest market. With a mean market distance of 6.72km, it shows that most farmers may be constrained to participate in the market except there are well developed transportation systems in the area. About 37.50% of the farmers have been visited by extension agents, 20.00% have access to credit and 74.17% of the farmers have access to climate information.

3.2 Climate Adaptation Strategies Adopted by Farmers

The farmers were presented with a number of climate adaptation strategies and then asked to indicate whether they have used any of the listed. The results are presented in Table 3. Analysis shows cultivation of different types of crops and use of chemical fertilizers have attracted more attention than other measures given that about 58.33% of the respondents adopted these measures to cushion the effect of climate change. Use of resistant varieties (56.67%), shortening of growing season (55.00%), mulching (55.00%), changing the proportion of land cultivated with crops (54.17%) and adoption of new farming techniques (53.33%) have also been used by most farmers. However, the use of drainage system is not very common given that only 30.83% of the farmers use it. This is not surprising given the costly nature of this strategy and the subsistence nature of farming in the study area. Altogether, about 58.33% of the farmers have adopted at least one climate adaptation strategy of the other. This is not very encouraging. These findings indicate the need to promulgate policies and programmes that will aid the farmers in understanding the effect of climate change better and the need to adopt strategies that will mitigate its effects.

3.3 Factors Affecting Adoption of Climate Adaptation Strategies

The Logit results of factors that determine farmers' decision on whether to adopt a climate adaptation strategy is presented in Table 4. The log likelihood function is statistically significant at 1% level. This implies that the variables (farmers socioeconomic characteristics, institutional and other policy variables) included in the logit model are jointly significant in determining farmers decision to adopt one or more climate adaptation strategies. All variables have expected sign. However, only five out of the nine variables are individually statistically significant. These are education, annual income, experience, extension and climate information.

The result in Table 4 indicates that primary education was significant at 10% level and positively related to the probability of adoption of climate adaptation strategies. This implies that farmers with at least primary education are more able to comprehend the complexities of farming than uneducated farmers and hence are more likely to adopt adaptation strategies that will mitigate the effect of climate change on their farm. This is in line with [45,46] who reported that education correlates positively with adoption. This emphasises the need for improving the current universal basic education programme in the country and also making it more accessible to the farming communities.

Table 2. Frequency distribution of respondents by socioeconomic characteristics

Variables	Frequency	Percentage
Sex:		
Male	73	60.83
Female	47	39.17
Age (Years):		
20 – 32	22	18.33
33 – 45	42	35.00
46 – 58	35	29.17
59 – 71	18	15.00
72 – 84	3	2.50
Mean	45.22	
Marital status:		
Single	21	17.50
Married	84	70.00
Widowed	10	8.30
Divorced	5	4.20
Education:		
No formal education	24	20.00
Primary	20	16.67
Secondary	34	28.33
Polytechnic	24	10.00
University	18	15.00
Household size:		
1 – 7	66	55.00
8 – 14	46	38.33
15 – 21	5	4.17
≥ 22	3	2.50
Mean	8	
Farming experience (Years):		
1 – 12	34	28.33
13 – 25	51	42.50
26 – 38	26	21.67
39 – 51	9	7.50
Mean	19.217	

Table 2. Frequency distribution of respondents by socioeconomic characteristics contd.

Variables	Frequency	Percentage
Farm size (Hectares):		
>3	70	58.33
3 – 5	40	33.33
>5	10	8.33
Mean	2.4	
Annual farm income (Naira):		
<200,000	37	30.83
200,000 – 399,000	51	42.51
400,000 – 599,000	25	20.83
>600,000	7	5.83
Mean	300535	
Tenancy		
Own	94	78.33
Rented	26	21.67
Market distance (km):		
>5	36	30.00
5 – 10	63	52.50
>10	21	17.50
Mean	6.72	
Extension:		
Access	45	37.50
No Access	75	62.50
Credit:		
Access	24	20.00
No Access	96	80.00
Climate information:		
Access	89	74.17
No Access	31	25.83

The effect of annual farm income on adoption of climate change adaptation strategies is positive and significant at 10% level. This implies that the probability of adoption of climate change adaptation strategies increases with increase in income. This is not surprising as increased income probably enables a farmer to purchase modern varieties and technologies (e.g irrigation facilities) that reduce the effect of climate change. This is consistent with [47] who found a positive impact of farm income on the probability of adoption of climate change adaptation strategies in Nile basin of Ethiopia.

The effect of experience on adoption of climate change adaptation strategies is positive and significant at 5% level. This implies that the probability of adoption of climate change adaptation strategies increases with increase in

level of farming experience. The result indicates that experienced farmers (farmers who have been farming for longer time period) are more likely to adopt the climate change adaptation compared to inexperienced farmers. The result corroborates findings from [47,48] which show that older farmers are more likely to adopt climate adoption strategies since age indexes experience.

Table 3. Frequency distribution of farmers by climate adaptation strategies

Adaptation strategy	Frequency	Percentage*
Cultivating diff type of crop	70	58.33
Shortening growing season	66	55.00
Changing extent of land put in crop production	65	54.17
Use of irrigation as water source	57	47.50
Use of chemical fertilizer	70	58.33
Mulching	66	55.00
Planting of cover crops	50	41.67
Planting of resistant crop varieties	68	56.67
Changing of planting dates	59	49.17
Adoption of new techniques	64	53.33
Use of drainage system	37	30.83

** Multiple responses*

The effect of access to climate information on adoption of climate change adaptation strategies is positive and significant at 1% level. This implies that the probability of adoption of climate change adaptation strategies increases with increase in farmers' access to climate information. The result indicates that informed farmers are likely to adapt to climate change. This finding is consistent with [25,47,48].

Meteorological stations could be established and where they already exists, they can be made more functional and effective so as to ensure rural farmers receive information on climate change issues.

The effect of extension on adoption of climate change adaptation strategies is positive and significant at 10% level. This implies that the probability of adoption of climate change adaptation strategies increases with farmers' exposure to extension agents. The result indicates farmers who are exposed to extension agents are likely to adopt the climate change adaptation strategies. The finding supports those of [24,46] who also showed that access to information through extension increase the chance of adapting to climate change. The extension system needs to be revitalise to provide more service to the farmers that go beyond the traditional adoption of farming technologies to those specific to mitigating the effect of climate change on agriculture. The content and timing of such deliveries are equally important.

Table 4. Logit regression of factors influencing adoption of climate adaptation strategies

Variables	Coefficient	Standard error	Z-statistic	P-value
Constant	3.610**	1.864	1.940	0.053
Primary education	2.193*	1.319	1.660	0.096
Secondary education	0.789	1.043	0.760	0.449
Polytechnic education	0.485	1.174	0.410	0.679
University education	1.004	1.217	0.820	0.410
Annual farm income	0.000*	0.000	1.770	0.077
Tenancy	0.236	0.760	0.310	0.756
Experience	0.069**	0.033	2.100	0.036
Market	0.084	0.108	0.780	0.433
Extension	1.137*	0.659	1.730	0.084
Credit	0.892	0.772	1.160	0.248
Climate information	2.346***	0.658	3.570	0.000
Gender	0.570	0.590	0.970	0.334
Log likelihood	-41.683***			0.000

The asterisks [, **, and ***] represent statistical significance at 10%, 5% and 1% levels respectively*

4. SUMMARY AND CONCLUSION

This study identified the various climate adaptation strategies used by farmers in Makurdi Local Government Area of Benue State, Nigeria. Subsequently it examined the factors that influence the adoption of climate change adaptation strategies these farmers. The study also provided a description of the farmers' socioeconomic characteristics.The primary data used in this study were collected through structured questionnaires administered to 120 randomly selected farmers. The data was analysed using both descriptive statistics and inferential statistics. The descriptive statistics includes frequencies, percentages and means while the inferential statistics used is the Logit regression model. Analysis shows that majority (60.83%) of the farmers were males, have been farming for about 19 years with average farm size of 2.4 hectares and annual farm income of about ₦300, 536. Farmers were mostly in their productive age (45 years on average). Only 37.5% had access to extension service while 20% had access to credit facilities. Majority (74.17%) has access to climate information. Results shows the farmers adopted the following climate change adaptation strategies: cultivating diff type of crop (58.33%), shortening growing season (55.00%), changing extent of land put in crop production (54.17%), use of irrigation as water source (47.50%), use of chemical fertilizer (58.33%), mulching (55.00%), planting of cover crops (41.67%), planting of resistant crop varieties (56.67%), changing of planting dates (49.17%), adoption of new techniques (53.33%) and use of drainage system (30.83%). Overall, 58% of the farmers adopted at least one of the climate adaptation strategies. Logit regression was used to identify the strategies smallholder farm households employ in cushioning climate change adaptation strategies. The result of the Logit model showed that annual farm income, farming experience, knowledge of climate information, education and extension access variables are significant determinants of climate change adaptation strategies.

From the foregoing, this study has shown that farmers in the study area are aware of climate change and its devastating effects and hence are striving to curb the effects on their farm using different adaptation strategies. However, the adoption of these strategies is not wide spread among the farmers yet given that only slightly half of the respondents adopted the strategies. This study has shown that annual farm income, farming experience, education, access to climate information and extension service are important factors to be considered in ensuring that farmers would adopt the state of the art climate adaptation strategies.

5. RECOMMENDATIONS

In view of the findings from this study, government policies that ensure that farmers have access to physical, human and social capital will help increase their ability and flexibility to change production strategies in response to climate condition. Specifically, first, extension workers should be well trained in research centres and extension organizations on the intricacies of climate change and their services should be made available to farmers. In other words there is need to strengthen the extension service delivery beyond the traditional role of extending information on new technologies and varieties to that related to climate change adaptation strategies. Second, government should establish functional metrological centres in the rural areas to make available climate information to farmers via radio and television. This will strengthen farmers' adaptability to climate change. Third, policies that will enhance farmers' incomes through increased productivity will also be of help. Finally there is need to revitalize the education system and make it more accessible to farming communities since education has been demonstrated to play a role in helping farmers adopt climate change adaptation strategies in the study area.

COMPETING INTERESTS

Authors have declared that there are no competing interests.

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