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HOW DO CLIMATE CHANGE PERCEPTIONS DETERMINE THE CHOICE OF CLIMATE-SMART AGRICULTURAL PRACTICES: EXPERIENCE FROM MAIZE FARMING HOUSEHOLDS IN SOUTHWESTERN NIGERIA

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Abstract. Enhancing maximized agricultural productivity entails farmers adopting synergized climate-smart agricultural practices (CSAPs). This study investigates how maize farmers in Southwestern Nigeria choose key CSAPs based on their perceptions of climate change dynamics. Using a multistage sampling procedure to select 370 smallholder maize farming households, primary data were sourced from the study area using a structured questionnaire with secondary data on temperature and precipitation from the Nigerian Meteorological Agency (NiMet). The data were analyzed using multivariate probit modeling (MVP) and descriptive statistics. Empirical evidence shows that about 86% of farmers were aware of climate change. Also, farmers experienced temperature increases, rainfall decreases, and drought frequency with ensuing consequences of changes in crop yield, soil fertility, and natural cover. According to the study, maize farmers' perceptions of climate change significantly affect the choice of a CSAP practice which farmers employed complimentarily.
Furthermore, the results show that age, education, and farm size significantly affect CSAPs choice. Also, gender, extension visits, climate information, and mean annual precipitation were significant variables affecting farmers' CSAPs choice.

Hence, policy direction that seek to embolden complimentary adoption of CSAPs that is strengthen with adequate and timely climate information should be provided.

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INTRODUCTION

The agricultural system in Sub-Saharan Africa (SSA) is mostly subsistence and rain-fed without adequate irrigation which makes climate change an alarming threat. Extremely climatic changes in regions around the world [1] have resulted in extreme yield reduction as a result of droughts, soil erosion, and floods [2]. Many of these irreversible changes in the climate have been unprecedented in thousands of years [3]. Literature [4, 5] is replete with incidences of diseases and pests among cultivated crops as a result of climate change. The occurrence of heat stress, which threatens growth and reproduction in livestock, has also been attributed to climate change. Worst still, the economies of SSA are particularly dependent on climate-sensitive Agriculture. Additionally, the astronomical trend of food price increase [6], and insecurity of food and nutrition in SSA, are resultant effects of climate change anomalies.

Nigeria's agricultural cultivation is mostly a rain-fed-dependent system [7]. Meanwhile, climate change has already negatively affected maize yields in many regions [8]. Several studies [9, 10] established the significant effect of rainfall anomalies on maize crop yield. In essence, maize may soon become less suitable for cultivation as a consequence of rising temperatures [11]. Furthermore, climate change can affect food quality, reduce access to food and rural household consumption and incomes [12]. Consequently, about 36% of maize-based farming households in southwestern Nigeria are food insecure [13, 14].

Meanwhile, it may be required that farmers adopt a combination of climate-smart agricultural practices (CSAPs) for the enhancement of household welfare by maximizing agricultural productivity. It is said that without farmers adopting (CSAPs), crop yield in SSA will continue to decline [15, 16]. In Southern Africa, [17] found that higher maize yield and income are obtained by the adoption of a combination of CSAPs. From empirical analysis, [18] concluded that enhanced food security and reduced poverty levels are achieved by farmers' adoption of adaptation practices. Equally, the combined use of CSAPs among smallholder farmers can potentially reduce food insecurity [19]. Given this, however, maize farmers' degree of climate change perceptions determines the extent and type of the strategies employed [20, 21]. This also depends on the extent of locally observable changes [22].

However, what determines farmers' probability of perception of climate change is poorly understood in Nigeria, resulting in little success in climate change communication and policy. This takes the form of lower levels of awareness and gross misperceptions about climate change dynamics among farmers [23]. The situation is worsened by the challenges of uncertainty and skepticism facing the policy strategies for climate change effective communication that must be resolved.

Otherwise, the resultant effect is "maladaptation" or "malmitigation" in climate change response in many instances. More so, there is an urgent need to recognize individual differences in perceptions [23], dissimilarity in perceptual processes, ensuing variation in responses [25, 26] , varied experiences of smallholder farmers, local realities and a good outlook in public opinions required for effective climate change communication and policy.

However, studies that investigate the effects of institutional and socio-cultural factors underlying individual perception response to climate change in the context of Southwestern Nigeria remain scanty. Extant literature [27, 21] has dwelt on the perception of climate change adaptation without inclusive of mitigation efforts. Additionally, climate policies relying solely on climate data may suffer ineffectiveness in implementation as they don't consider the grassroots dynamics, and perceptions of smallholder farmers, which are essential for successful communication [28]. These are marginally insufficient as risks posed by climate change need an all-inclusive approach. Marginal perception can lead to wrong responses and policy inertia.

Therefore, climate change perceptions dynamics are yet to be fully comprehended. The current study aims to investigate the forms and effects of perceptions on the key response options that influence farmers' choice of climate change resilience strategies in Southwestern Nigeria. By understanding smallholder farmers' perspectives, policymakers can gain valuable insights into the local impacts of climate change crucial for developing sustainable policies. This is essential for promoting sustainable climate change mitigation and adaptation efforts, leading to successful policy outcomes that promote excellent food security in Nigeria.

This study is framed upon the conceptual framework of farmers being profit maximizers in their farming enterprise. As farmers are risk averse, and profit maximizing agents, the framework seeks to explore the multi-faceted relationship between farmers' perceptions of climate change and their adoption of CSAPs. It highlights the key variables influencing farmers' decision-making processes and the potential pathways through which perceptions can shape CSAP choices. It links observable changes in weather patterns to climate change, impacting on livelihood with resultant vulnerability. It shows how farmers' climate change perceptions (perceived risks and opportunities) are predicted upon by socio-economic, demographic and institutional factors. Our study contributes to the existing literature by capturing all manners of farmers' climate change amelioration strategies including adaptation, mitigation, and coping/income generation mechanisms for a comprehensive outcome.

MATERIAL AND METHODS

The study design and area

The study was conducted in Southwestern Nigeria, a geopolitical zone comprising six states: Oyo, Ogun, Osun, Ondo, Ekiti, and Lagos. The zone covers an area of 77,818 km2 with a population of approximately 38 million people [29]. It is bounded by neighboring states and the Gulf of Guinea, and its tropical climate features dry and wet seasons with significant annual rainfall ranging from 1500mm to 3000mm [30].

The region's vegetation includes freshwater swamps, mangrove forests, and secondary forests, making it suitable for cultivating various crops like cassava, cocoa, and maize. Maize production is significant in the region, with Osun, Oyo, and Ogun selected for the study, being the top three producer states, accounting for 5,000 and 5,200 hectares of land in 2012 and 2013, respectively [31].

The region's average maize yield is 2 tons/ha [30]. The primary source of income and employment is agriculture accounting for about 75% of the population in the study area.

Sample size, sampling techniques and instruments

This study employed a multistage sampling procedure to select respondents. In the first stage, three top maize-producing states (Oyo, Osun, and Ogun) were purposefully chosen. Next, two Local Government Areas (LGAs) with high concentrations of smallholder maize farmers were purposefully selected from each state. Then, five villages were randomly chosen from each of the six selected LGAs, totaling 30 villages. To determine the appropriate sample size, the study considered the confidence level, level of precision, and degree of variability, as recommended by [32]. Due to the unavailability of a reliable list of registered farmers, the sample size was determined using the confidence level technique (Z-score table) for unknown populations, as described in [33] expressed as follows:

$$n_0 = \frac{z^2 * \mathrm{p}(q)}{e^2} \qquad \text{……………..(1)}$$

Where:
n_o = sample size to be estimated,
z^2 = selected critical value of the desired level of confidence or risk.
p = estimated proportion of an attribute that is present in the population or maximum variability of the population.
q = 1 – p
e = error margin.

Therefore, at the standard and recommended 5% (0.05) error margin (which is a 95% confidence interval), the sample size is:

n_o == 384.16

$$\frac{(1.96)^2 \times 0.5\,(1 - 0.5)}{(0.05)^2}$$

Finally, in the fourth stage, a list provided by the Agricultural Development Programs (ADPs) in the states was used to select 13 smallholder farmers from each of the 30 villages. This resulted in a total of 390 farmers being interviewed for the study. However, due to inadequate data provided, the 20 copies of the questionnaire were not captured in the analysis.

Data collection procedure

This study utilized both primary and secondary data. Primary data were collected through a comprehensive survey of maize farmers in the study area, using a semi-structured questionnaire to gather information on farmers' socio-economic profiles, climate change perceptions, maize inputs and outputs, adaptation, coping, and mitigation strategies. Due to the unavailability of climate data at the local level, secondary data on temperature and precipitation patterns over 39 years (1981-2019) were obtained from the Nigerian Meteorological Agency (NIMET) to supplement the primary data.

Climate-smart agricultural practices (CSAPs)

In this study, classifying CSAPs, we followed [34] coded each group, we classified adaptation strategies into crop management strategies (CMGT), nutrient management strategies (NMGT), soil and water management strategies (SWMGT). Then, mitigation strategies (MSTR) are classified into mulching/crop residue, terracing, agroforestry, and tree planting. Consulting literature, we then modified this methodology to capture all manners of farmers' resilience strategies concurrently adopted against climate change anomalies. We grouped and coded coping strategies/income generation (CSTR) into crop and livestock diversification, off-farm activities, and social networking.

DATA ANALYSIS TECHNIQUES AND MODEL SPECIFICATION

Multivariate Probit (MVP) model

Model specification

To determine the variables influencing smallholder maize farmers in the study area in adopting various climate change resilience strategies, a multivariate probit (MVP) model was used. The MVP model was selected due to the fact that the model can support the concurrent estimation of several resilience strategies utilized by farmers, contingent upon the explanatory factors. Moreover, the model permits a free correlation between the error components of every strategy. The multivariate model is based on the idea that the error terms jointly follow a multivariate normal distribution (MVN), with zero variance and the mean normalized to unity.

Instead of depending solely on one mechanism, farmers are more likely to use a combination of mechanisms to address the impact of climate change on their farms when faced with unfavorable fluctuations in the weather. Therefore, a farmer has the option to implement multiple strategies in adapting to climate change. In this work, we develop a multivariate model that takes into account the it maize farmer (i = 1,..., N) choosing whether or not to use at least one of the various climate change resilience strategies on his farm. Let U_0 represent the utility derived by the ith maize farmer when he/she does not adopt any resilience strategy, and let U_m represent the utility of the ith maize farmer by employing the *m*th resilience strategy, where m represents the choice of crop management strategies (CMGT), nutrient management strategies (NMGT), soil and water management strategies (SWMGT), mitigation strategies (MSTR), and coping strategies (CSTR).

If the net utility (Y^*_{ik}) from using the mth CSA strategy on his or her farm is higher than the net utility from not implementing the resilience strategy, the ith maize farmer will adopt it. Consequently, the latent variable net utility (Y^*_{ik}) resulting from the implementation of the mth resilience strategy is dictated by the socioeconomic factors of maize farmers, climate variables and institutional features jointly represented as X_i, in addition to the error term ():

Following [35], and adopted by [36] involving estimating a model with multiple dependent variables, specifically y_1, ..., y_5., such that:

$$Y_{ik}^* = B_m X_i' + \varepsilon_i \qquad \text{……………. (2)}$$

Transforming Eq. (1) into an observed binary outcome equation, we have:

$$Y_{im}^{*} = \begin{cases} 1 \; if \;\; Y_{im}^{*} > 0 \\ 0 \; otherwise \end{cases} \quad \text{………. (3)}$$

Given that *m* = CMGT, NMGT, SWMGT, MSTR and CSTR

$$yi = 1 \; if \; \beta_i x_i + \varepsilon_i > 0 \quad \text{……….(4)}$$

$$yi = 0 \; if \; \beta_i x_i + \varepsilon_i \leq 0 \quad i = 1, 2, \ldots., 10 \quad \text{……………..(5)}$$

RESULTS AND DISCUSSION

Farmers' climate change perception and awareness

Farmers' perception and awareness of climate change play an important role in adopting resilience measures to mitigate its adverse effects. The more farmers recognize the likelihood of climate-related losses, the more likely they implement resilience strategies [34]. From the findings, majority, 86.49% of maize farmers were aware of climate change, while 13.51% were not (Figure 1). This implies that they are more likely to adopt strategic responses to alleviate its negative impacts. These results align with [37], who found most farmers perceive climate change based on their personal experiences.

Also, about 65 percent of farmers expressed a lack of access to climate change information, whereas only 35 percent affirmed their access, meaning, most farmers lack crucial knowledge on the latest technologies of combating climate change adverse effects. Furthermore, more than 70 percent had climate change experience for an average of ten years. The implication is that majority of the sampled households had the requisite experience to help them make informed decisions on climate change resilience measures.

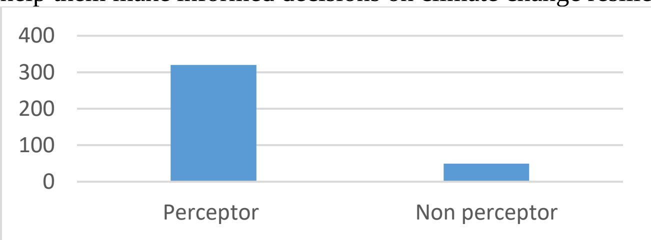

Figure 1. Farmer's perception of climate change
Source: Author construction from survey data, 2023.

Indicators of climate change

Farmers reported indicators that are perceived as proof of climate change in the study area. Most households perceived at least an aspect of temperature and rainfall anomaly (Table 1). Majority 84.59 percent of the sampled households reported an increase in temperature, while the others perceived no change. Most, 79.46 percent of maize farmers reported a reduction in precipitation amount, whereas the remaining 20.54 percent perceived an increasing dimension. Similarly, for drought frequency, 76.5 percent reported extended water scarcity, whereas, 23.5 percent asserted non-committal.

As for flooding frequency, about 51.35 percent had no flooding experience, while the remaining few reported flooding in their farms.

The results suggest that rising temperatures and decreased rainfall are the primary indicators contributing to weather anomalies in the study area. Numerous researches conducted in SSA have reported similar trends. [38, 37] have shown that over 78% and 83% of respondents observed rising average temperatures and declining precipitation, respectively, over the past 10-20 years, pointing to a significant perception of climate change among the respondents.

Table 1. Indicators of climate change

Climate change indicators	Frequency	Percentage
Temperature increase		
Yes	313	84.59
No	57	15.41
Rainfall decrease		
Yes	294	79.46
No	76	20.54
Drought frequency		
Yes	283	76.50
No	87	23.5
Total	370	100
Flooding frequency		
Yes	180	48.65
No	190	51.35
Total	370	100

Source: Author construction from survey data, 2023.

Resultant effect of climate change

Majority (93.51, 83.24, 81.62) percent of farmers perceived that changes respectively in natural forest cover, crop yield change, and soil erosion are the results of climate change (Table 2).

Implications of the consequences are that smallholder farming households were faced with ramifications of the adverse effect of climate change, in tandem with previous research [39, 37].

Table 2. Resultant effect of climate change

Variables	Frequency	Percentage
Climate change consequences		
Soil erosion		
Yes	164	44.32
No	206	55.68
Soil fertility change		
Yes	303	81.62
No	68	18.38
Crop yield change		
Yes	308	83.24
No	62	16.76
Total	370	100
Natural forest cover change		
Yes	346	93.51
No	24	6.49
Total	370	100

Source: Author construction from survey data, 2023.

Forms of farmers' response to climate change

Climate change strategies

This study investigated the strategies employed by respondents to adapt to, mitigate, and cope with climate change, as well as the factors that influence their adoption in the study area. It was hypothesized that the use of these strategies would be affected by several variables, such as climate change perception, socio-economic factors (education level, farm size), demographic characteristics (gender, age, household size), and institutional factors (extension services, information, social networks). The table shows that adaptation strategies were the most adopted among the mechanisms. This is followed by coping mechanisms and the least, mitigation strategies. Overall, farmers integrated various strategies to combat climate anomalies. Smallholder farmers may employ synergized strategies simultaneously to reap complementary benefits, including: enhanced climate resilience, improved agricultural productivity and better livelihoods. As observed by various studies [40, 41]. This multi-faceted approach can lead to synergistic advantages, ultimately supporting farmers' overall well-being and sustainability.

Adaptation strategies

Table 3 show that the major adaptation strategies to climate change employed by maize farmers, as reported by the respondents, were Intercropping (60%), crop rotation (75%), improved crop varieties (54.8), and change in the farming calendar (84%), inorganic fertilizer (36%), animal manure (63.1%), fertilizer + manure (71%), planting strips (18.2%), tied ridging (14.7%), contour farming (34.8%), and only (8%) uses small scale irrigation farming.

A farmer's ability to respond to climate change serves as a pointer to their adaptability. In this study, farm households were asked to rate various adaptation options, and those with a rating of 50% or higher were deemed the most effective strategies in the region, and thus selected as the primary focus for the study.

Mitigation strategies

The research reveals that the major mitigation strategies against climate change adopted by maize farmers in the study area were mulching/crop residue (67%), agroforestry (20%), and terracing (19.3%). Of all the mitigation mechanisms, the most adopted is mulching/crop residue and the least is terracing (Table 3). Generally, among the three identified climate change resilience responses, mitigation mechanisms were the least adopted by farmers. This could be due to its knowledge drawbacks and the financial implications that could not easily be bored by smallholder farmers.

Table 3. Smallholder utilization of adaptation and mitigation mechanisms in response to climate change

Adaptation mechanisms	Adopters		Non-Adopters	
Cropping practices	Freq	Percentage	Freq	Percentage
Intercropping	224	60	150	40
Crop rotation	280	75	94	25
Improved crop varieties	205	54.8	169	45.2
Change farming calendar	314	84	60	16
Nutrient management practices				
Inorganic fertilizer	135	36.0	240	64.0
Animal manure	236	63.1	138	36.9
Soil and water conservation				
Planting strips	68	18.2	306	81.8
Tied ridging	55	14.7	319	85.3
Contour farming	130	34.8	244	65.2
Small scale Irrigation farming	30	8.0	344	92.0
Mitigation mechanisms (Conservation agriculture)				
Mulching/crop residues	248	67	122	33
Agroforestry	75	20	295	80
Terraces	72	19.3	299	80.7

Source: Author construction from survey data, 2023.

Coping/Income diversification strategies

Table 4 reveals coping/income diversification mechanisms employed by farmers were crop and livestock diversification 73%, off-farm activities 61%, and social networking 55%.

It could be deduced that the most prominent coping mechanism adopted by maize farmers was crop and livestock diversification. These responses were thus common short-term measures taken by farmers in the study area to cope with extreme weather events, providing temporary relief from the negative impacts of climate change.

Table 4. Smallholder utilization of coping/income diversification mechanisms in response to Climate Change

Coping/income diversification mechanisms	Adopters	Adopters	Non-Adopters	Non-Adopters
	Frequency	Percentage	Frequency	Percentage
Crop and livestock diversification	270	72.9	100	27
Engage in non and off-farm activities	225	60.8	145	78.1
Social networking	205	55.4	165	44.6

Source: Author construction from survey data, 2023.

Effect of perceptions on specific CSAP synergies choice

The result of the multivariate model which assumes that there should be significant correlations across all equations specified in the model is presented. The Wald test [$X^2(190) = 552.41$; $p = 0.000$] which rejected the null hypothesis that all coefficients in each equation of the model are jointly equal to zero, is statistically significant at the 1% level. The likelihood ratio test result [$X^2 (46) = 265.428$; $p = 0.0000$] of the model rejected the null hypothesis of uncorrelated covariance of the error terms across the equations of the model. This result justified that MVP is fit for the data collected for this study. Table 5 presents the multivariate probit regression parameter estimates.

The study's outcome of multivariate probit model analysis identified nine key factors across five predictor sets that influence farmers' utilization of CSAPs in responding to climate change. These significant factors include farmers' perception of climate change, gender, age, education, family size, farm size, climate information, extension visits, and annual mean precipitation.

The summary statistics indicate that farmers who perceived losses due to changes in climate conditions were more inclined to use cropping practices (adaptive) and coping/income diversification strategies, while other control covariates significantly affect the choice of soil and water conservation, mitigation, and nutrient preservation. This is to be expected given their potential in improving farmers' capacity to mitigate and adapt to the negative impact of climate change.

The analysis revealed a positively significant correlation between the perception of farmers of climate change and their utilization of adaptive cropping strategies (CMGT) and coping mechanisms (CSTR) at significance levels of 10% and 5%, respectively. The result is in tandem with the previous study [42], suggesting that understanding climate change directly influences perceived risk. In essence, maize farmers' beliefs about climate change and their perceived risks significantly influenced their adoption decisions on adaptive and coping strategies, as well as income-generating activities.

For example, farmers overwhelmingly endorse adaptive measures that prepare them for more extreme weather events, which is linked to their beliefs and perceived risks.
This means that farmers who believe in climate change and see it as a threat to their farming practices are more likely to take action to protect their land from future extreme weather events. In essence, our findings suggest that belief in climate change and perception of its risks are the triggers that motivate farmers to take adaptive action.

Furthermore, we indicate that encouraging creative solutions from farmers to address extreme weather risks may be the best practical approach to climate change adaptation and outreach.

Our findings also reveal a surprising lack of correlation between perceived agricultural risks and the choice of mitigation actions (MSTR). This suggests that maize farming households still have a limited understanding of mitigation strategies, which may be attributed to the high cost of mitigation measures like irrigation farming for smallholder farmers. In contrast, adaptive actions like investing in cropping practices (CMGT) can have immediate benefits at the individual farm level, neutralizing climate risks. Moreover, the long-term and diffuse impacts of government actions on greenhouse gas emissions (mitigation) may not be fully comprehended by maize farmers, contributing to the uncertainty surrounding mitigation actions

The results further indicate that farmers' belief in climate change has a significant and positive ($p < 5\%$) influence on their adoption of coping strategies (CSTR). In other words, the more farmers believe in climate change, the more the likelihood of diversifying their income and adopting coping strategies (CSTR) to mitigate its impacts. Coping strategies are the actual temporary responses to crises associated with livelihood systems in the face of inaccessible, unavailable, and unaffordable food substances. It is a pointer to the existence of strong social networks among rural households [43]. Our research showed that households adopted a combination of strategies to mitigate its impacts

Similarly, regarding explanatory variables in the model, coefficients of age of farmers reduce the likelihood of choosing mitigation (MSTR) and soil and water management (SWMGT) but increase the likelihood of using cropping practices, nutrient management (NMGT), and coping/income generation mechanisms. The results align with the study by [44], which found that farmers' age and the adoption of crop management practices under Climate-Smart Agriculture are positively related. In other words, older farmers were more expected to adopt climate-resilient crop management strategies. Also, the family size and gender of the household head directly affect the use of coping/income generation strategy and cropping practices respectively but reduces the probability of using all other techniques. Furthermore, the coefficients of farm size and extension visits increase the likelihood of using mitigation and soil and water management but reduce the likelihood of choosing all other techniques.

In the same vein, coefficients of access to climate information increase the likelihood of choosing nutrient management and coping mechanisms but reduce the farmer's propensity to use cropping practice (CMGT), soil and water management (SWMGT), and mitigation mechanisms (MSTR). Furthermore, another positively significant variable was the coefficient of annual mean precipitation to crop management strategies (CMGT), nutrient management mechanisms (NMGT), mitigation strategies (MSTR), and coping strategies (CSTR). This indicates that increased precipitation will encourage farmers to plant flood-tolerant maize varieties that withstand adverse climatic changes [20]. In addition, it encourages farmers to diversify in livestock and social networking as a way to cope with the effects of adverse weather.

Our study reveals that various factors, including climate change farmers' perceptions interwoven and have cumulative outcomes that influence the response options adopted by maize farmers in the study area.

While these interactions occur, it's essential to guide farmers in managing the combined effects of these factors to enhance their ability to cope and improve food security. This result conforms to the study [45], which showed that the cumulative impact of multiple shocks influences the choice of coping strategies.

Table 5. Multivariate probit estimates of Climate Change Perceptions on the key Response Options

Variables	CMGT	NMGT	SWMGT	MSTR	CSTR
PERCEPTION	0.6121*	0.2433**	0.4595	0.6505**	0.5842***
	(0.3381)	(0.1158)	(0.4158)	(0.3097)	(0.1884)
AGE	0.2861*	0.3642	-0.2271*	-0.3852*	0.4842
	(0.1580)	(0.3152)	(0.1281)	(0.2122)	(0.3942)
EDU	0.2651**	0.3167*	0.1975	0.4145	0.2983**
	(0.1100)	(0.1809)	(0.2006)	(0.3987)	(0.1269)
GENDER	0.2512	0.309	0.681	0.4252	0.3340*
	(0.2060)	(0.2920)	(0.5190)	(0.3881)	(0.1964)
FAMLY_Z	0.3851*	0.2144	0.4712	0.1045	0.3052
	(0.2115)	(0.1964)	(0.3843)	(0.1045)	(0.3102)
FARM_Z	0.3103	0.7530	0.5432***	0.4679**	0.3470
	(0.3045)	(0.6915)	(0.1866)	(0.2025)	(0.3107)
CLIM_INFO	0.2342	0.3215**	0.3741	0.3972	0.2987***
	(0.2251)	(0.1454)	(0.3190)	(0.3815)	(0.0963)
EXT_VISIT	0.8935	0.6266	0.4817**	0.4895**	0.3156
	(0.7855)	(0.5945)	(0.2015)	(0.2225)	(0.3012)
MTEMP	-0.2031*	-0.3522	-0.4152	-0.2801	-0.3945
	(0.1147)	(0.2972)	(0.3891)	(0.1623)	(0.3231)
MPREC	0.1689***	0.1180***	-0.2292	0.1065*	0.2441***
	(0.0544)	(0.0524)	(0.2348)	(0.0598)	(0.0827)

Source: Authors' calculation, 2023.
*; **; & *** = Statistical significance at the 10 % ; 5 % and 1 %, respectively.

CSAPs correlation matrix from the MVP model

Table 6 reveals the pair-wise correlation of the different climate-smart agricultural practices adopted by maize-based farmers in the study area.

From the results, it is evident that each pair of adaptation strategies, almost all, has positive correlation coefficients between them and had a statistically significant level of 5 %. This is an indication of complementarity among the CSAP strategies as maize farmers employed them as compliments in the study area, [20].

The result revealed that crop management strategies boosted the adoption of diverse CSAP strategies such as nutrient management strategies, soil and water management strategies, mitigation strategies, and coping strategies.

Similarly, farmers who adopted nutrient management strategies also employed soil and water management strategies, mitigation strategies, and coping strategies. Furthermore, soil and water management strategies were adopted concurrently with mitigation strategies and coping strategies. These results imply that maize farmers adopted CSAP strategies complementarily to alleviate climate change's negative threat to their farming practices.

Table 6. Estimates of the correlation among the CSA strategies from MVP model.

Pair-wise correlation of climate smart agricultural practices	Correlation coef.	Standard error
Rho 21 nutrient management strategies and crop management strategies	0.481***	0.106
Rho 31 soil and water management strategies and crop Management strategies	0.372***	0.093
Rho 41 mitigation strategies and crop management strategies	0.432**	0.061
Rho 51coping strategies and crop management strategies	0.751***	0.234
Rho32 soil and water management strategies and nutrient management strategies	0.159***	0.039
Rho 42 mitigation strategies and nutrient management strategies	0.335**	0.139
Rho 52 coping strategies and nutrient management strategies	0.651***	0.072
Rho 43 mitigation strategies and soil and water management strategies	0.153	0.109
Rho 53 coping strategies and soil and water management strategies	0.361***	0.072
Rho 54 coping strategies and mitigation strategies	0.535***	0.059

Source: Authors' calculation, 2023.

CONCLUSION AND RECOMMENDATIONS

The study assessed perceptions outlook of maize-based farming households that influenced their choice of adaptation, mitigation, and coping/income generation strategies in southwestern Nigeria. Using multivariate probit modeling to determine influencing factors that determine the employment of such multiple mechanisms. We strategically used climate data together with the field's cross-sectional data to examine the adoption of such strategies for a better comprehension of the major drivers of farmers' climate change amelioration efforts.

The study's outcome of multivariate probit model analysis identified nine key factors across five predictor sets that influenced farmers' utilization of CSAPs in responding to climate change. Such significant factors include farmers' perception of climate change, which suggests that belief in climate change and perception of its risks are the triggers that motivate farmers to take adaptive, mitigation, and coping actions to combat threats of climate change

It was discovered that adaptive strategies were the most adopted, while mitigation action was the least, probably because of its associated costs, for instance, irrigation farming.

In addition, gender, family size, age of the household head, and farm size were other significant factors that influence farmers' adoption.

Furthermore, extension visits, climate information, and mean annual precipitation, all significantly affected farmers' choice of resilience mechanisms. Our study further reveals that various factors, including climate change farmers' perceptions interwoven and have cumulative outcomes that influence the response practices employed by maize farmers. While these interactions occur, it's essential to guide farmers in managing the combined effects of these factors to enhance their ability to cope and improve food security. Also, encouraging creative solutions from farmers to address extreme weather risks may be the best practical approach to climate change adaptation and outreach.

Therefore, policymakers and development partners should put in place policy frameworks that seek to promote the synergistic use of CSAP strategies in the most complimentary ways. Furthermore, there should be adequate provision of climate information through various media that will keep farmers informed of the current threat and the latest amelioration strategies available on climate change.

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KAKO PERCEPCIJE O KLIMATSKIM PROMENAMA ODREĐUJU IZBOR KLIMATSKI PAMETNIH POLJOPRIVREDNIH PRAKSI: ISKUSTVA DOMAĆINSTAVA KOJA GAJE KURUZ U JUGOZAPADNOJ NIGERIJI

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Apstrakt. Povećanje maksimalne poljoprivredne produktivnosti podrazumeva da faremeri usvoje sinergizovane klimatski pametne poljoprivredne prakse -KPPP, (eng. CSAP-Climate-Smart Agricultural Practices). Ova studija istražuje kako farmeri u gajenju kukuruza u jugozapadnoj Nigeriji primenjuju ključne CSAP (eng. Climate-Smart Agricultural Practices) na osnovu razumevanja dinamike klimatskih promena.

Koristeći višestepenu proceduru uzorkovanja za odabir 370 malih gazdinstava koja se bave gajenjem kukuruza, primarni podaci su dobijeni iz oblasti istraživanja korišćenjem strukturisanog upitnika sa sekundarnim podacima o temperaturi i padavinama iz Nigerijske meteorološke agencije (NiMet). Podaci su analizirani korišćenjem multivarijantnog probit modeliranja (MVP - Multivariate Probit Modeling) i deskriptivne statistike. Empirijski dokazi pokazuju da je približno 86% farmera bilo svesno klimatskih promena. Takođe, farmeri su registrovali povećanje temperature, smanjenje padavina i učestalost suša sa posledicama promene prinosa, plodnost zemljišta i prirodnog pokrivača.

Prema ovoj studiji, saznanja farmera o klimatskim promenama značajno utiču na izbor CSAP prakse koju su farmeri besplatno koristili. Pored toga, rezultati pokazuju da starost, obrazovanje i veličina farme značajno utiču na izbor CSAP. Takođe, pol, stručne dodatne posete, klimatske informacije i srednja godišnja količina padavina bile su značajne varijable koje su uticale na izbor CSAP-a kod farmera.

Zato bi trebalo dati smernice politike koja nastoji podstaći besplatno usvajanje CSAP koje je ojačano adekvatnim i blagovremenim klimatskim informacijama.

Ključne reči: *Klimatski pametna poljoprivreda, MVP model, percepcija klimatskih promena, farmeri proizvođači kukuruza, poljoprivredna proizvodnja*

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