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Determinants of Farmer's Perception and Adaptation to Climate Change: The Case of Maize and Sorghum Farmers in Benin and Nigeria.

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ABSTRACT

Despite the fact that the majority of Africans are employed in agriculture, providing food to meet the demand of the fast-increasing population continue to be a challenge, especially with the changing climate. This study examined the determinants of farmers' perception of climate change and the effect of their perception on adaptation. This involved 644 maize and sorghum farmers, selected from Benin and Nigeria using multi-stage sampling. The data was analyzed using Heckman ordered probit model. From the result, farmers perception of climate change was high. The empirical model revealed education, experience, access to extension services and country of the farmer as significant factors influencing the farmers' perception of climate change. Farmer perception had a positive significant effect (with a p-value= 0.001) on farmers' adaptation which suggested that farmers who predicted all three climate variables (precipitation, temperature and wind) correctly adopted more climate change adaptation strategies. Adaptation was also found to be higher for male farmers, less educated farmers, farmers with less household members, experienced farmers, farmers with off-farm activities and farmers who had access to credit. To enhance adaptation of the farmers therefore, factors that influence the farmers' perception of climate have to be given a prime consideration. Policymakers keen on enhancing farmers' adaptation should consider providing climate-related extension and education services to farmers.

Keywords: Adaptation, Climate change, Heckman ordered model, Perception

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1. INTRODUCTION

In recent times, climate change has become one of the greatest developmental challenge[1] that the whole world, especially, through the United Nations Framework Convention on Climate Change (UNFCCC) is in constant efforts to reducing the impacts. It is now flawless that the changes in climate is increasing with more damaging impacts such as floods and droughts than in the past three decades [2]. Given this consideration, the transition of the Millennium Development Goals (MDGs) into the Sustainable Development Goals (SDGs) lead to the birth of SDG 13 which seeks to 'take urgent action to combat climate change and its impacts[3]. In fact, in the ranking of the SDGs by level of transformational challenge in the developed countries, the SDG 13 score the highest point of 7.1 out of a maximum score of 8 [3]. Similarly, in the ordering of the SDGs, poverty and food insecurity eradication were put at the first two positions which are the focal importance for the developing countries and the international development agenda [3]. The implication is that while policies are designed and efforts directed towards ending poverty and food security, it must be done in considerations to its environmental impacts.

Agriculture is the major employer in Africa employing 65 percent of the workforce. While the situation of Benin and Nigeria is not different, production in these countries is largely rain-fed. Unfortunately, while food insecurity (undernutrition) continues to increase in SSA [4], the region is said to be the most vulnerable to climate change [5], with the agriculture sector is going to experience one of the largest impacts [6]. Thus, climate change has become more prominent in aspects of global discussion especially due to its negative impacts on sectors such as the agriculture sector[7]. While the changes in climate may reflect slow noticeable impacts on most economic activities, farmers are already realizing lower yields with increasing erratic rains. As a result, there are gaps between potential and observables yields for most major crops [5,8]. This means that, climate change may catalyze a decreased in agriculture production, thereby, affecting income mobilization for a large portion of the population in SSA. Generally, various researchers including [9]concluded that the impact of climate change is much or going to be higher in SSA than other parts of the world. While the effects are becoming more superficial, projections show that the variability or change in climate will continue in the next decades. Aside the direct impact on yield reduction, households' welfare is affected by climate change through efficiency reduction, increase costs of production, health problems and catalyzing social conflicts.

The only option towards achieving higher yields is through adaptation. Adaptation refers to the process of adjustment to actual or expected changes in the climate as well as the effects associated with the changes. Thus, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities [9]. It is not surprising that adaptation is an increasingly policy option for reducing climate impacts [10], especially at the local levels. However, the decision to adapt to climate change has been reported as a function of a number of factors. One of such factors that shapes farmer's adaptation is perception on the direction of changes and impacts of the climate change. For instance, perception studies[10,11] revealed that smallholder farmers have high knowledge on climate change. Perception is an important aspect of reducing the impacts of climate change as the nature of response to risks depends on the perception, in which case, misconception may lead to no adoption or even worse this can lead to maladaptation[12].

A number of adaptation strategies have been widely adopted by farmers and these are leading into positive gains. For instance, adaptation strategies such as adjustments in technologies and livelihood diversification are leading to a reduction in vulnerability[9]. However, most of these adaptation strategies do not provide the needed result on individual levels but through combination. This means that farmers would choose a number of strategies to increase their farm outputs. Empirically, studies examining perception and/or adaptation to climate change have largely used logit/probit[13,14] or multinomial logit [15,16]. The implication of this models is that the farmer adopts only a technology at a time. Other studies estimating perception and adaptation in a two-step used the Heckman probit model [17,18] while in estimating the effect of perception on adaptation, the treatment effect model was also used [7]. In this application also, the selection variable, perception, is given as binary. In these cases, perception is defined as predicting climate change rightly or wrongly or if a farmer perceives a change for a given period or not. Thus, perception on climate change has been centered on changes in precipitation and/or temperature. However, considering the recent impacts of wind on crop production especially maize and sorghum, this study has extended the perception frontier to include a third variable, wind. Therefore, in this study, perception is defined as perceived changes in precipitation, temperature and wind. As such, the study is innovative in using Heckman ordered probit model where we are able to categorise farmers into more than two groups as those who perceived changes in all three variables in line with scientific directional changes, those who perceived only two rightly and so on. The authors believe this would provide more insight on the perception of farmers and the effects of the perception on climate change adaptation.

2. METHODOLOGY

2.1. Study area

The study was carried out in Benin and Nigeria. Both countries are located in West Africa. Benin is bordered by Nigeria (Eastern border), Togo (Western Border), Niger (North- Eastern border), Burkina-Faso (North- Western border), and the Atlantic sea (Southern border). Nigeria is bordered by Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast in the south lies on the Gulf of Guinea in the Atlantic Ocean. Data were collected from the northern regions which are identified to be the most vulnerable areas to climate change in both countries. In each country, the study sites (i.e. municipal areas and villages) were selected after a series of exploratory field visits and consultation with agricultural extension officers. As a result, the municipal areas of Bembereke and Ouake were selected in Benin whereas Lapai and Rijau were selected in Nigeria.

2.2. Data and methods of collection

The research unitis the households and the household head were the response unit. In each country, a total of 350 households were randomly sampled from the selected areas. However, after data cleaning the final sample size reduced to 344 households in Benin and 300 households in Nigeria. In practice, a rapid census of the households was carried out to have a list of households in each village. A number was assigned to each household and the sample of respondents was drawn by using the table of random numbers. The random sampling was carried out at the village level.

Regarding the research frameworks and the study objectives, primary data was collected at the household level. These data included 1) the households' socio-economic characteristics (e.g. location, structure, activities, access to credit) and 2) the observed agrarian transformations and resulting agricultural development due to climate change. The primary data was collected through a household survey. A set of questionnaires was utilized to elicit the desired information from the respondents. Furthermore, investigations were conducted using non-structured and semi-structured interviews with key informants (e.g. agricultural extension officers, village leaders) and farmers. Some focus groups, observations and the triangulation were additional data collection tools. Focus group discussions were conducted by using a discussion guide.

2.3. Data analysis

The data was analysed using Heckman ordered probit model. An ordered response model with sample selection can be represented through the following bivariate threshold-crossing model.

$$Y_j^* = \beta_j^T X_j + U_j \qquad \text{where } j = 1, 2 \qquad (1)$$

$$Y_1 = I(Y_1^* \geq 0) \qquad (2)$$

$$Y_2 = \sum_{h=0}^{H} hI(\alpha_h \leq Y_2^* \leq \alpha_{h+1}) \qquad \text{if } Y_1 = 1 \qquad (3)$$

Where Y_1^* and Y_2^* represent continuous latent variables for the selection process and the outcome of interest, respectively; the β_j are k_j vectors of unknown parameters; the Xj are k_j vectors of exogenous variables; and the U_j are random errors. The latent variable Y_1^* is related to the binary indicator Y_1 through the observational rule (2), where I(A) denotes the indicator function of the event A. The latent variable Y_2^* is related to the binary indicator Y_2 through the observational rule (3) where $\alpha = (\alpha_1, \ldots, \alpha_H)$ with $\alpha < \alpha_{h+1}$, $\alpha_0 = -\infty$ and $\alpha_{h+1} = +\infty$ is a vector of H strictly increasing thresholds that partition Y_2^* into H + 1 exhaustive and mutually exclusive intervals.

The parametric specification of the model assumes that the errors U_1 and U_2 follow a bivariate Gaussian distribution with zero mean, unit variance, and correlation coefficient ρ. This is the same distributional assumption imposed in specifying a binomial family with an ordered probit[19]. Under this parametric assumption on the distribution of the latent regression errors, the log-likelihood function for a random sample of n observations $\{(Y_{1i}, Y_{2i}, X_{1i}, X_{1i}): i = 1, \ldots n\}$ is:

$$L(\theta) = \sum_{i=1}^{n} \{(1 - Y_{1i}) \ln \pi_{\theta i}(\theta) + \sum_{h=0}^{H} Y_{1i} I(Y_{2i} = h) \ln \pi_{1hi}(\theta)\} \qquad \textbf{(4)}$$

Where $\theta = (ß_1, ß_2, a, \rho)$ is the vector of all model parameters and $(\pi_0, \pi_{10}, \ldots \pi_{1H})$ are the conditional probabilities associated with the H + 2 possible realizations of Y_1 and Y_2

$$\pi_0(\theta) = \Pr(Y_1 = 0) = 1 - \varphi(\beta_1^T X_1) \qquad \textbf{(5)}$$

With φ denoting the standardized Gaussian distribution.

Empirical model

From the above theoretical model, the present study estimated two equations, one for perception and the other for adaptation, simultaneously. This is given below:

$$Perception = \beta_0 + \beta_1 Sex + \beta_2 Education + \beta_3 Experience + \beta_4 FBO + \beta_5 Extension + \beta_6 country \quad (6)$$

and

$$\begin{aligned} Adaptation = {} & \delta_0 + \delta_1 Sex + \delta_2 Education + \delta_3 Household\,size + \delta_4 Experience \\ & + \delta_5 Extension + \delta_6 FBO + \delta_7 Off - farm + \delta_8 Credit + \delta_9 Perception \end{aligned} \qquad (7)$$

Where sex is a dummy variable describing males as 1 and females as 0; education is the number of years of formal education; household size is the number of people in the same household pooling and sharing same household resources; Farmer Based Organisation (FBO) is a dummy variable that is defined as 1 for farmers belonging to an FBO and 0 if a farmer belongs to no farmer group; experience is the number of years a farmer had been into the cultivation of maize or sorghum;

extension is the number of times a farmer had contact with extension officers either on their farms or at home; off-farm is a dummy variable, 1 for farmers who engaged in off farm activities and 0 for those who did not; and credit is a dummy, 1 for farmers who had access to credit for maize or sorghum crop production and 0 for those who did not. Adaptation is the total number of adaptation strategies adopted by a farmer out of the 12 strategies examined. Perception is defined as an ordered variable taking values from 0 to 4 where 0 is for farmers who predicted all three climate variables (precipitation, temperature and wind) in the wrong direction, 1 for those who predicted only one correctly and the other two wrongly, 2 for those who predicted two correctly and one wrongly and 3 for those farmers who predicted all three correct. Right predictions are: precipitation is reducing, temperature is increasing and wind is increasing.

The potential explanatory variables considered are listed in the following Table (Table 1)

Table1: Explanatory variables considered in the model

Variables	Types[a]	Modalities	Excepted Sign
Sex	D	0= Female; 1=Male	+
Education	C	-	+
Farmer based organisation (FBO)	D	No=0; Yes=1	+
Experience	C	-	+
Country	D	Benin=1; Nigeria=2	±
Contact with Extension service	D	No=0; Yes=1	+
Off-farm activities	D	No=0; Yes=1	+
Access to credit	D	No=0; Yes=1	+

[a]Types: D = discontinuous variables; C = continuous variables

Source: Authors' Specification

3. RESULTS AND DISCUSSION

3.1. Farmer's socioeconomic and demographic characteristics

The descriptive statistics of farmers' socio-economic and demographic characteristics (Table 2a and 2 b) show that respondents are about 40 (±11.39) years of age with 20.67 (± 11.29) years of experience in agriculture, Respondents from Benin (23.20 years ± 12.17) record a statistically higher experience as compared to the respondents in Nigeria (17.76 years ± 9.395; P <0.01). The respondents are all head of their household. On average, a household in the study area is composed of 11 (± 7) persons. About half of the respondents attended formal school. In the study area, about 13% of the respondents have access to formal credit. Finally, about half of farmers are had contact with extension service.

Table2a: Descriptive statistics of qualitative variables

		Country		
		Benin	Nigeria	Total
Gender				
	Female	16 (2.48)	26 (4.04)	42 (6.52)
	Male	328 (50.93)	274 (42.55)	602 (93.48)
	Total	344 (53.42)	300 (46.58)	644 (100)
Fisher's exact = 0.054				
Repartition of the respondents according to level of education attained				
Highest level of formal educational achievement	No formal education	158 (24.53)	144 (22.36)	302 (46.89)
	Primary education	102 (15.84)	55 (8.54)	157 (24.38)
	Secondary education	76 (11.80)	70 (10.87)	146 (22.67)
	University education	8 (1.24)	31 (4.81)	39 (6.06)
	Total	344 (53.42)	300 (46.58)	644 (100)
Fisher's exact = 0.000				
Repartition of the respondents according to contact with extension officers				
Contact with any extension agent	No	243 (37.73)	72 (11.18)	315 (48.91)
	Yes	101 (15.68)	228 (35.4)	329 (51.09)
	Total	344 (53.42)	300 (46.58)	644 (100)
Fisher's exact = 0.022				
Repartition of the respondents according to access to credit facility				
Access to credit facility	No	294 (45.72)	269 (41.84)	563 (87.56)
	Yes	49 (7.62)	31 (4.82)	80 (12.44)
	Total	343 (53.34)	300 (46.66)	643 (100)
Fisher's exact = 0.151				

NB: Values in brackets are relative frequencies.

Source: Authors' computation

3.2. *Farmers perception of climate change*

Farmers perception of climate change is an important step in the fight against climate change as this influences their adaptation and economic activity choices. Farmers largely rely on their description and expectation of the climatic conditions especially rainfall in their farm decisions. This study provides the perception of climatic variables with definitions based on scientific principles. Thus, largely, while rainfalls are expected to be reducing, temperature and wind are expected to be increasing in SSA.

Table2b: Descriptive statistics of quantitative variables

Descriptive statistics of the respondents' age			
Country	Mean	Std. Dev.	Freq.
Benin	40.86	11.79	344
Nigeria	39.87	10.91	300
Total	40.40	11.39	644
Analysis of Variance: F=1.21; df1=1; df2=643; Prob=0.2719			
Mean and standard deviation of the number of years of school attendance			
Benin	7.67	4.32	188
Nigeria	10.97	5.38	141
Total	9.08	5.07	329
Analysis of Variance: F=37.97; df1=1; df2=327; Prob=0.0000			
Descriptive statistics of experience in agriculture			
Benin	23.20	12.17	344
Nigeria	17.76	9.39	299
Total	20.67	11.29	643
Analysis of Variance: F=39.34; df1=1; df2=641; Prob=0.0000			
Descriptive statistics of the number of household size			
Benin	9.69	5.95	344
Nigeria	11.89	7.43	300
Total	10.71	6.76	644
Analysis of Variance: F=17.23; df1=1; df2=642; Prob=0.0000			

Source: Authors' computation

The study observed that more farmers (91.6%) perceived rainfall correctly, thus reducing, than the case of wind (86.3%) and temperature (75.8%). In the second panel of Table 3, it was observed that some farmers (7.8%) could not predict the direction of changes in these climate variables. Generally, though, the majority (73.8%) of the farmers were able to perceive changes in all climate variables. The importance is that farmers who are able to perceive climate change rightly are likely to adopt efficient and effective strategies that would reduce the impacts of climate change on their farms and households. Although this study did not provide meteorological data using the rate of changes in these climatic variables, empirical evidence in the literature provided sufficient ground to justify that farmers in the study areas have good knowledge of the directional changes in climate. [20] also estimated that over 94% and almost 90% of their respondents perceived rainfall as reducing and temperature as increasing respectively. Other studies [7,21–24]found that majority of their respondents perceived changes in climate change. The conclusion from these studies are generally that perception influences livelihood and adaptation. Studies such as [25] asserted that farmers have knowledge on the impacts of climate change. The synergy between these studies and the current one is that not only are farmers aware of changes on climate variables but also, are aware and perhaps, experiencing impacts or shocks from these changes.

Table 3: Perception of farmers

Variable	Frequency	Percentage
Rainfall (Decreasing)	590	91.6
Temperature (Increasing)	488	75.8
Wind (Increasing)	556	86.3
Grouping		
All three wrong	50	7.8
Only one right	29	4.5
Only two right	90	14.0
All three right	475	73.8
Total	644	100.0

Source: Authors 'calculations

3.3. Factors influencing farmers' perception

Empirical literature suggests that a number of socioeconomic and institutional variables influences the perception of farmers on climate change. As a result, this study examined the effects of selected variables on the probability of predicting changes in three of the climatic variables as in Table 3. Aside the estimated coefficients, the log odds ratios indicate the odds of number of right predictions. From Table 4, education, experience, extension and country significantly influenced farmers' perception. The significance of the rho means that the two error terms in the perception and adaptation models are correlated, and justify the use of the two-stage approach.

Education had a positive effect on farmers' perception which means that the higher the level of education of a farmer, the higher the probability of predicting the changes in the climate variables rightly. The result also showed that the odds ratio turns to increase with the number of the number of right perceptions of the farmers but decrease with all three right predictions. Thus, an additional year of formal education would increase the odds of right predictions of one climate variable by 1.14, two climate variables by 1.182 and all three climate variables by 1.137. This finding indicates the importance of 'knowledge' in understanding climate changes. Perhaps the highly educated farmers are far able to take notice and interpret climate information more than the less educated. In their study also, [15] (using multinomial logistic regression) and [21] (using chi-square), education was found to have a positive significance on the perception of climate change. [22] asserted that for adaptation to climate change to move beyond spontaneous adaptation, it is essential that education is provided on the main aspects of climate change especially among the rural dwellers.

It is expected that farmers with higher experience in crop production would have a higher probability of predicting rightly the changes in more climatic variables. However, the opposite is the case in this study. The odds of predicting changes in the climatic variables decreases for all combinations. Perhaps these farmers are the older farmers and did not take historical information into consideration. This study contradicted the findings where experience had a positive effect on farmers perception [26].

Extension services is one the main mechanisms by which information on crop production gets to the farmers. Extension services include the introduction of farmers to new technologies and linking farmers to input sources. It is therefore expected that farmers with higher number of extension will have greater odds of having a right perception on the changes in climate variables. However, the odds of right perception of climate change increase higher for any two variable combinations than for the three variables. The positive significance of the extension variable warrant that in other to improve the knowledge of farmers on the current developmental challenge, climate change, extension services must be intensified.[17] and[24] also estimated a positive effect of extension service on farmers' perception.

The study also finds that farmers in Benin have some higher odds of having the right perception about climate change than farmers in Nigeria. Perhaps, climate information provision and delivery are more effective in the former country than the later.

Table 4: Factors influencing farmers' perception

				Log odds ratio		
Variable	Coefficient	Std. Error	P-Value	Only one right	Only two right	All three right
Sex	-0.369	0.501	0.462	0.229	0.139	0.295
Education	0.098***	0.024	0.00	1.140	1.182	1.137
Experience	-0.024**	0.010	0.013	0.940	0.943	0.951
FBO	0.218	0.259	0.400	0.813	0.988	0.629
Extension	0.106***	0.024	0.000	1.229	1.292	1.067
Country	2.444***	0.301	0.000	146.005	264.771	34.543
Constant	0.569	0.578	0.326			
rho	-0.757	0.071				
Log-likelihood test of independence =37.78***						

***, ** and * indicates significance at 1%, 5% and 10%, respectively

Source: Authors 'estimation

A cross-tabulation also revealed that while 86.3% of farmers in Benin correctly perceived changes in the three variables, only 56.3% of the farmers in Nigeria do correctly perceived changes. However, the mechanisms through which this occurs is not investigated in this study and needs to be taken up in future studies. Considering the importance of perception on adaptation and crop production, it is important that farmers in Nigeria are given more education on climate change.

3.4. *Existing climate change adaptation strategies*

The study identified twelve (12) climate change adaptation strategies been adopted by the farmers (Table 5). The strategy adopted by the highest percentage (84.2%) is changing of planting date. That is, most farmers do not plant at the same periods of the year they used to plant, instead, they plant some few weeks ahead of the previous planting season. This strategy is a way of responding the delay of the rains in recent times. Following this strategy is the related change in harvesting date by 63.4% of the respondents. The implication is that changing the planting date would affect the harvesting period as well unless there is a change in cropvarieties. On change of varieties, 54.5% and 36% of the farmers changed their previous varieties to the use of early maturing and drought resistant varieties, respectively. It is ironically that as high as 57.8% of the farmers indicated that they used to pray to the ‘icons’ they worship for good production environment especially, good rains. The least adapted strategy is off-farm engagement (7%).

Table 5: Climate change adaptation strategies adopted by farmers

Adaptation strategy	Frequency	Percentage
Change planting date	542	84.2
On-farm diversification	225	34.9
Change harvesting dates	408	63.4
Drought resistant varieties	232	36.0
Early maturing varieties	351	54.5
Off-farm diversification	045	07.0
Land tenure	328	50.9
Land relocation	330	51.2
Repeated sowing	336	52.2
Food consumption pattern	206	32.0
Gender role (labour allocation)	144	22.4
Prayers (Cushioning)	372	57.8

Source: Authors ‘calculations

3.5. *Effect of farmer perception on climate change adaptation*

One of the objective of this study is to estimate the effect of farmers' perceptions of climate change on the number of adoption strategies adopted by a farmer. This is provided in table 3. The study provided evidence that the perception of farmers in Benin and Nigeria has a significant influence on their adaptation to climate change. Thus, farmers who perceived changes in climate variables correctly adopts more climate change adaptation strategies. Generally, for the uncertainty of outcomes from individual adaptation strategies, farmers who have perceived changes in climate change would adopt more strategies as a risk distribution measure. Also, it was observed that there is a relationship (correlation) between some of the adaptation strategies which means that the adoption of one strategy would force autonomous adoption of another. This study has confirmed other empirical results across the globe, where it was concluded that having knowledge on changes in climate would influence the decision to adapt or mitigate. Naturally, adaptation is a way of life where farmers adopt strategies without any objective of minimising the impacts of climate change while maximising the gains from their economic ventures. But this natural tendency is catalysed by the changing climate. Previous studies also found that farmers who perceive increase in temperature and a decrease in precipitation had a higher probability of adapting to climate change[7, 24, 26]. Other factors that significantly influenced climate change adaptation include sex, education, household size, experience, off-farm activity and credit. The significance of the Wald chi-square suggested that the estimated model is appropriate and the variables jointly explained the variations in perception and adaptation.

The positive significance of sex suggest that male farmers adopt more adaptation strategies than female farmers. This is no irony since agriculture have traditionally been known as a man's job. Also, male farmers often have much exposure in terms of awareness to the adaptation strategies and access to resources for adaptation than females. This provided evidence that climate issues are not gender neutral, hence the need to specifically target women in addressing climate change. Existing literature provide that male farmers have a higher probability of adjusting their planting periods in order to reduce impacts of climate change[27].Similar results are also reported by other scholars[18].

Farmers with higher education were found to adopt less adaptation strategies than farmers with lower levels of education. This could mean that formal education provides the opportunity for farmers to identify few effective strategies for adoption, hence, a reduction in uncertainty about the adaptation strategies. Also, considering the fact that crop farming is engaged mostly by the less educated, it is expected that indigenous knowledge could play a significant role in farmers' adaptation other than formal education. Empirically, other studies estimated a positive effect of education on climate change adaptation[24, 26].

Contrary to expectations, the study estimated that farmers with larger household members adopted less adaptation strategies. It was expected that considering the important role of family members in providing cheap and readily available labour to the farmers, farmers with larger household members would adopt more of the strategies. However, this is not an isolated finding as a negative significant effect of household size on adaptation was also estimated by other scholars who explained that larger family members provide labour for these households to engage in off-farm activities in their bid for household income to resolve the problem of meeting the consumption needs that comes with a larger household size[24].

Although experience had a negative effect on perception (Table 6), farmers with higher experience adopted more adaptation strategies than those with less experience. This can be as a result of their ability to understand the farming systems better and respond accordingly. Farmers who have been cultivating crops over the years have known much on the production environment, when to plant and when to do other activities and therefore choose strategies that have proven effective under their economic and social conditions. Perhaps, they might have tried various strategies over the years. Other authors estimated a positive effect of experience on adoption [17, 26]where it wasargued that experienced farmers are able to spread risk of climate change due to the high skills of the experienced farmers[26].

Off-farm had a positive significant effect on climate change adaptation which means that farmers with off-farm activities adopts more climate change adaptation strategies. Off-farm is one of the common livelihood or income source diversification among farmers in the region. Therefore, it is expected that additional income from these off-farm activities could be used to supplement on-farm income for climate change adaptation, especially, for those strategies that are capital intensive or require more financial investment.

Farmers who had access to credit also adopted more adaptation strategies than those without credit. Considering the various adaptation strategies adopted by the farmers, it is appropriate that credit would enhance the adaptation of these strategies. This is an important finding which justify the support for farmers with credit facilities in order to increase their farm outcomes amidst the changing climate. Other empirical studies found credit access to enhance climate change adaptation [14, 18, 24].

Table 6: Effect of farmer perception on climate change adaptation

	Coefficient	Std. Error	P-Value
Sex	0.622***	0.193	0.001
Education	-0.038***	0.008	0.000
Household size	-0.016**	0.008	0.040
Experience	0.016***	0.004	0.000
Extension	-0.009	0.006	0.129
FBO	0.116	0.098	0.233
Off-farm	0.472***	0.089	0.000
Credit	0.721***	0.133	0.000
Perception	0.364***	0.114	0.001
Wald chi2(9)	167.93***		

***, ** and * indicates significance at 1%, 5% and 10%, respectively

Source: Authors 'estimation

4. CONCLUSION AND POLICY RECOMMENDATIONS

Climate change is one of the most challenging global phenomenon in recent periods. While the rains are becoming erratic, temperatures and winds especially associated with rains are increasing. In line with global commitment to climate mitigation and adaptation, farmers on their small scale have also resorted to responding to the changing climates by introducing adaptation strategies as farmingpractices. This is the only way food can be produced to feed the increasing the population. The objective of this study was to examine farmer's perception of climate change and the effects of perception on farmer's adaptation strategies. Respondents were drawn from maize and sorghum communities in Benin and Nigeria. Unlike other studies that modelled perception as dichotomous variable, this study defined perception as an ordered response, considering three climate variables as precipitation, temperature and wind. The study concluded that farmers' perception has a positive effect on their adaptation decisions. What it means is that to increase adaptation, more education is needed to be given to farmers on the direction of change in the climate variables. The study also concluded that adaptation is higher for male farmers, less educated farmers, farmers with less household members, experienced farmers, farmers with off-farm activities and farmers who had access to credit. These factors can be described as 'sufficient factors' for climate adaptation.

However, a number of factors were responsible for the farmers' perception and this include education, years of farming, access to extension service and country of the farmer. These are thereby 'necessary factors' for climate change adaptation. To enhance adaptation of the farmers therefore, factors that influence the farmers' perception of climate have to be given a prime consideration. For instance, extension and education services are vital and should be promoted.It is important to recall from the results that education had a positive effect on farmers' perception of climate change but a negative effect on adaptation. Therefore, the mechanisms through which formal education play a role in adaptation needs to be given a further attention. This study admitted that the ultimate aim for adaptation by farmers is to improve output or yield. However, this study did not examine the impact of adaptation of farmers on crop production. Therefore, further studies could consider considering estimating the response of output to adaptation as a third stage approach.

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