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ANALYSIS OF MAIZE FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN SOUTHWESTERN NIGERIA

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ABSTRACT

The broad objective of this study is to analyse climate change adaptation strategies among smallholder farmers in Southwestern Nigeria. Multistage sampling procedure was employed in selecting respondents for this study. In the first stage, three states (Osun, Oyo and Ogun) were purposively selected based on predominance of maize production in the region. In the second stage, two (2) Local Government Areas (LGAs) were purposively sampled from each of the selected states based on the concentration of smallholder maize farmers in the area. In the third stage, five (5) villages from each of the selected six LGAs were randomly selected to make a total of thirty (30) villages. Both primary and secondary data were used for this study. The primary data were collected through a cross-sectional survey of maize farmers in the study area. A semi-structured questionnaire was used to obtain data pertaining to socio-economic characteristics of the farmers, output of male and female farmers, output of maize and corresponding inputs which include values of productive and non-productive assets, perception of climate change and adaptation strategies. Data were analysed using descriptive statistics and Double Hurdle Analysis. Majority (64.31 per cent) of the farmers had climate change perception intensity between 0.1 and 0.4, while 16.72 per cent had climate change perception intensity ranging from 0.41 to 1.00. The average climate change perception intensity among the maize farmers was 0.27 with a standard deviation of 0.20. The results in research results showed the profile of different adaptation strategies employed by farmers in the study area. As shown, the common agronomic practices adapted by most of the maize farmers were intercropping (75.24 per cent), crop rotation (66.88 per cent) and change in planting date (65.27 per cent). It was also observed that 44.05 per cent of the farmers planted drought resistant varieties while mulching and changes in fertilizer application were used by 39.55 per cent of the farmers. Research results showed that 36.01, 19.29, 10.93 and 9.65 per cent of the sampled farmers employed non-agribusiness enterprise, selling of firewood, selling of livestock, and looking for employment in towns and cities respectively as their adaptation strategies to effects of climate change on their farms. Most smallholder maize farmers employed multiple adaptation strategies to cope with the effects of climate change on their farming activities and maize yield. The adaptation strategies adopted most by the farmer were intercropping, crop rotation band early planting of maize. Also, some of the maize farmers adopted non-agronomic adaptation strategies such as non-farm activities to cope with the effect of climate change.

Keywords: Maize Farmers, Adaptation Strategies, Climate Change, Southwestern Nigeria

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INTRODUCTION

Agriculture being one of the most weather-dependent of all human activities is highly vulnerable to climate change. This vulnerability to climate change is particularly felt by African countries because of their dependence on rain fed agriculture, high levels of poverty, low levels of human and physical capital, inequitable land distribution and poor infrastructure (Bamire, 2010; Tologbonse *et al.,* 2021). Climate change as defined by United Nation Framework Convention on Climate Change (UNFCC, 2001; 2007, 2015) refers to a change of climate that is attributed directly or indirectly to human activity which alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. According to Harvey *et al.* (2022), changes in climatic conditions have already presented significant challenges to smallholder maize farmers in Africa as it is being experienced in Central America.

Nigeria, like the rest of Africa, is experiencing increasing risk from climate change, including rising temperatures and heat waves, shortfalls in water supply/increasing floods arising from shortage/excessive rainfalls, sea level rise, increasing likelihood of conflict and induced environmental and vector borne diseases. These emanating conditions have compromised agricultural production (crop, livestock, forest and fishery resources), nutritional and health statutes, trading in agricultural commodities, human settlements (especially of agricultural communities), tourism and recreation among others (Adefolalu, 2007; Fadina and Barjolle, 2018). The adverse effects of climate change have negatively impacted the welfare of millions of people, most especially small holder farmers (Intergovernmental Panel on Climate Change (IPCC, 2007).

Smallholder farmers are the bed rock of Nigeria's agriculture and rural economy. They produce over 90 per cent of Nigeria's agricultural output and constituted about 60 per cent of the national population domiciling in rural areas (Akinsuyi, 2011; Federal Ministry of agriculture and Rural Development (FMARD), 2012; Adekanye, 2014). According to FMARD, (2017), smallholder farmers are those whose production capacity falls between 0.1 and 4.99 hectares holding. Clearly defined, smallholder farmers are those marginal and sub-marginal farm households that own and/or cultivate their farmlands under certain excruciating conditions (Nwankpa, 2017). Some of the myriads of challenges faced by smallholder farmers are the poor access to modern improved technologies and their general situations that fail to attract merit and tangible investments in forms of capital, labour and other inputs (FMARD, 2017; Nwankpa, 2017). These factors have led to their low efficiency and productivity which in turn culminates to their decreasing contribution to the nation's economy (NBS, 2017). The manifestations of climate changes are diverse and far reaching. One of the resulting consequences that the increasing frequency and severity of droughts are likely to cause include crop failure, high and rising food prices, distress sale of animals, de-capitalization, impoverishment, hunger, and eventually famine (Bishwa, 2014). How much one can hold climate responsible for changes in agricultural productivity in Nigeria will, for a long time, remain a subject of research as long as other factors are at interplay in determining agricultural productivity (Collier, 2008). Therefore, building capacity against the influence of climate change requires understanding the impact of the change and effectiveness of the adaptation strategies (McCarthy, 2012). This is because different crops thrive under different climatic condition which has not been adequately explored in sub-Sahara Africa (Heltberg *et al.,* 2020).

Farmers have developed a number of coping and adaptation mechanisms in order to live with climate variation and uncertainty (Shikuku, *et al.,* 2017). Effectively adapting to climate

change requires both an understanding of the causes and impacts of climate change and willingness to change behaviours: either those behaviours that contribute to greenhouse gas emissions or those that may be insolvent in the face of future climate impacts (Niles and Mueller, 2016). Such actions are predicated on recognition that climate change is happening and action is necessary (Niles and Mueller, 2016). For climate change, perceived personal experiences affect climate change belief and adoption (intended or actual) of climate adaptation and mitigation behaviours (Spence *et al.,* 2011; Broomell *et al.,* 2015). Most individuals and households employ a combination of responses to the impacts of climate on their livelihoods (Thomas *et al.,* 2005), suggesting that actions constantly change with different situations and crops.

For adaptation to be successful, it should be taken within a comprehensive and interactive process of social institutions and organizational learning and changes (Shongwe *et al.,* 2014). In many parts of sub-Sahara Africa, households rely on a combination of self-insurance and informal risk sharing arrangements (Mengistu, 2011). Many Africans cope with shocks and stresses through informal strategies that rely on family and community structures-gift exchanges, sharing food, migration, remittances, child labour, informal cash or in-kind loans, or sending children to live with relatives rather than government or market instruments (Hertberg and Siegel, 2008). Decisions made concerning the localised coping and adapting strategies is expected to have far reaching effect on the livelihood of farmers that depends on maize for survival in Nigeria (Fadina and Barjolle, 2018).

The issue of climate change is increasingly becoming a threat not only to the sustainable development of socio-economic and agricultural activities of any nation but to the totality of human existence (Adejuwon, 2004). Drastic changes in rainfall patterns and rise in temperatures have introduced unfavourable growing conditions into the cropping calendars thereby modifying growing seasons which consequently affect the crop productivity. These changes affect food prices, food security, land use (Lobell and Field, 2007) and raising uncertainty for crop managers (Pathak and Wassmann, 2009). According to Kahil *et al*. (2015), the severity of climate change impact depends on the degree of adaptation at the farm level, farmers' investment decisions and policy choices, though these factors are interrelated and negatively affects quantity of output most times.

In order to have a sustainable level of output by farmers, measures are taken by farmers to adapt to risks posed by climate change on their productive activities. Tobey *et al*. (1992) and Adger *et al*. (2003), asserted that there are various and numerous types of adaptation and coping strategies available to different farmers and these are influenced by the level of perception of climate change which also determines the type and extent to which the strategies are employed (Ayinde *et al*., 2010).

According to Coster and Adeoti (2015), maize productivity depends on climate and nature of soil among others which are regarded as the yield potentials of a certain area. This crop survives with the mean daily temperature between 16 to 19 ^{o}C and a consistently right amount of precipitation. However, this is being threatened with persistent and erratic climate change thus affecting farming within the predominantly rain-fed systems. Climate change has induced rainfall and temperature stresses, which reduced maize yields in Nigeria. Furthermore, empirical evidence shows that there is likelihood that yield will continue to decrease by 15% and 24% by the year 2030 and 2050 respectively compared to the baseline year 2000, implying a decline of about 1.4million tons and 2.9million tons respectively using an average simulated yield of 1.3 tons per hectare (Coster and Adeoti, 2015). These changes

in climate will in no small measure limit maize production, thus, prospecting lowered welfare status of farming families who solely depend directly on maize cultivation as their source of food and income.

To ensure continuous production, maize cultivators are practically taking steps to mitigate against the economic losses associated with climate change, however, it is noteworthy that these coping strategies and adaptation options utilized by various maize producers do not come without costs. The effect of climate change and its cost implications on farmers have been assessed by studies in countries like Egypt and Senegal on various crops but limited studies exist on the subject matter, most especially on maize production in some areas in Nigeria (Ayinde *et al*., 2010). Moreover, the economic loss inventories and estimation associated with maize cultivation has not been adequately documented. It is therefore imperative to estimate the economic implications and effects that are posed by climate change specifically on maize production in Southwestern Nigeria. This study therefore will proffer answers to the following pertinent research questions;

Research Questions

i. What are the perceptions of the maize farmers to climate change?
ii. What are the factors influencing maize farmers' perception to climate change?
iii. What are the adaptation strategies to climate change employed by the farmers?

Objectives of the Study

The broad objective of this study is to analyse climate change adaptation strategies among smallholder farmers in Southwestern Nigeria.

The specific objectives are to:

i. evaluate the climate change perception of maize farmers and;
ii. profile the adaptation strategies to climate change by the maize farmers in the study area;

RESEARCH METHODOLOGY

Study Area

The study was carried out in Southwestern Nigeria, which is one of the six geographical zones in the country. The zone consists of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo States. The zone lies between longitude 2^0 31^1 and 6^0 00^1 East and Latitude 6^0 21^1 and 8^0 37^1N with a total land area of 77,818 km^2 and an estimated population of 38,257,260 (NBS, 2016). The study area is bounded in the East by Edo and Delta States, in the North by Kwara and Kogi States, in the West by the Republic of Benin and in the South by the Atlantic Ocean.

The climate of Southwestern Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature ranges between 25^0 C and 35^0 C while the annual rainfall ranges between 1300mm and 2500mm. The wet season is associated with the Southwest monsoon wind from the Atlantic Ocean while the dry season is associated with the Northeast trade wind from the Sahara Desert (Umar *et al.,* 2015). The ecological condition in Southwest Nigeria is made up of fresh water swamp and mangrove forest at the belt, the low land in forest stretches inland to Ogun and part of Ondo States while secondary forest is towards the northern boundary where derived and southern Savannah exist (Bamire *et al.,* 2010). This ecological condition encourages the cultivation of early and/or late crops such as cassava, yam, millet, rice, plantains, cocoa, palm produce, cashew and maize.

The total land area used for maize production in 2012 and 2013 are 5,000 and 5,200 ('000) hectares respectively (Iken and Amusa, 2014). The size of the land devoted to maize in the region gives the third highest production with an average yield of 2 tons/ha (Umar *et al.,* 2015). The three states that will be selected are Oyo, Osun and Ogun as the three highest producers of maize in the region. The major source of occupation and income in the study area is agriculture. Agriculture provides income and employment for about 75% of the population and they produce both food and cash crops. Residents in these areas are also engaged in other non-farm activities like trading, commercial transport service, and some artisan activities. The artisans make hand-woven textiles, tie and dye clothes, leather work, calabash carving and mat weaving among others. Some mining activities and quarry are also carried out by people in the study area.

Sampling Procedure

Multistage sampling procedure was employed in selecting respondents for this study. In the first stage, three states (Osun, Oyo and Ogun) were purposively selected based on predominance of maize production in the region. In the second stage, two (2) Local Government Areas (LGAs) were purposively sampled from each of the selected states based on the concentration of smallholder maize farmers in the area. In the third stage, five (5) villages from each of the selected six LGAs were randomly selected to make a total of thirty (30) villages. The proportionality factor that was used in the selection of smallholder maize farmers is stated as:

$X_{i=(n)x}\,30$.....(1)

Where X_i = number of villages to be sampled from a LGA
n= number of villages in the particular LGA
N = total number of villages in all the LGAs

In the fourth stage, eleven (11) smallholder farmers will be selected in each of the villages based on the list provided by the ADPs in the states. In all, a total of nine hundred (990) smallholder maize farmers will be interviewed.

Methods of Data Collection

Both primary and secondary data were used for this study. The primary data were collected through a cross-sectional survey of maize farmers in the study area. A semi-structured questionnaire was used to obtain data pertaining to socio-economic characteristics of the farmers, output of male and female farmers, output of maize and corresponding inputs which include values of productive and non-productive assets, perception of climate change and adaptation strategies. 900 copies of questionnaire were administered to the farmers to elicit adequate information for analysis.

Analytical Techniques

Descriptive Analysis of Adaptation Strategies

Objective 1 was captured using the descriptive statistics. The data after being grouped will be analysed using descriptive statistics first to summarize the data. It involves the use of frequency distribution in the form of frequencies and percentages to show the different characteristics of smallholder maize farmers which includes socio-economic, demographic, institutional and behavioural as well as the farm level. These will all be reported accordingly.

Double Hurdle Analysis

To examine the influence of socio-cultural, socio-demographic and experimental factors on farmers' perceptions about climate change, a double hurdle estimation procedure put forward

Cragg (2010) was adopted. Under this estimation technique, a maize farmer crossed two hurdles to perceive climate change. First, a maize farmer became a "potential perceiver" of climate change after crossing the "first hurdle". Given positive perception, socio-cultural, socio-demographic, and experiential scenarios will lead to actual perception, termed the "second hurdle". The Double Hurdle model of climate change perception is, therefore, a two-equation framework:

$d_i^* = Z_i \gamma + \varepsilon_i$ first hurdle.....(2)

$CCP_i^* = X_i \beta + \mu_i$ second hurdle.....(3)

Where $d_i^*$is the binary variable depicting whether a farmer perceives seasonal climate change or not; CCP_i^* (a shorthand for climate change perception) is the latent variable which reflects perceived intensity; the observed shape of climate change perception. It will also be determined as $CCP_i = d_i^*$. CCP_i^*; *Z and X* are vectors of factors explaining the probability of perceiving climate change and the perceived intensity of changes, respectively; α and β are vectors of coefficients estimated; ε_i and μ_i are the two error terms assumed to be independently distributed such as $\binom{\varepsilon i}{\mu i} \sim N\left[\binom{0}{0}, \begin{pmatrix} 1 & 0 \\ 0 & \text{å}2 \end{pmatrix}\right]$

In the double-Hurdle model, the regression analysis of the probability to perceive was estimated using probit regression and the second stage, the equation is calibrated using a truncated regression procedure (Cragg, 1971).

Dependent Variables
Y = perception of Climate Change (1 = local climate is changing; 0 = otherwise (dummy))
PC = Intensity of Climate change perception

Independent Variables
X_1 = (FEDU) = Formal education of maize farmer (Years)
X_2 (EXTSERV) = Farmer's access to extension service
X_3 (MZFRMSZ) = Household maize farm size (hectare)
X_4 (REL) = Religion of maize farmers (Christianity = 0, Islam = 1, Traditional = 2)
X_5 (AGE) = Age of household head (Years)
X_6 (FEXP) = Experience in maize farming (Years)
X_7 (CLMINFO) = Access to climate-related information (1 = Access, 0=Otherwise)
X_8 (FAMEM) = Membership of farmers' association (1=Member, 0=Otherwise)
X_9 (SEX) = Sex of maize farmer (1=Male, 0 = Otherwise)
X_{10} (DSTRD) = Distance from farm to the main tarred road (Km)

Descriptive Analysis of Adaptation strategies

Objectives 2 were captured using the descriptive statistics. The data after being sorted will be analysed using descriptive statistics first to summarize the data. It involves the use of frequency distribution in the form of frequencies and percentages to show the different adaptation strategies employed by smallholder maize farmers. The adaptation strategies were differentiated into agronomic and non-agronomic.

Multivariate Probit Analysis

Multivariate probit (MVP) model was employed to determine factors that influence adaptation strategies adopted by smallholder maize farmers in order to cope with climate change. This is because when farmers are faced with adverse climatic changes, they are more likely to adopt a mix of strategies as a way of coping with the effects of climate change on their farms as well as their livelihoods rather than relying on a single strategy to exploit complementaries among alternatives. Adoption could be path dependent with earlier adopted

strategies informing decisions on subsequent practices in the future. This was the rationale behind the use of multivariate probit model to estimate the influence of exogenous factors on the adoption of the adaptation strategies simultaneously since the model allows for the error terms of each of these strategies to be freely correlated. Failure to correct for these interrelations can lead to biased estimates (Lin *et al.,* 2005; Kassie *et al.,* 2013). Thus, a multivariate probit model was employed in this study to investigate the interdependent strategy adoption decisions. This study followed Lin *et al.,*(2005) in formulating the multivariate model which has n dependent variables, $y_1,...,y_n$ such that:

$y_i = 1$ *if* $\beta_i x_i + \varepsilon_i > 0$.....(4) and

$y_i = 1$ *if* $\beta_i x_i + \varepsilon_i < 0$ $i = 1, 2, ..., 12$.....(5)

where x is a vector of the explanatory variables; $\beta_i,..., \beta_{14}$ are conformable vectors and $\varepsilon_1,..., \varepsilon_{12}$ are random errors distributed as a multivariate normal distribution with zero mean, unitary variance and an n x n correlation matrix.

Yi = Method of Adaptation strategies of Climate Change
X_1 (SEX) = Sex of maize farmer (1=Male, 0 = Otherwise)
X_2 (AGE) = Age of household head (Years)
X_3 (FEDU) = Formal education of maize farmer (Years)
X_4 (HHSIZE) = Household Size (Number)
X_5 (FEXP) = Experience in maize farming (Years)
X_6 (CREDIT) = Access to credit (1=Access, 0= Otherwise)
X_7 (MZFRMSZ) = Size of maize farm cultivated by farmer (hectare)
X_8 (CLMINFO) = Access to climate information (1 = Access, 0=Otherwise)
X_9 (EXTSERV) = Access to farmer extension service (1 = Access, 0=Otherwise)
X_{10} (MEMFA) = Membership of farmers' association (1=Member, 0=Otherwise)
X_{11} (MNTEMP) = Mean of Annual Temperature (Number)
X_{12} (MNPREC) = Mean of Annual Precipitation (Number)

Dependent Variables

The farmers were asked about their perceptions on changes in climate over the previous ten years and the number of times they had encountered specific climate risks like drought, floods, crop pests, diseases, and hailstorms, among other livelihood shocks. Based on these experiences, farmers were asked to list strategies they had recently used to reduce risks associated with such unexpected. Consistent with the literature on climate change adaptation, the most adopted practices specific to climate-related distresses are: Planting of improved maize seed varieties, changing planting date, crop rotation, intercropping, practicing minimum tillage, changing quantity of fertilizer application and engagement in non-agronomic activities. These variables were adopted in this study as outcome variables in the multivariate probit analysis.

Independent Variables

This study incorporated the explanatory variables based on the review of existing literature on adoption studies and climate change adaptation, conceptual framework and the availability of the variables in the data sets.

RESULTS AND DISCUSSION

Perception of climate change by respondents

The level of climate change awareness among farmers influences their decision to mitigate the effects of climate change on the farms. Table 1 shows that majority (80.06%) of the farmers affirmed that they were aware of climate changes whereas 19.34 per cent expressed their ignorance about it Since the level of awareness of climate change could stimulate

farmers to effect changes in their farming methods in response to climate change, it is expected that most of the farmers would adopt strategies that would mitigate potential losses. This result is consistent with the findings of Komba and Muchapondwa (2012) that most maize farmers are aware of the changing climate conditions and are concerned with taking proactive measures to limit its effect on their farming activities.

The level of proactive measures taken by farmers to adapt to the impacts of climate change on their farms is strongly connected with their awareness about climate hange (Le Dang et al., 2014; Raworth, 2007). Farmer that is aware of changes in climate in terms of temperature and precipitation is more likely to utilize some important adaptation strategies on his farm (Maddison, 2006). The result on Table 1 showed that Majority (96.08, 93.33 and 50 per cent) of the sampled farmers in Osun, Oyo and Ogun States respectively observed clear cut variations in climate within the area. On the aggregate, 79.74 per cent of the farmers reported that they were aware of climate variations on their farms while only 20.26 per cent said there is no climate variation on their farms. This implies that majority of the farmers were aware of climate variation in the study area and therefore, made informed decisions about climate change on their farms. This result is consistent with the findings of Tilahun (2014) that most farmers are conscious of the climate change taking place in their environment which influences their farming activities.

Aside the awareness of climate change by farmers, the level of perception among those that are aware varies and this influences the extent to which they adapt to the changes by engaging different coping strategies. Since perception is a prerequisite for adaptation to climate change, the result in Table 1 showed the intensity of climate change perception among farmers in the study area. It was revealed that 18.37 per cent of the farmers had zero level of climate change perception intensity, believing there was no change in climate. The table also showed that Majority (64.31 per cent) of the farmers had climate change perception intensity between 0.1 and 0.4, while 16.72 per cent had climate change perception intensity ranging from 0.41 to 1.00. The average climate change perception intensity among the maize farmers was 0.27 with a standard deviation of 0.20. This finding agrees with the results of Di Falco *et al.,* (2011) that the extent to which climate change is perceived stimulates the level of adaptation strategies employed by farmers.

TABLE 1: Description of maize farmers by level of awareness and perception of climate change characteristics.

Variables	Description	Osun (102) Freq	Percent	Oyo (105) Freq.	Percent	Ogun (104) Freq.	Percent	Pooled (311) Freq.	%
Climate change awareness	Aware	92	90.20	100	95.24	57	54.81	249	80.06
	Not aware	10	9.80	5	4.76	47	45.19	62	19.94
Climate information	Access	14	13.73	13	12.38	49	47.12	76	24.47
	No access	88	86.27	92	87.62	55	52.88	235	75.56
Climate Variation	Variation	98	96.08	98	93.33	52	50.00	248	79.74
	No variation	4	3.92	7	6.67	52	50.00	63	20.26
Climate change perception intensity	0	11	10.78	5	4.76	43	41.35	59	18.37
	0.1-0.4	88	86.27	70	66.67	42	40.38	200	64.31
	0.41-1.0	3	2.94	28	28.57	19	18.27	52	16.27
	Mean	0.21		0.36		0.25		0.27	
	S.D	0.13		0.21		0.26		0.23	

Factors influencing maize farmers' perception of climate change

This section presents the estimates of factors that determine climate change perception and its intensity among farmers using double hurdle model. The double hurdle model is a two-part model that consists of a participation equation and an intensity equation (Mullahy, 1986; Gurmu, 1997). The participation (perception) equation was estimated with truncated regression simultaneously. In order to assess the effect of the explanatory variables on the perception intensity of climate change among farmers, conditional and unconditional marginal effects were calculated for both continuous and discrete variables after the estimation of the double hurdle model. The marginal effect of explanatory variables on climate change perception among farmers that cross the first hurdle is termed the conditional effect, while the sum of this effect and the increased probability of climate change perception and its intensity are termed the unconditional margin effect.

The results of the probit model presented in Table 4 showed estimates of factors that determine farmers' perception of climate change. The coefficient of years of formal education (FEDU) is positive and statistically significant at 10 per cent suggesting that farmers that are more educated bare more likely to perceive that there is climate change than those that are less educated. This result is corroborated by Hitayezu, Wale, and Ortmann (2017) and Asrat and Simane (2018) who also reported similar result that education enhances farmers' perception about climate change.

The coefficient of access service (EXTSERV) is positive and statistically significant at 5 per cent level. This implies that maize farmers that have access to extension service are more likely to perceive climate change than their counterparts that do not have access to extension service as they will be privilege to access up to date scientific information.

TABLE 2: Estimates of double hurdle model on climate change perception intensity

Variables	Climate perception	Perception intensity	Unconditional marginal effect	Conditional marginal effect
FEDU	0.039	-0.001	0.001	-0.001
	(0.020)	(0.003)	(0.002)	(0.002)
EXTSERV	0.728**	0.071**	0.091**	0.057**
	(0.369)	(0.033)	(0.031)	(0.028)
MZFARMSZ	0.056	0.039***	0.029***	0.031***
	(0.086)	(0.010)	(0.008)	(0.008)
REL				
ISLM	0.248	-0.069**	-0.029	-0.054**
	(0.225)	(0.029)	(0.023)	(0.022)
TRAD	-1.092**	-0.029	-0.114*	-0.024
	(0.446)	(0.112)	(0.064)	(0.087)
AGE	-0.020*	0.001	-0.001	2.58e-04
	(0.012)	(0.002)	(0.001)	(0.001)
FEXP	0.009	-0.001	-3.85e-06	7.68e-05
	(0.010)	(0.001)	(0.001)	(0.001)
CLMINFO	1.218***	0.005	0.104***	0.003
	(0.200)	(0.038)	(0.027)	(0.029)
SEX	-	-0.131***	-0.087***	-0.107***
		(0.031)	(0.027)	(0.025)
DSTRD	-	-0.009***	-0.006***	-0.007***
		(0.003)	(0.002)	(0.002)
_Constant	0.434	0.`420		
	(0.537)	(0.079)		
In (_Cons)	-1.671***	0.188		
	(0.060)	(0.011)		

Consistent with the findings of Langyintuo and Mekuria (2008) that extension contact facilitates increased perception of climate change and influences the choice of strategies to adopt by farmers.

The coefficient of farm size (MZFARMSZ) is positive and statistically significant at 1 per cent level. This implies that farmers with larger farm size are more likely to perceive climate change than farmers that cultivate smaller farm size. This is due to the fact that its effect will be drastically felt on the level of output of the farm than marginal farmers. This is in consonance with the result of Eskander and Barbier (2016) that farmers with large farms do adjust the sizes of the farmland in response to climate change.

The coefficient of religion of farmers (REL) is negative and statistically significant at 5 per cent level for farmers who are traditional worshippers. This implies that farmers who are traditional worshippers are less likely to perceiver climate change when compared with their counterparts.

The coefficient of access to climate information (CLMINFO) is positive and significant at 1 per cent significantly level. This suggests that farmers that have access to climate information are more likely to perceive climate change when compared to their counterparts who do not have access to climate information. This is in line with the findings of Asrat and Simane (2018) and Habtemariam, Gandorfer, Kassa and Heissenbeur (2016) that access to climate information by farmers enhances their knowledge about climate anomaly.

The estimates of the second hurdle (climate change perception intensity) model are also presented in Table 2. The coefficients and estimates of marginal effects (Uncomditional and conditional) of the second hurdle (truncated regression) model were also reported.

The coefficient of farmers' year of formal education (FEDU) is negative and not statistically significant. This implies that an increase in farmers' years of formal education will reduce climate change perception intensity. The estimates of the marginal effects revealed that the unconditional marginal effect is positive but not significant while the estimate of conditional marginal effect shows that, conditioning of the climate change perception of farmers, a year increase in formal education of farmers will decrease climate change perception intensity by 0.001 units. This contradicts the findings of Tilahun et al. (2014) that has the level of education of a farmer increases, their perception about climate change increases.

The coefficient of access to extension service (EXTSERV) is positive and statistically significant at 5 per cent level. This implies that an increase in the number of extension visit to maize farmers will increase their likelihood of perception of climate change and as well as their intensity of climate change perception. In addition, the unconditional and conditional marginal estimates reveals that, a unit increase in extension visit to farmers will increase the likelihood of climate change perception intensity at 1 per cent and 5 per cent level of significance by 0.091 and 0.057 unit respectively`. This is in tandem with the result of Langyintuo and Mekuria (2008) that extension visits increase the level of climate change perception among farmers.

The coefficient of farm size (MZFARMSZ) is positive and statistically significant at 1 per cent, implying that as farm size of smallholder maize farmers' increases, there is increase in the likelihood of climate change perception intensity. Furthermore, both the unconditional and conditional margin effect of climate change perception are positive and significant at 1 per cent, indicating that a unit addition to farm size will increase climate change perception intensity of farmers by 0.029 and 0.03w2 units respectively. This is also consistent with the findings of Eskander and Barbier (2016) that as farm size increases, the sensitivity of farmers to climate change increases.

The coefficient of farmers' religion (REL) shows it has a negative relationship with climate change perception that is significantly significant at 5 per cent level for farmers that choose Islam as their religion as compared to Christianity. The estimate of the unconditional marginal effect shows 7hata change from Christianity to Traditionalist will reduce climate change perception by 0.114 units which is significant at 10 per cent level. On the other hands, the estimate of conditional marginal effect, conditioning the perception of farmers, shows that a change from Christianity to Islam will reduce climate change perception intensity by 0.054 per cent and it is significant at 5 per cent.

The coefficient of farmers' access to climate information (CLMINFO) and its estimate of unconditional marginal effect are positive and statistically significant at 1 per cent. This implies that farmers have more access to climate information will increase their climate change perception intensity by 0.104 units as compared to their counterparts that do not have access. This is in conformity with the findings of Flatnes and Carter (2016) that the farther away the sources of climate information to farmer, the lower the level of perception of farmers about climate change.

The coefficient of farmers' sex (SEX) shows us that a negative relationship with climate change perception intensity and is statistically significant at 1 per cent level. This implies that

male farmers when compared with their female counterparts are less likely to have higher perception intensity of climate change. The estimate of conditional marginal effect shows that, conditioning of the climate change perception of farmers; a shift from female farmers to male farmers to female farmers decreases their climate change perception by 0.107 units. Also, the estimate of the unconditional marginal effects shows that a shift from female farmers to male farmers will reduce their climate change perception by 0.087 units. This result is corroborated by findings from Habtmeriam *et al.,* (2016) and Liu *et al.* (2014) that women are more likely to perceive climate change than men because they are more concerned about environmental issues that threaten their families and communities.

The coefficient of distance between their farm and a tarred road (DSTRD) shows it has a negative relationship with their climate change perception intensity and is statistically significant at 1 per cent level. This implies that the further away from a major tarred road /their farms are located less likely they are going to perceive any change in the climate. The estimate of conditional marginal effect shows that, conditioning of the climate change perception of farmers, an increase of 1 kilometre in the distance between the farmer and a major tarred will result in 0.007 units reduction in farmers' climate change perception in the study area. Also, the estimate of the unconditional marginal effect shows that a unit increase in the distance between the farm land and nearest tarred road will reduce their climate change perception by 0.006 units. This conforms to the findings of Smith and Watts (2009) that as farther are located farther away from urban centres, farmers stand the risk of not having access to climatic information from weather stations which influences their perception about climate change.

Profile of Climate Change Adaptation Strategies Used by Maize Farmers

Agronomic Adaptation Strategies used by Maize Farmers

It is not only sufficient to know whether farmers' perceptions about climate change are consistent with reality but also knowing their pro-adaptation response to these perceptions would be appropriate and helpful to all stakeholders in a bid to avoid potential losses from the effects of climate change on this vulnerable group (Komba and Muchapondwa, 2012).

The results in Table 3 showed the profile of different adaptation strategies employed by farmers in the study area. As shown, the common agronomic practices adapted by most of the maize farmers were intercropping (75.24 per cent), crop rotation (66.88 per cent) and change in planting date (65.27 per cent). It was also observed that 44,05 per cent of the farmers planted drought resistant varieties while mulching and changes in fertilizer application were used by 39.55 per cent of the farmers. This finding is in line with the outcome of similar research conducted by Kombai and Muchapondwa (2012) that farmers adopted different combinations of coping strategies to militate against the effect of climate change.

Non-Agronomic Adaptation Strategies used by Maize Farmers

Diversifying both within the agricultural and non-agricultutal enterprises, are other forms of adaptation strategies that can potentially help households manage climate change (World Bank, 2007).

In addition to the agronomic adaptation strategies used by farmers to tackle the effects of climate change on their farms, some farmers employed a few non-agronomic adaptation strategies in the study area (also, the number of adaptation strategies, both agronomic and non-agronomic, employed by smallholder maize farmers in the study area was presented in table 3 below). The result in Table 3 showed that 36.01, 19.29, 10.93 and 9.65 per cent of the

sampled farmers employed non-agribusiness enterprise, selling of firewood, selling of livestock, and looking for employment in towns and cities respectively as their adaptation strategies to effects of climate change on their farms. This finding is in conformity with the result of similar research by Baez *et al.* (2013) who reported that most farming household mitigate against the detrimental effect of climate change by diversifying their source of livelihood and income.

TABLE 3: Distribution of maize farmers by their climate adaptation strategies

Description	**Osun**		**Oyo**		**Ogun**		**Pooled**	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
A. Agronomic Strategies								
Intercropping	97	41.45	58	24.79	79	33.76	234	75.24
Crop rotation	94	45.19	34	16.35	80	38.46	208	66.88
Changes in planting date	97	47.78	61	30.05	45	22.17	203	65.27
Drought resistant variety	82	59.85	43	31.39	12	8.76	137	44.05
Changes to fertilizer	80	69.57	15	13.04	20	17.39	115	36.98
Minimun tillage	78	72.90	25	23.36	4	3.74	107	34.413
B. Non-agronomic strategies								
Non-agribusiness enterprises	42	46.43	47	41.96	13	11.61	112	36.01
Selling firewood	24	40.00	11	18.33	25	41.67	60	19.29
Selling livestock	11	32.35	14	41.18	9	26.47	34	10.93
Seeking job opportunities	19	63.33	8	26.67	3	10.00	30	9.65

The multivariate probit regression results revealed that farmer's sex influenced planting improved maize seed variety ($p<0.1$), changing planting date ($p<0.1$), practicing minimum tillage ($p<0.05$) and changing quantity of fertilizer applied ($p<0.01$) as choices of climate change adaptation strategies. Farmer's age influences planting improved maize seed variety ($p<0.1$) as choices of climate change adaptation strategies. Farmer's years of formal education influenced changing planting date ($p<0.05$) and non-agronomic activities ($p<0.05$) as choices of climate change adaptation strategies. The size of farmer's household member influenced changing planting date ($p<0.05$) and crop rotation ($p<0.05$) as choices of climate change adaptation strategies. Farmer's years of maize farming experience influenced

practicing minimum tillage ($p<0.1$) and changing quantity of fertilizer applied as choices of climate change adaptation strategies. Farmer's access to credit influenced practicing minimum tillage ($p<0.01$) and engagement in non-agronomic activities ($p<0.05$) as choices of climate change adaptation strategies. Farmer's access to climate information influenced planting improved maize seed variety ($p<0.1$), practicing minimum tillage ($p<0.1$), practicing intercropping ($p<0.05$) and engagement in non-agronomic activities ($p<0.05$) as choices of climate change adaptation strategies. Farmer's access to extension service influenced crop rotation ($p<0.05$) as a climate change adaptation strategy. Membership of farmers' association influenced planting improved maize seed variety ($p<0.05$), practicing intercropping ($p<0.05$) and changing quantity of fertilizer applied ($p<0.1$) as choices of climate change adaptation strategies. Annual mean temperature influenced changing planting date ($p<0.05$) and practicing intercropping ($p<0.01$) as choices of climate change adaptation strategies. Finally, annual mean temperature influenced planting improved maize seed varieties ($p<0.05$), practicing minimum tillage ($p<0.05$), crop rotation ($p<0.1$), intercropping ($p<0.05$), changing quantity of fertilizer applied ($p<0.01$), and engagement in non-agronomic activities as choices of climate change adaptation strategies employed by smallholder maize farmers in the study area.

Conclusion and recommendations

The study concludes that Small-scale maize production was dominated by male farmers in the study area and on the farmers, on the average, were in their active age with high level of awareness of climate change. The study also concluded that most of the farmers have attained at least primary school level of formal education. The level of climate change perception and the intensity of climate change perception among smallholder maize farmers were influenced by their access to extension services, larger farm sizes, religion, maize farmer's access to climate information, sex and the distance from farm to a major tarred road.in climate in form of increasing annual mean temperature and precipitation influenced the adaptation strategies employed by smallholder maize farmers. Also, age of farers, sex of farmers, years of formal education attained by farmers, family size, access to extension service, and access to climate information significantly affected the choice of adaptation strategies to climate change employed by maize farmers. Further, farmers who cultivated maize on more expanse of farmland are less likely to employ non-agronomic/non-agribusiness methods of adaptation to climate change in the study area. Most smallholder maize farmers employed multiple adaptation strategies to cope with the effects of climate change on their farming activities and maize yield. The adaptation strategies adopted most by the farmer were intercropping, crop rotation band early planting of maize. Also, some of the maize farmers adopted non-agronomic adaptation strategies such as non-farm activities to cope with the effect of climate change.

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