https://doi.org/10.17221/87/2024-AGRICECON

Psychological perspectives on smallholder farmers' choice of climate change adaptation strategies and productivity nexus in Southwest, Nigeria

Adetomiwa Kolapo[1]*, *Akeem Abiade Tijani*[1], *Seyi Olalekan Olawuyi*[2], *Adeyera James Kolapo*[3], *Temitope Oluwaseun Ojo*[1], *Nolwazi Zanele Khumalo*[4], *Khalid Mohamed Elhindi*[5], *Hazem Kassem*[6]

[1]*Department of Agricultural Economics, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria*
[2]*Department of Agricultural Economics and Extension, University of Fort Hare, Alice, South Africa*
[3]*Department of Agricultural Economics and Extension, Afe Babalola University, Ado-Ekiti, Nigeria*
[4]*Department of Agriculture, University of Zululand, Richards Bay, South Africa*
[5]*Department of Plant Production, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia*
[6]*Department of Agricultural Extension and Rural Society, Faculty of Agriculture, Mansoura University, Mansoura, Egypt*

**Corresponding author: kolapoadetomiwa@gmail.com*

Citation: Kolapo A., Tijani A.A., Olawuyi S.O., Kolapo A.J., Ojo T.O., Khumalo N.Z., Elhindi K.M., Kassem H. (2025): Psychological perspectives on smallholder farmers' choice of climate change adaptation strategies and productivity nexus in Southwest, Nigeria. Agric. Econ. – Czech, 71: 185–202.

Abstract: In recent pasts, high priority has been placed on encouraging the implementation of various climate change adaptation techniques to adapt to the disastrous effects of climate change. Like in other countries affected by climate change, Nigerian farmers were also encouraged by governmental and non-governmental organisations to implement techniques for adapting to climate change impact. In this study, we use a psychological approach to investigate how a mix of socioeconomic and psycho-cognitive factors affect smallholder farmers' decisions about various climate change adaptation strategies and the consequent impact of the adoption of adaptation strategies on crop yield. Following the theory of planned behaviour (TPB), the adoption decision of farmers was modeled using the partial least squares structural equation modeling (PLS-SEM) and the ordered probit model. The impact of adopting adaptation strategies on productivity was evaluated using multinomial endogenous switching regression (MESR). The MESR helps to address endogeneity issues that might arise as a result of inconsistencies in the behavioural responses of the farmers. Our result indicates that psycho-cognitive factors like intentions and personal norms significantly predicted the number of climate change adaptation strategies the farmers ultimately embraced and implemented on their farms. We also found that the smallholder farmers' yield and income were most significantly impacted by the adoption of land restoration as a climate change adaptation strategy. The findings will assist in the design of more effective policy instruments to remove adoption hurdles as well as crafting tailored extension services that resonate with the realities of the farmer and thus help foster behavioural change.

Keywords: MESR; Nigeria; structural equation modelling; theory of planned behaviour

Supported by The Researchers Supporting Project No. (RSPD2024R952), King Saud University, Riyadh, Saudi Arabia.

https://doi.org/10.17221/87/2024-AGRICECON

Climate change is rapidly becoming an increasingly important global development issue that poses a threat to the long-term viability of a wide range of worldwide occupations, most notably the agricultural sector (IPCC 2018; Arora 2019; Kolapo and Kolapo 2023). An ongoing increase in greenhouse gas emissions has led to an increase in the impacts of change in climate on the agricultural sector. These impacts can be either favourable or negative, depending on factors such as geographical location and other factors (Teklu et al. 2023).

Nigeria's agricultural sector is vulnerable to climate change, especially smallholder maize farmers who depend on rain-fed crops. Changes in rainfall patterns brought on by climate change may result in drought, which lowers maize yields (Mare et al. 2018). Nigeria's average maize output decreased in 2017 from 1.7 metric tonnes per ha in 2016 to 1.5 metric tonnes per ha, falling short of the averages for Africa (2.17 metric tonnes per ha) and the world (5.7 metric tonnes per ha) (FAOSTAT 2020) has been linked to the disastrous impact of climate change. Thus, to ensure increased maize productivity, ensure food security, and improve the livelihood of smallholder maize farmers, most nations in the world, including Nigeria, should consider sustainable practices in agricultural production (Ojo et al. 2021; Adetoro et al. 2020). Sustainable practices like agroecology, agroforestry, integrated pest management etc. under climate change involve a holistic approach that considers environmental, economic, and social dimensions (Ojo et al. 2021). By integrating these practices, farmers can enhance resilience, reduce environmental impacts, and contribute to global efforts to combat climate change. While sustainable practices could help to mitigate the impact of climate change, adaptation strategies on the other hand help the farmers to adapt to the impact of climate change. Since the farmers in Nigeria could minimally implement practices to mitigate climate change impact, they are better at adopting adaptation strategies to cushion the impact of climate change.

The concept of adaptation as a means of adjusting to the negative effects of change in climate on agricultural productivity in low-income countries like Nigeria has been the subject of serious debate and policy discussions all around the world. According to Thinda et al. (2020), the implementation of adequate adaptation strategies can lessen the effects that climate change has on crop production and, in the long term, could boost agricultural output. Similarly, Ojo and Baiyegunhi (2018) in their work showed that the implementation of adaptation techniques will result in higher productivity of main cereal crops in developing nations, while simultaneously ensuring that farmers will have access to sufficient food supplies. Different climate change adaptation strategies (CCAS), such as cropland management, water management, land restoration, seed selection, and fertility management (Belay et al. 2017; Asrat and Simane 2018; Harvey et al. 2018; Ojo and Baiyegunhi 2018; Jellason et al. 2019; Diallo et al. 2020; Marie et al. 2020), have been promoted by development institutions in Nigeria to encourage climate-smart agriculture, increase farmers' productivity, improve soil health, and improve smallholder farming systems' resilience. However, smallholder farmers in many parts of Sub-Saharan Africa, including Nigeria, are lagging behind in adopting climate change adaptation techniques (Ojo and Baiyegunhi 2018; Jellason et al. 2019). Meta-analytic reviews have shown that a wide range of socioeconomic, institutional and agro-ecological factors influences farm-level adoption decisions (Mutyasira et al. 2018).

Most empirical studies have generally focused on the economic factors influencing farmers' ability to adopt CCAS (Asrat and Simane, 2018; Ojo and Baiyegunhi 2018; Jellason et al. 2019; Diallo et al. 2020; Marie et al. 2020). Relatively less research has focused on understanding farmers' willingness to invest in CCASs and the intrinsic factors influencing farmers' adaptation behaviour. Behavioural approaches are needed because it has pointed out the inadequacies of the traditional economic approaches to understanding farmer's adaptation behaviour, particularly given that adaptation-related decisions are not always made on an economically rational basis (Stern 2000; Chouinard et al. 2008). There are suggestions that non-economic and intrinsic factors such as farmers' attitudes, norms, and stewardship motives may influence individual decision-making processes (Lynne et al. 1988), and hence interventions to promote CCASs must target changing farmer's behaviour (Clayton and Myers 2009). Thus, behavioural approaches have been used to examine farmers' pro-environmental behaviour (Quinn and Burbach 2008; Ahnström et al. 2009), uptake of organic farming (Läpple and Kelley 2013) and general perceptions toward SAPs (Tatlidil 2009). Understanding farmers' adaptation behaviour is complex. Developing a clear picture on the drivers and processes shaping the uptake of CCASs therefore requires a strong understanding of the psycho-social factors influencing farmers' willingness to adopt CCASs, and the socioeconomic factors affecting their ability to implement these practices on their farms. This study adopts an integrative approach, examining how both

https://doi.org/10.17221/87/2024-AGRICECON

socioeconomic and psycho-social factors, such as attitudes and personal norms, influence adoption of CCASs by smallholder maize farmers in Nigeria. We use the theory of planned behaviour (TPB) (Ajzen 1985; 1988; 1991) as our framework to understand the main behavioural constructs underpinning farmers' behaviour regarding CCASs. Structural equation modeling techniques are used to derive summated indices of the behavioural latent variables, as well as to examine their significance in explaining farmers' intentions. An ordered probit regression model is used to examine the relative importance of socioeconomic and psycho-social variables as predictors of the number of CCAPs adopted by the maize farmers.

Furthermore, the impact of climate change on crop productivity has also been a subject of debate since climate change impact has been felt more in the agricultural sectors. Climate change is adversely affecting maize productivity in Nigeria through temperature increases, altered rainfall patterns, increased pest and disease pressures, and challenges in adaptation. Climate change has led to rising temperatures in Nigeria, which can negatively affect maize growth and development. Higher temperatures accelerate crop maturation, reducing the time available for grain filling and ultimately affecting yield. Studies have shown that increased temperatures can decrease maize yield due to heat stress during critical growth stages (Etwire et al. 2022). Irregular rainfall patterns can lead to droughts or floods, both of which can significantly reduce maize yields. Droughts, in particular, can reduce soil moisture levels and impair plant growth, leading to yield losses (Abid et al. 2016). Addressing these impacts requires a multifaceted approach that includes enhancing agricultural resilience using climate change adaptation strategies.

Most of empirical studies (Ojo and Baiyegunhi 2018; Asrat and Simane 2018; Jellason et al. 2019, Diallo et al. 2020; Marie et al. 2020) on climate change adaptation have focused mainly on the factors influencing adaptation strategies. Relatively less research has focused on understanding how adoption of climate change adaptation strategies has impacted maize yield and income in Nigeria creating a knowledge gap. This study therefore assesses the effect of adoption of climate change adaptation strategies on maize yield and income using endogenous switching regression model. This model helps to correct endogeneity issues that might arise from inconsistent behavioural responses of the farmers with respect to the adoption of climate change adaption strategies.

The connection between TPB and endogenous regression analysis lies in the necessity to account for potential endogeneity when testing the theory. Since TPB constructs are often influenced by unobserved variables or measurement error, using endogenous regression techniques ensures that the estimates of how attitudes, norms, and perceived control affect behaviour are unbiased and valid. Without addressing endogeneity, the conclusions drawn about the predictors of behaviour in TPB may be flawed. By combining TPB with endogenous regression techniques, we are able rigorously test the relationships between psychological factors and behaviour, ensuring that their findings are robust and reflective of true causal effects.

The findings will assist in the design of more effective policy instruments to remove adoption hurdles as well as crafting tailored extension services that resonate with realities of the farmer and thus help foster behavioural change.

The rest of the section of the study includes the following: we presented the methodology where we describe the study area, data collection techniques and data analysis. We then presented the results while concluding with policy implications.

MATERIAL AND METHODS

Study area

We collected baseline data on climate change adaptation methods, attitudes, and behaviour of farmers toward climate variability from 360 farming families in Southwestern Nigeria, with a special survey constructed around TPB to assess attitudes toward climate change adaptation behaviour in the region. Lagos, Ondo, Osun, Oyo, Ogun, and Ekiti are part of the South West geographical zone of Nigeria with a total land area of 77 818 km^2 and a predicted population of 28 767 752 people in 2002, the territory is located between longitude 2°31' and 6°00' East, and latitude 6°21' and 8°37' North (Aliyu et al. 2022; Kassali et al. 2024). Edo and Delta States border is on the east, Kogi and Kwara States on the north region, Republic de Benin on the west, Gulf of Guinea on the southern region (Kolapo et al. 2022; Jimoh et al. 2023).

Southwest Nigeria's climate is tropical in nature, with wet and dry seasons. Temperatures range from 21 °C to 34 °C, with annual rainfall ranging from 150 mm/m^2 to 3 000 mm/m^2. South-western Nigeria's vegetation comprised of freshwater marsh with mangrove forest at belt, low terrain in forest reaches inland to Ondo and parts of Ogun State, and second-

https://doi.org/10.17221/87/2024-AGRICECON

ary forest are found at north border, where southern and derived Savannah occur (Ogunleye et al. 2020; Rabirou et al. 2022). Agriculture is the primary source of employment and revenue in the Southwest. Maize, cassava, yam, and rice are food crops, while cocoa, oil palm, kolanut, plantain, banana, cashew, citrus, and timber are cash crops. The map of Nigeria and Southwest are presented in Figure 1.

The community leaders of the chosen communities in the Local Government Areas of Oyo State also granted approval to the gatekeepers. Throughout the investigation, the ethical precepts of beneficence, principle of justice, anonymity and confidentiality, and regard for human dignity were all upheld. For example, only after verbally obtaining informed consent from the respondents was data collection carried out. Throughout the study, all participants were treated equally and fairly, regardless of their ethnicity or creed.

Method of data collection

The respondents in the study area were chosen using a multistage sampling procedure. The first stage required the purposeful selection of three states, namely Ondo, Ogun, and Lagos, and the second stage entailed the application of the same technique to select four local Government Areas (LGAs) from each State based on the presence of smallholder farmers in these areas. The third stage entailed selecting five villages at random from each of the four LGAs chosen in the second round. The final stage involved a random selection of 6 smallholder maize farmers from each of the villages, giving the study a total of 360 respondents.

Structure of questionnaire

The questionnaires included a list of statements (see Table 1 for list of questions) that is based on the TPB model's constructs, which were then used to elicit data on smallholder farmers' attitudes toward climate change adaptation strategies, perceived social pressure to adopt climate change adaptation strategies, perceived behavioural control (PBC) over use of climate change adaptation strategies, and overall intentions to implement climate change adaptation strategies on their respective farms following previous studies (Quinn and Burbach 2008; Ahnström et al. 2009; Tatlidil 2009; Läpple and Kelley 2013; Mutyasira et al. 2018). The study uses the TPB (Ajzen 1991) as the main theoretical framework to analyse farmers' general attitudes toward climate change adaptation strategies. The theory argues that a person's intention (INT) is a good predictor of their actual behaviour. According to this theory, a person's attitude (ATT) toward a behaviour, subjective norms (SN), and their PBC are the key antecedents of INT. ATT is the extent to which a person has a favourable or unfavourable evaluation of a behaviour. Subjective norm refers to an individual's perceived social pressure to perform a certain behaviour. It comprises beliefs about social expectations and the motivation to comply with those expectations. Finally, PBC is the extent to which an individual feels able to perform the behaviour (Ajzen 1991).

Four questions on the instrument were used to directly measure ATT (ATT1, ATT2, ATT3, ATT4). The four questions questioned the farmers how much they agreed that implementing climate change ad-

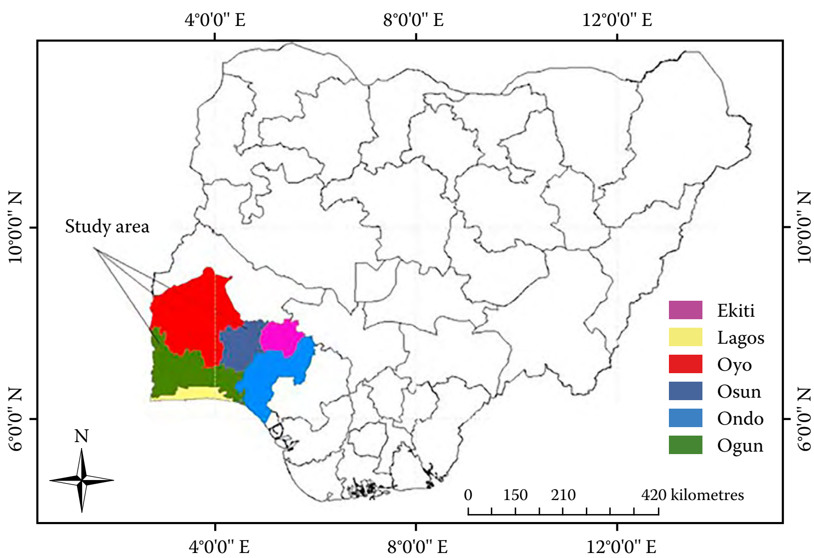

Figure 1. Map of Nigeria showing southwestern Nigeria and bounded States

The area lies between longitude 2°31' and 6°00' East and latitude 6°21' and 8°37' North with a total land area of 77 818 km^2

Source: Authors' modification using MATLAB

https://doi.org/10.17221/87/2024-AGRICECON

Table 1. Descriptive statistics for psycho-cognitive variables

Constructs	Item	Descriptions	Mean	SD
Attitude	ATT1	I think adoption of climate change adaptation strategies increase my crop yields	0.38	0.51
	ATT2	I think adoption of climate change adaptation strategies increase my farm income	0.41	0.32
	ATT3	I think adoption of climate change adaptation strategies improve my welfare	0.37	0.31
	ATT4	I think adoption of climate change adaptation strategies improve fertility of my soil	0.44	0.35
Subjective norm	SN1	Most farmers close to me adopt climate change adaptation strategies on their farms	0.37	0.28
	SN2	People close to me would think that adopting climate change adaptation strategies would be a very good idea	0.61	0.48
	SN3	Majority of farmers in the community expected me to adopt climate change adaptation strategies on my farms	0.46	0.33
	SN4	I want to look like other farmers in the community when choosing farm practices	0.66	0.39
PBC	BPC1	I would be able to practice at least one of the climate change adaptation strategies	0.71	0.52
	BPC2	I have the resources to implement climate change adaptation strategies on my farm	0.51	0.37
	BPC3	I have the requisite knowledge to practice climate change adaptation strategies on my farm	0.42	0.26
Intention	INT1	I intend to use climate change adaptation strategies on my farm	0.74	0.53
	INT2	I will try to adopt at least one of the climate change adaptation strategies	0.79	0.59
	INT3	I am planning to adopt adaptation strategies on my farm	0.76	0.54

SD – standard deviation; PBC – perceived behavioural control; ATT – persons attitude; SN – subjective norms; BPC – behavioural perceived control; INT – persons intention
Source: Authors' computation

aptation measures improved farm yields, earnings, farmer welfare, and reputation in the community. As indicated in Table l, four questions captured the subjective norm (SN1, SN2, SN3, SN4) that referred to the opinions of prominent persons and other farmers in the community. The extent to which farmers felt confident in their abilities to execute climate change adaptation techniques on their farms was measured by three items (BPC1, BPC2, and BPC3). Finally, three statements (INT1, INT2, and INT3) were used to assess a person's readiness to implement climate change adaptation strategies. These questions were written following the advice of (Ajzen 2002). To develop indices for each of the four constructs, fourteen questions directly based on theory were employed. Farmers' responses on these measuring items were recorded on a five-point Likert scale ranging from 1 to 5, where 1 = strongly disagreed and 5 = strongly agreed with the set of statements. Table 2 shows descriptive data for the study's measuring items.

Data were also collected on the socioeconomic features of the selected respondents, adopted adaptation strategies to climate change such as cropland management, water management, land restoration, and fertility management. Questions on productivity such as input used, cost of labour, fertiliser, machinery, etc. including yield, and income realised from maize production were collected using a pre-tested, well-struc-

https://doi.org/10.17221/87/2024-AGRICECON

Table 2. Descriptive statistics of the socioeconomic variables

	Variable	Description	Mean	SD	Max.	Min.
Dependent variables	*CM*	1 = adopted; 0 = not adopted	0.62	0.44	–	–
	WM	1 = adopted; 0 = not adopted	0.24	0.18	–	–
	LR	1 = adopted; 0 = not adopted	0.73	0.35	–	–
	SS	1 = adopted; 0 = not adopted	0.59	0.42	–	–
	FM	1 = adopted; 0 = not adopted	0.78	0.51	–	–
	Yield	fg/ha	37.27	21.49	–	–
	income	USD/ha	148 290.74	173 530.39	–	–
Independent variables	age of the HH head	age of HH head in years	48.32	12.21	82	16
	gender	if HH head male = 1; if female = 0	0.58	0.53	1	0
	educational Status	HH head years of education	14.39	6.83	16	0
	income from off-farm sources	HH engages in off-farm work = 1	0.53	0.61	1	0
	farm experience	years of experience in maize production	16.13	7.29	24	6
	accessibility to credit	HH had access to credit = 1; otherwise = 0	0.52	0.43	1	0
	land size	total land owned in hectares	6.28	2.79	12	2
	accessibility to climate info	if HH had access = 1; otherwise = 0	0.27	0.32	1	0
	accessibility to extension services	if HH had access = 1; otherwise = 0	0.41	0.38	1	0
	cooperative membership	if HH is a member = 1; otherwise = 0	0.58	0.52	1	0

SD – standard deviation; CM – cropland management; WM – water management; LR – land restoration; SS – seed selection; FM – fertility management; HH – household head

Source: Authors' computation

tured questionnaire. A team of extension workers and field facilitators administered a well-structured questionnaire and conducted household interviews.

Data analysis

Following the approach of Mutyasira et al. (2018), we used partial least squares structural equation modelling (PLS-SEM) to examine the behavioural response of the maize farmers to the use of climate change adaptation strategies on their maize farm. We then use ordered probit to examine the number of climate change adaptation strategies used on their farm since some of these adaptation strategies are complementary. We then used the multinomial endogenous switching regression to capture the effect of adaptation on productivity.

Partial least squares structural equation modelling (PLS-SEM). The initial step in the modelling approach is to estimate the link between the three TPB components using partial least squares structural equation modelling (PLS-SEM). Because TPB constructs are latent, they cannot be directly ob-

https://doi.org/10.17221/87/2024-AGRICECON

served or assessed (Mutyasira et al. 2018). Instead, a set of indications for an underlying latent variable is constructed from a list of queries. As a result, the structural equation model includes an outer sub-model that specifies the relationships between the latent variables and their observed indicators, as well as an inner sub-model that evaluates the relationship between the dependent and independent latent variables, as well as their path coefficients (Wong 2013; Mutyasira et al. 2018). Because no assumptions regarding data distribution are made, this work uses a partial least square approach to structural equation modelling (Giller et al. 2009; Sarstedt et al. 2014; Mutyasira et al. 2018). The model aims to increase variance explained while lowering the overall error terms (Hair et al. 2011; Lin 2013).

Ordered probit model. Second stage involved developing an econometric model to determine the relative importance of socio-economic with psychosocial variables in predicting farmer behaviour and adaptation to climate change. The TPB behavioural components are included as independent variables in the model, along with a collection of socio-economic variables derived from economic theory and related research, whose indices are created using the structural equation model discussed earlier (Knowler and Bradshaw 2007; Mutyasira et al. 2018). The number of climate change adaptation measures selected by the farmer is utilised as the dependent variable in the model, avoiding the difficulties of deciding on an adoption or non-adoption threshold point (D'Souza et al. 1993; Wollni et al. 2010). Given the ordinal structure of the dependent variable, an ordered probit model is utilised for an empirical estimate (Daykin and Moffatt 2002). While Poisson regression model makes sense in count data analysis, its underlying assumptions that all events must have similar probability (Wollni et al. 2010) renders it unsuitable for predicting climate change adaptation strategy adoption. Climate change adaptation strategies are likely to follow a path in which the likelihood of adopting the first technology differs from the likelihood of the second and thus subsequent technologies because the farmers will have acquired experience with the former technologies and will have developed a more positive attitude towards climate change adaptation strategies in general.

Empirically, the model was estimated using random utility procedures (Greene and Hensher 2008), where the dependent variable depict if the farmer adopts none ($S_i = 0$); 1 ($S_i = 1$); 2 ($S_i = 2$); 3 ($S_i = 3$); 4 ($S_i = 4$) or 5 ($S_i = 5$) several climate change adaptation strategies. Following (Wollni et al. 2010; Mutyasira et al. 2018), assume the farmer i choose to adopt a number of climate change adaptation strategies so as to maximise his underlying utility function (U):

$$U_i = V_i(\beta' x_i) + u_i \tag{1}$$

where: $i = 1, \ldots n$; U – utility level of an individual farmer; u – random error term; V – observed portion of utility function; x_i – vector of the exogenous covariates; β – vector of the parameters estimated.

Finally, unobserved portions of the utility function were indicated by independently and identically distributed random error term u_i with a mean of zero (Wollni et al. 2010; Mutyasira et al. 2018). While the utility level of an individual farmer U_i is unobserved, a latent utility was observed in a discrete form through censoring mechanisms (Daykin and Moffatt 2002):

$$\begin{aligned} S_i &= 0 \text{ if } U_i \le \alpha_1 \\ S_i &= 1 \text{ if } \alpha_1 < U_i \le \alpha_2 \\ S_i &= 2 \text{ if } \alpha_2 < U_i \le \alpha_3 \\ S_i &= 3 \text{ if } \alpha_3 < U_i \le \alpha_4 \\ S_i &= 4 \text{ if } \alpha_4 < U_i \le \alpha_5 \\ S_i &= 5 \text{ if } U_i > \alpha_5 \end{aligned} \tag{2}$$

where: S – rep numbers of adaptation adopted; $\alpha_1 < \alpha_2 < \alpha_3 < \alpha_4$ – unknown threshold parameters which were estimated using β; α – unknown parametr.

Parameter β didn't contain an intercept term as the intercept term is normalised to zero, allowing the threshold parameter to be free (Daykin and Moffatt 2002). Assume the random error, u_i, is normally distributed (Wollni et al. 2010), the following probabilities can be derived:

$$\begin{aligned} Prob(S = 0|x) &= Prob(U \le \alpha 1|x) \\ &= Prob(\beta' x + u \le \alpha 1|x) = \Phi(\alpha 1 - \beta' x) \\ Prob(S = 1|x) &= \Phi(\alpha 2 - \beta' x) - \Phi(\alpha 1 - \beta' x) \\ Prob(S = 2|x) &= \Phi(\alpha 3 - \beta' x) - \Phi(\alpha 2 - \beta' x) \\ Prob(S = 3|x) &= \Phi(\alpha 4 - \beta' x) - \Phi(\alpha 3 - \beta' x) \\ Prob(S = 4|x) &= \Phi(\alpha 5 - \beta' x) - \Phi(\alpha 4 - \beta' x) \\ Prob(S = 5|x) &= 1 - \Phi(\alpha 5 - \beta' x) \end{aligned} \tag{3}$$

where: S – rep numbers of adaptation adopted; Φ(.) – standard normal cumulative distribution functions; x – parametr of independent variables.

https://doi.org/10.17221/87/2024-AGRICECON

Parameters α and β were estimated with maximum likelihood using the following log-likelihood function:

$$L = \sum_{i=1}^{n}\sum_{s=1}^{n}\log[\Phi(\alpha_i - \beta' x) - \Phi(\alpha_1 - \beta' x)] \quad (4)$$

where: L – likelihood function.

We calculated the marginal impacts of change in the regressors on the adoption probabilities because the coefficients of the ordered probit regression model are difficult to interpret (Greene and Hensher 2008). Following Chen et al. (2002) and Mutyasira et al. (2018), the marginal effects are estimated as follows:

$$\frac{\delta(S_{i=j})}{\delta X_n} = \Phi(\alpha_j - 1 - \sum\nolimits_{\alpha-1}^{n}\beta_n X_n) - \Phi(\alpha_j - \sum\nolimits_{\alpha-1}^{n}\beta_n X_n)\beta_n \quad (5)$$

where: j – number of climate change adaptation strategies chosen by smallholder farmers; n – n^{th} farmer.

Multinomial endogenous switching regression (MESR). In order to examine the impact of adoption of climate change adaptation strategies on farmers productivity, i.e. maize yield and income, we used the multinomial endogenous switching regression (MESR). The choice of the model was based on the fact that the MESR helps to address endogeneity issues that might arises as a result of inconsistences in the behavioural responses of the farmers. It was also used because it employs a selection bias correction method by computing an inverse mill ratio (IMR) using a shortened normal distribution. This model has also been previously employed in similar studies like Bidzakin et al. (2019); Solís et al. (2007); Kolapo and Kolapo (2023).

In comparison to other impact approaches, such as the propensity score matching (PSM) technique, this approach has an advantage since it enables the creation of a counterfactual based on advantages to adopters' and non-adopters' attributes (Kassie et al. 2018). This shows that the influence of strategy choice is not limited to the intercept of the result equations but can also have a slope effect. It also allows the strategy set choices to interact with noticeable variables and unseen variability. The MESR analysis is done concurrently in two parts. In the first step, the multinomial logit (MNL) model is used to estimate the alternative complementary technology package that farming families choose while taking unobserved heterogeneity into account. The predicted probabilities in the MNL model are also used to calculate the IMR concurrently. The influence of the various complementing technology packages of CCAS techniques is assessed using the ordinary least square (OLS) estimator in the second stage, with IMRs introduced as additional covariates to account for selection bias resulting from temporally varying undetected heterogeneity. The next parts go into the specific econometric estimate strategy and estimation of average treatment effects.

Following Kolapo and Kolapo (2023), to investigate the relationship between productivity and net farm income variables and a group of covariates (α) for a particular technology choice, the multinominal endogenous switching regression (MESR) model entails estimating an OLS regression with selectivity adjustment in the second stage of the MESR. e.g., non–adoption of the adaptation strategies as reference category (NA), j = 0; crop management (CM), j = 1; water management (WM), j = 2; land restoration (LR), j = 3; seed selection (SS), j = 4; and fertility management (FM), j = 5 (Table 1). The productivity equation for specific likely regime p is specified as:

$$\begin{cases} \text{Regime 1: } A_{li} = \beta_1\alpha_1 + \partial_j\theta_{li} + \varphi_{li} & \text{if } j = 1 \\ \text{Regime } P\text{: } A_{pi} = \beta_p\alpha_{ji} + \partial_p\theta_{pi} + \varphi_{pi} & \text{if } j = p;\ p = 2, 3, 4 \end{cases} \quad (6)$$

where: j = 1; A_{pi} – regime-p farmers' productivity indicators; β – parameter vectors; φ_{li} and φ_{pi} – stochastic error terms; ∂ – parameter vector for category j; θ – partial derivative.

These error terms φ_{pi} have distributions $E[(\varphi_{pi} | X, \alpha) = 0]$ and var $(\varphi_{pi} | X, \alpha) = \sigma 2_p$. In this case, A_{pi} is observed if only bundle p is adopted, wherein $\pi^*_{ip} > \max_{p\neq a}(\pi^*_{ia})$. In order to reduce the unobserved heterogeneity restrictions, Wooldridge (2002) states that Equation (6) is supplemented with the mean plot changing covariates (∂) (machinery use, labour use, etc.). The stochastic error term (φ_{pi}) consists of a random error term with unobserved particular effects. Therefore, if the error terms of the adoption (ε_{pi}) and outcome (φ_{pi}) equations are dependent, the OLS estimates in Equation (6) will be biased. Therefore, the inclusion of the choice correction factors is necessary for consistent estimations of β_p and ∂_p in Equation (5). There are p–1 choice correction terms in the multinomial choice situation, one for each replacement adoption bundle. The second MESR phase with accurate estimates is written as:

https://doi.org/10.17221/87/2024-AGRICECON

$$\begin{cases} \text{Regime 1}: A_{li} = \beta_1 \alpha_1 + \sigma_1 \lambda_{li} + \partial_j \theta_{li} + \varphi_{li} & \text{if } j = 1; p = 2, 3, 4 \\ \text{Regime P}: A_{pi} = \beta_p \alpha_{pi} + \sigma_p \lambda_{pi} + \partial_p \theta_{pi} + \varphi_{pi} & \text{if } j = p \end{cases} \quad (7)$$

where: φ_{li} – disturbance term with an expected value of zero; σ – covariance amongst (ε_{pi}) and φ_{li}; λ_{pi} – IMR calculated from predicted probabilities in Equation (6).

The IMR (λ_{ai}) is given as follows:

$$\lambda_{\alpha i} = \sum_{p \neq \alpha}^{\alpha} \rho_{\alpha} \left[\!\left[\frac{\rho_{ip} 1n(\hat{P}_{ip})}{1 - P_{ip}} + 1n\left(\hat{P}_{\alpha i}\right) \right]\!\right] \quad (8)$$

where: correlation between (ε_{pi}) and φ_{li} – ρ; *P* – farmers productivity indicator.

The zero value of the error terms is predicted. The Inverse Mills Ratio regressor, λ_{ait}, has a high likelihood of heteroscedasticity, as was indicated by the use of bootstrap standard errors. Teklewold et al. (2013) advise adding selection instruments to the choice model (Equation 6), which is created automatically by the non-linearity of the selection model, in order to obtain accurate estimates of β_p. In order to determine the selection equation, this study employed three instrumental variables: interactions with extension agents (yes = 1), participation in farmers associations (yes = 1), and access to credit (yes = 1). It is presumable that the instrumental factors included directly affect the adoption of CCASs, but that CCASs adoption is the primary way to influence the outcome indicators.

Average treatment effects (ATT). The average treatment effect (ATT) on the treated was calculated using the multinomial endogenous switching regression (MESR) by comparing the anticipated values of the outcomes of the treated (adopters) and untreated (non-adopters) in real (actual) and unreal (counterfactual) situations. The change in the outcome variable of interest that can be solely attributable to the adoption of CCASs is known as the ATT. The restrictive expectations for the productivity variables in both the actual and their counterfactual setups are defined as follows by Khonje et al. (2015).

Adopters with adoption (actual):

$$E(A_{pi} | U = p, \alpha_{pi}, \theta_{pi}, \lambda_{\alpha i}) = \beta_p \alpha_{ji} + \partial_p \theta_{pi} + \sigma_p \lambda_{\alpha i} \quad (9)$$

Adopters had they decided not to adopt (counterfactuals):

$$E(A_{li} | U = p, \alpha_{pi}, \theta_{pi}, \lambda_{\alpha i}) = \beta_1 \alpha_{ji} + \partial_1 \theta_{pi} + \sigma_1 \lambda_{\alpha i} \quad (10)$$

If the coefficients on the features of adopters (α_{pi}; θ_{pi}; $\lambda_{\alpha i}$) had been identical to the coefficients on the features of non-adopters, the adopters' outcome variable values would have been as shown in Equation (10) (Kassie et al. 2018). For the purpose of estimating ATT, the MESR estimation in Equation (8) was used to forecast the real (counterfactual) Equation (10) predicted values of productivity outcome for a farmer who adopted technology *p* and the unreal (counterfactual) Equation (9) predicted values. The difference between the two equations is given as follows:

$$\begin{aligned} ATT &= E(A_{pi} | U = p, \alpha_{pi}, \theta_{pi}, \lambda_{\alpha i}) - E(A_{li} | U = p, \alpha_{pi}, \theta_{pi}, \lambda_{\alpha i}) = \\ &= \alpha_{pi}(\beta_p - \beta_1) + \theta_{pi}(\beta_p - \beta_1) + \lambda_{\alpha i}(\sigma_p - \sigma_1) \end{aligned} \quad (11)$$

The first term (α_{pi}), in Equation (11) right side will represent the predicted change in the average outcome variable assuming adopters and non-adopters shared identical characteristics. On the right-hand side of Equation (11), the third term ($\lambda_{\alpha i}$) and the Mundlak method (θ_{pi}), account for selection bias and endogeneity resulting from unobserved heterogeneity.

RESULTS AND DISSCUSION

The result in Table 2 reveals the average years of education of household heads as 14.39 years which indicates that they are literate and thus can read and write. About 58% of the respondents were male indicating that men are more involved in maize production in the region surveyed. Also, the average age of household head (HH) is found to be 48.32 years revealing that the smallholder maize farmers were in their active years. Majority (58%) of the respondents were members of cooperative societies. This shows that they might have access to farm inputs and other useful information like climate information that will help them improve their maize production. They tend also to enjoy group dynamism. About 27% had access to climate information while 41% had access to extension agents. About 52% assessed credit facilities which is a necessary determinant of the adoption of adaptation strategies (Kolapo and Kolapo 2023). About 62% adopted cropland management, only 24% used water management, 73% implemented land restoration strategy, 59% used seed selection and the majority (78%) used fertility management. We observed from the result that the implementation of fertility management is much more adapted. This might be attributed to the fact that the use of fertiliser for fertility management is a common practice among maize farmers in Nigeria.

https://doi.org/10.17221/87/2024-AGRICECON

Table 3. Indicator loadings of constructs

Indicator	Attitudes	Intensions	PBC	Subjective norms
ATT1	0.78	0.41	0.39	0.18
ATT2	0.83	0.35	0.38	0.27
ATT3	0.75	0.26	0.18	0.33
ATT4	0.71	0.38	0.27	0.16
INT1	0.46	0.88	0.36	0.26
INT2	0.38	0.88	0.36	0.37
INT3	0.36	0.89	0.28	0.46
BPC1	0.18	0.36	0.65	0.53
BPC2	0.17	0.28	0.69	0.35
BPC3	0.14	0.19	0.66	0.25
SN1	0.31	0.38	0.27	0.59
SN2	0.26	0.17	0.32	0.60
SN3	0.35	0.18	0.37	0.63
SN4	0.18	0.29	0.19	0.60

ATT – persons attitude; INT – persons intention; BPC – behavioural perceived control; PBC – perceived behavioural control; SN – subjective norms
Source: Authors' computation

PLS-SEM analysis

Psycho-cognitive factors affecting smallholder farmers' climate change adaptation behaviour. In PLS-SEM analysis, the first step always involves assessing the reliability and validity of the identified key latent variables and indicators. The results of our diagnostic test indicate that all the indicators we used were reliably high in individual indicators which reveal they loaded high in their constructs (Table 3). We presented the result of Cronbach's alpha, composite reliability and the average variance extracted in Table 4 for each of the four constructs.

Results in Table 4 indicate that the alternative measure of internal consistency and reliability i.e. Cronbach's alpha and composite reliability revealed a high internal consistency among the four constructs. According to Gliem and Gliem (2003), the closer their values to l, the greater the internal consistency of the indicators in the constructs. In addition, the average variance extracted also shows a high convergent validity. We also carried out the Fornell–Larcker Criterion test which state that discriminant validity is achieved when the square root of average variance extracted is greater than its inter-construct correlations (Fornell and Larcker 1981). The result of the Fornell–Larcker Criterion presented in Table 5 reveal that discriminant validity was well established across all constructs.

From our analysis, next step involved examining the path coefficients and test theoretical relationship which was shown in Figure 2. The result of the inner model path coefficients indicate that attitude has the strongest effect on farmers' intention to implement climate change adaptation strategies (0.62) followed by perceived behavioural control (0.31) and then subjective norm (0.11).

Furthermore, we used Bootstrapping method to test the significance of both the indicators and structural model constructs to obtain *t*-statistics. Our significant value was set to be larger than 1.96. The result of the structural path significance test was presented in Table 6. We observed that the relationship between attitude and intention, perceived behavioural control and intension and the relationship between subjective norm were all significant at 1% level of probability. This thus indicate that attitude, perceived behavioural

Table 4. Cronbach's alpha, composite reliability and the average extracted variance

Construct	Cronbach's alpha	Composite reliability	Average extracted variance
Attitudes	0.77	0.83	0.66
Intentions	0.89	0.92	0.82
Subjective norms	0.61	0.75	0.57
PBC	0.67	0.74	0.52

PBC – perceived behavioural control
Source: Authors' computation

https://doi.org/10.17221/87/2024-AGRICECON

Table 5. Fornell–Larcker Criterion analysis for discriminant validity

Constructs	Attitudes	Intentions	PBC	Subjective norms
Attitudes	0.77*	–	–	–
Intentions	0.38	0.89*	–	–
Perceive behavioural control	0.31	0.67	0.67*	–
Subjective norms	0.26	0.32	0.38	0.61*

*average extracted; PBC – perceived behavioural control
Source: Authors' computation

control and subjective norm were all strong predictors of farmers intention to adopt and implement climate change adaptation strategies. This agrees with (Bandura 1977, 1982; Conner and Sparks 1996; Conner and Armitage 1998; Dang et al. 2014).

Factors influencing the adoption of number of climate change adaptation strategies (Ordered probit). We then estimated the ordered probit regression model to identify the key determinants affecting the number of climate change adaptation strategies adopted by the smallholder farmers. We used maximum likelihood to estimate the Model. The result of the likelihood ratio test [X^2 (14) = 52.829, P = 0.000)] implies that Chi-square stats were highly significant ($\underline{P}$ < 0.0001) suggesting that the model has strong explanatory power. The results of the ordered probit model are presented in Table 7.

The result in Table 7 reveals that the number of climate change adaptation strategies adopted by households increases as the age of the household head increases. As the age of the HH head increases, the probability of adopting more than two climate change adaptation strategies increases by 4.71%; the cumulative of probabilities of adopting two, three, four, and five climate change adaptation strategies (Table 7). Gender of the household head was found to significantly influence the decision of the farmers to adopt more than two climate change adaptation strategies. This implies that household headed by a male smallholder farmer has the tendencies of adoption more

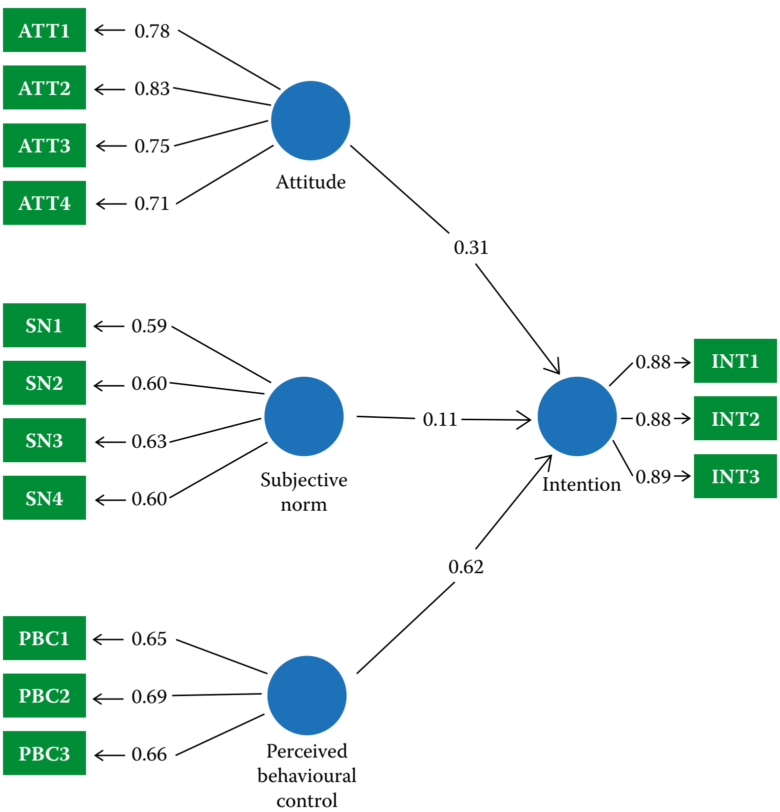

Figure 2. Indicator loadings and coefficients' path of key behavioural constructs

Source: Authors' computation

https://doi.org/10.17221/87/2024-AGRICECON

Table 6. *T*-statistics for path coefficients

Relationship	Path coefficient	*T*-statistics
Attitude effect on intention	0.62	23.46***
PBC effect on intention	0.31	15.63***
Subjective norm effect on intention	0.11	8.73***

PBC – perceived behavioural control; ***significance at 1%
Source: Authors' computation

than two climate change adaptation strategies than their female headed HH counterpart. Education status of the household head was also found to significantly impact the decision of the household head to adopt more than two climate change adaptation strategies. Thus, as household level of education increases, the probability of adoption more than two climate change adaptation strategies increases by 4.9%. This agrees with Ojo and Baiyegunhi (2018); Abdulai and Abdulai (2017); Awazi et al. (2019). As the farmers acquire more education inform of training, they tend to be more informed about adaptation practices that will improve their farm productivity. Farming experience was found to positively and significantly influence the number of climate change adaptation strategies adopted by the farmers. This might be attributed to the fact that as farmers accumulate experiences over the years, they tend to be more aware of the important strategies they could combine to adapt to the negative impact of climate change. Thus, as number of years of experience of farmers increases, the probability of the smallholder farmer adopting more than two climate change adaptation strategies increases by 11.6%.

Access to credit was positive and significantly influence the number of climate change adaptation strategies to be adopted by the farmers. According to Giller et al. (2009); Toluwase et al. (2017), One of the major impediments to the successful adoption of technologies is that they frequently necessitate large initial investments with benefits that can be realised in few seasons. Improved credit facilities will help to alleviate liquidity constraints and hence improve access to complementary technically, mechanical, and capital inputs (Deressa et al. 2009; Mutyasira et al. 2018b; Oyetunde-Usman et al. 2021; Kolapo et al. 2022; Kolapo and Kolapo 2023). Access to extension contacts was found to be positive and significantly influence the number of climate change adaptation strategies to be adopted by the farmers. As number of contacts with extension agents increases, the probability of adopting more than two climate change adaptation strategies increases by 11.3%. This is unconnected with the fact that extension agent keeps the farmers abreast of climate information and many methods to cushion the adverse impact of climate variability, hence their tendencies to adopt multiple adaptation strategies.

In our analysis, we included psycho-cognitive social factors which was found to be significant. Intention was found to be a strong predictor of the number of climate change adaptation strategies that farmers adopted on their farm. Thus, as intention of the farmer increases, the probability of the farmers adopting and implementing two or more climate change adaptation strategies increases by 67.8%. The Intention variable included in the analysis reflected farmers' attitudes toward climate change adaptation strategies and their perceived behavioural control over implementation of climate change adaptation strategies on their farm. Therefore, the broader implication of this is that if the smallholder farmers view climate change adaptation strategies to potentially improve their farm productivity and feel confident that they possess the required knowledge and resources to implement the climate change adaptation strategies on their own, then there would be strong intentions to adopt climate change adaptation strategies. This implies that changing farmers' perceptions and attitudes toward climate change adaptation strategies is central in the quest to cushion the adverse impact of climate change and promote the widespread adoption of climate change adaptation strategies. Increased awareness and on-farm demonstrations of climate change adaptation strategies and technologies should assist in this regard.

One other psycho-cognitive social factor included in our model is personal norm. This variable captured the extent to which a smallholder farmer felt the conviction and to adopt and implement climate change adaptation strategies as a farmer or community member. The results reveal that personal norms were found to positively and significantly influence the number of climate change adaptation strategies adopted by the farmers. Thus, farmers' norm increases the probability of adopting more than two climate change adaptation strategies by 19.9%.

Effect of choice of climate change adaptation strategies on farmers' productivity (MESR result). We presented the result of the MESR of the average treatment effect of adopting climate change adaptation strategies on productivity outcomes in Table 8 (maize yield and maize income) under actual and counterfactual conditions.

https://doi.org/10.17221/87/2024-AGRICECON

Table 7. Determinants of adoption of climate change adaptation strategies (ordered probit results)

			Marginal effects					
Variables	coeff.	SE	*Prob* (*Y* = 0|*x*)	*Prob* (*Y* = *l*|*x*)	*Prob* (*Y* = 2|*x*)	*Prob* (*Y* = 3|*x*)	*Prob* (*Y* = 4|*x*)	*Prob* (*Y* = 5|*x*)
Age of the HH head	0.110***	0.007	0.695**	0.282***	0.023**	0.011	0.041***	0.021
Gender	0.042***	0.007	0.353	0.045	0.026**	0.028	–0.010	0.174**
Educational status	0.282***	0.058	2.097*	0.005	0.002	–1.160	–0.750	0.440*
Income from off-farm	0.045	0.029	0.006**	0.042***	0.005	0.016	0.055**	0.096**
Farming experience	0.042***	0.007	0.931***	0.024***	0.033	0.003	0.051	0.029**
Credit access	0.610**	0.273	0.305***	0.005	1.330*	0.845**	0.006	–5.32e–07
Land size	0.282***	0.058	0.659***	0.023	0.163	0.102**	3.20e–06	6.36e-05
Climate information access	0.197	0.139	0.005	0.068***	0.015***	1.175	0.491	0.686
Extencion-services access	0.659***	0.439	0.023	1.330***	0.022	0.011***	0.042***	0.038
Cooperative membership	4.286	4.281	0.031	1.593***	1.061	0.531	0.104*	0.861***
Intention	0.045***	0.017	1.219	0.639***	0.330***	0.086	0.072	0.190
Personal norms	0.947***	0.103	0.369***	0.004	0.053	0.022	–0.040**	0.084
Cut1	0.057**	0.024	–	–	–	–	–	–
Cut3	0.931***	0.322	–	–	–	–	–	–
Cut4	0.731	0.143	–	–	–	–	–	–
Cut5	0.803***	0.152	–	–	–	–	–	–
Observations	329	–	–	–	–	–	–	–

HH – household head; SE – standard error; ***, **, *significance at 1%, 5% and 10%, respectively
Source: Authors' computation

Table 8 shows that the average effects of adopting climate change adaptation strategies on smallholder productivity (maize yield and maize income) thus accounting for selection biases originating from both observed and unobserved sources. In Table 8, column three, we found that the adoption of land restoration as a climate change adaptation strategy is highly connected with a significant increase in yields of maize. Thus, smallholder farmers who had adopted land restoration strategies would have realised lower yields had they not adopted this climate change strategy. We observed from Table 8 that farmers who adopted land restoration had the highest maize yield (908 kg/ha), followed by seed selection with a yield gain of 803 kg/ha, followed by water management (582 kg/ha), followed by crop management (513 kg/ha) and fertility management (467 kg/ha). Realising the highest yield gain by land restoration adopters indicates that there is a strong connection between restoring land and the cultivation of maize. This is expected because the production of maize benefits from agricultural activities that restore the land by reducing soil erosion,

https://doi.org/10.17221/87/2024-AGRICECON

reducing soil nutrient depletion, and conservation of soil moisture. (Arslan et al. 2014; Kassie et al. 2015; Jaleta et al. 2016; Awazi et al. 2019). In addition, the cultivation of leguminous crops alongside maize will fix the required nitrogen into the soil which help to restore the lost land nutrients.

The results of the effects of adopting climate change adaptation strategies on income realise from maize production were also presented in Table 8. It shows that the adopters on average would have earn less income from the adaptation strategies choice had they not adopted them. This implies that adoption of climate change adaptation strategies in maize production increases income of the farmers. In all, it was found that adoption of land restoration strategies has the highest income being realised from maize production having a value of USD 1.17/ha on average. This is followed by seed selection (USD 0.90/ha), water management (USD 0.82/ha), crop management (USD 0.64/ha) and lastly by fertility management (USD 0.51/ha) on average. Thus, increased yield from adoption of climate change adaptation strategies translate to increased income. This result agrees with that of Ojo and Baiyegunhi (2018), Ojo et al. (2021) that adoption of different climate change adaptation strategies increase the income of smallholder farmers in Nigeria.

CONCLUSION

The decade long adverse impact of climate change on farmers which has adversely reduced farm productivity and income of smallholder farmers who are the most affected set of people has been a source of major concern for international organisations, agencies, stakeholders and researchers. Several research studies have attempted to understand the factors impeding the adoption of climate change adaptation strategies and their continued utilisation by smallholder farmers. For long, research on climate change adaptation strategies has predominantly focused on economic drivers, with little emphasis on the psycho-cognitive social and behavioural factors affecting farmers' general attitudes toward adoption of number of climate change adaptation strategies.

In this study, we adopted a psycho-cognitive approach where we analysed how a mix of economic and psycho-cognitive social factors influenced the adoption of a set of climate change adaptation strategies by smallholder farmers in Southwestern, Nigeria. Our conclusions are as follows: we found that both economic and psycho-cognitive variables were significant predictors of the numbers of climate change adaptation strategies that are adopted by the smallholder farmers. We found that the significant economic pre-

Table 8. MESR result of the average treatment effects of adoption of climate change adaptation strategies on farmers' productivity

Outcome variables	adaptation strategies choice (j)	Adoption status: adopting (j = 1, 2, 3, 4, 5)	non-adopting (j = 0)	average treatment effects
		(1)	(2)	(3) = (1)–(2)
Maize yield (kg/ha)	CM	2 471 (37)	1 958 (93)	513***(74)
	WM	1 973 (58)	1 391 (73)	582***(49)
	LR	3 011 (99)	2 103 (48)	908***(63)
	SS	2 628 (31)	1 825 (65)	803***(47)
	FM	1 878 (41)	1 411 (82)	467***(94)
Maize income (USD/ha)	CM	1 921 (53)	1 614 (61)	307***(63)
	WM	1 815 (83)	1 423 (126)	392***(105)
	LR	1 524 (38)	962 (55)	561***(46)
	SS	1 725 (48)	1 302 (77)	432***(39)
	FM	1 026 (101)	782 (76)	244*** (93)

j – adoption of adaptation strategies presented in Table 1; ***significance at 1%, standart error in parenthesis, respectively; CM – cropland management; WM – water management; LR – land restoration; SS – seed selection; FM – fertility management; MESR – multinominal endogenous switching regression

Source: Authors' computation

https://doi.org/10.17221/87/2024-AGRICECON

dictors of adoption of climate change adaptation strategies included access to credit, farm size and access to extension contacts while non-economic variables included age, gender, educational status and farming experience. The research also found that psycho-cognitive variables such as farmers' intentions and personal norms were strong predictors of the number of climate change adaptation strategies they adopt and implement on their farms. It was equally found that adopting land restoration, a climate change adaptation strategy had the highest significant contribution to yield and income of the smallholder farmers. This study concludes that the adoption of different climate change adaptation strategies increased the maize yield and income realised by the maize farmers. This implies that the adoption of climate change adaptation strategies could improve the livelihood of the farmers and ensure they become food secure.

Policy recommendations

However, the identified climate change adaptation strategies significantly increased crop yield and income of the farmers. Collectively, these findings will be important in the promotion of climate change adaptation strategies and in tailoring current interventions to the specific needs of smallholder farmers. Furthermore, holistic and interdisciplinary approaches should form part of effective strategies for promoting climate change adaptation strategies among smallholder farmers whereby major focus will be on both economic and psycho-cognitive social factors. In addition, strategies to improve adoption rates of climate change adaptation strategies should include the provision of financial packages to help the smallholder offset initial investment they might encounter while strengthening farmers access to extension agents that provide relevant information on climate change adaptation strategies and thus help dispel common misconceptions and shorten the learning circle. More emphasis should also be placed on enhancing farmers' knowledge and education through training and seminars.

Limitations and suggestion for further studies

This study is unable to capture the dynamic relationships between the adoption of climate change adaptation strategies and productivity of the maize-based farming households since these empirical analyses are based on 1-year cross-sectional data. However, these are interesting topics for further investigation in the future once the data (multiple years data) needed are accessible. In addition, climate impacts might be different across the six regions in Nigeria, this study only focused on one region. Future studies should endeavour to cut across all the regions in Nigeria so that the differential impact of climate change on the productivity of farmers can be assessed. Future studies could also look at the dynamic relationship between the adoption of climate change adaptation strategies and farmers' productivity in Nigeria. Lastly, one of the weaknesses of the Theory of Planned Behaviour is that it does not account for the influence of past behaviour on future behaviour. Future studies should be carried out to fill this gap.

REFERENCES

Abdulai A.N., Abdulai A. (2017): Examining the impact of conservation agriculture on environmental efficiency among maize farmers in Zambia. Environment and Development Economics, 22: 177–201.

Abid M., Schneider U.A., Scheffran J. (2016): Adaptation to climate change and its impacts on food productivity and crop income: Perspectives of farmers in rural Pakistan. Journal of Rural Studies, 47: 254–266.

Adetoro A.A., Singels A., Paraskevopoulos A.L., Owusu-Sekyere E., Jordaan H., Orimoloye I.R. (2020): Alleviating water shortages by decreasing water footprint in sugarcane production: The impacts of different soil mulching and irrigation systems in South Africa. Groundwater for Sustainable Development, 11: 100464.

Ahnström J., Höckert J., Bergeå H.L., Francis C.A., Skelton P., Hallgren L. (2009): Farmers and nature conservation: What is known about attitudes, context factors and actions affecting conservation? Renewable Agriculture and Food Systems, 24: 38–47.

Aliyu K.T., Kamara A.Y., Huising E.J., Jibrin J.M., Shehu B.M., Rurinda J., Vanlauwe B. (2022): Maize nutrient yield response and requirement in the maize belt of Nigeria. Environmental Research Letters, 17: 064025.

Ajzen I. (1985): From intentions to actions: A theory of planned behaviour. In action control: From cognition to behaviour. Berlin/Heidelberg. Springer: 11–39.

Ajzen I. (1988): Attitudes, Personality, and Behaviour. Chicago. IL. Dorsey: 24–37.

Ajzen I. (1991): The theory of planned behaviour. Organisational Behaviour and Human Decision Processes, 50: 179–211.

Ajzen I. (2002): Perceived behavioural control, self-efficacy, locus of control, and the theory of planned behaviour. Journal of Applied Social Psychology, 32: 665–83.

Akano O., Modirwa S., Oluwasemire K., Oladele O. (2023): Awareness and perception of climate change by smallholder farmers in two agroecological zones of Oyo State, Southwest Nigeria. GeoJournal, 88: 39–68.

https://doi.org/10.17221/87/2024-AGRICECON

Arora N.K. (2019): Impact of climate change on agriculture production and its sustainable solutions. Environmental Sustainability, 2: 95–96.

Arslan A., McCarthy N., Lipper L., Asfaw S., Cattaneo A., (2014): Adoption and intensity of adoption of conservation farming practices in Zambia. Agriculture, Ecosystems and Environment, 187: 72–86.

Asrat P., Simane B. (2018): Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. Ecological Processes, 7: 1–13.

Awazi N.P., Tchamba M.N., Avana T.M.L. (2019): Climate change resiliency choices of small-scale farmers in Cameroon: Determinants and policy implications. Journal of Environmental Management, 250: 109560.

Bandura A. (1977): Self-efficacy: Toward a unifying theory of behavioural change. Psychological Review, 84: 191–215.

Bandura A. (1982): Self-efficacy mechanism in human agency. American Psychologist, 37: 122.

Belay A., Recha J.W., Woldeamanuel T., Morton J.F. (2017): Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agriculture & Food Security, 6: 1–13.

Bidzakin J.K, Fialor S.C, Awunyo-Vitor D., Yahaya I. (2019): Impact of contract farming on rice farm performance: Endogenous switching regression. Cogent economics and Finance, 7:1618229.

Chen K., Ali M., Veeman M., Unterschultz J., Le T. (2002): Relative importance rankings for pork attributes by Asian-origin consumers in California: Applying an ordered probit model to a choice-based sample. Journal of Agricultural and Applied Economics, 34: 67–79.

Chouinard H.H., Paterson T., Wandschneider P.R., Ohler A.M. (2008): Will farmers trade profits for stewardship? Heterogeneous motivations for farm practice selection. Land Economics, 84: 66–82.

Clayton S., Myers G. (2009): Conservation psychology: Understanding and promoting human care for nature. Environmental Conservation C Foundation for Environmental Conservation, 37: 222–225.

Conner M., Armitage C. (1998): Extending the theory of planned behaviour: A review and avenues for further research. Journal of Applied Social Psychology, 28: 1429–1464.

Conner M., Sparks P. (1996): The theory of planned behaviour and health behaviours. In Predicting Health Behaviour: Research and Practice with Social Cognition Models. Edited by Mark Conner and Paul Norman. Buckingham, Open University Press: 121–162.

Dang H.L., Li E., Nuberg I., Bruwer J. (2014): Understanding farmers' adaptation intention to climate change: A structural equation modelling study in the Mekong Delta, Vietnam. Environmental Science & Policy, 41: 11–22.

Diallo A., Donkor E., Owusu V. (2020): Climate change adaptation strategies, productivity and sustainable food security in southern Mali. Climatic Change Springer, 3: 1–12.

D'souza G., Cyphers D., Phipps T. (1993): Factors affecting the adoption of sustainable agricultural practices. Agricultural and Resource Economics Review, 22: 159–165.

Daykin A.R., Moffatt P.G. (2002): Analysing ordered responses: A review of the ordered probit model. Understanding Statistics, 1: 157–166.

Deressa T.T., Hassan R.M., Ringler C., Alemu T., Yesuf M. (2009): Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, 19: 248–255.

Etwire P.M., Koomson I., Martey E. (2022): Impact of climate change adaptation on farm productivity and household welfare. Climatic Change, 170: 11.

FAOSTAT (2020): Statistical Database. Food and Agriculture Organization of the United Nations, Rome. Available at https://www.fao.org/home/fr/ (accessed Apr 8, 2021).

Fornell C., Larcker D.F. (1981): Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18: 39.

Giller K. E., Witter E., Corbeels M., Tittonell P. (2009): Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114: 23–34.

Gliem J.A., Gliem R.R. (2003): Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education. Available at https://scholarworks.indianapolis.iu.edu/items/63734e75-1604-45b6-aed8-40dddd7036ee (accessed July 10, 2017).

Greene W.H., Hensher D.A. (2008): Modelling ordered choices: A primer and recent developments. SSRN Electronic Journal. Available at SSRN: https://ssrn.com/abstract=1213093 or http://dx.doi.org/10.2139/ssrn.1213093 (accessed June 11, 2021).

Harvey C.A, Saborio Rodríguez M., Martinez Rodríguez M.R., Viguera B., Chain Guadarrama A., Vignola R., Alpizar F. (2018): Climate change impacts and adaptation among smallholder farmers in Central America. Agriculture & Food Security, 7: 1–20.

Hair J.F., Ringle C. M., Sarstedt M. (2011): PLS-SEM: Indeed a silver bullet. The Journal of Marketing Theory and Practice, 19: 139–152.

Pörtner H.O., Roberts D.C., Tignor M.M.B., Poloczanska E.S., Mintenbeck K., Alegría A., Weyer N. (2022): Climate Change 2022: Impacts, adaptation and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change. Cambridge, Cambridge University Press. 16–31.

https://doi.org/10.17221/87/2024-AGRICECON

Jaleta M., Kassie M., Tesfaye K., Teklewold T., Jena P.R., Marenya P., Erenstein O. (2016): Resource saving and productivity enhancing impacts of crop management innovation packages in Ethiopia. Agriculture Economics, 47: 513–522.

Jellason N.P., Baines R.N., Conway J.S., Ogbaga C.C. (2019): Climate change perceptions and attitudes to smallholder adaptation in northwestern Nigerian drylands. Social Sciences, 8: 1–20.

Kassali R., Kolapo A., Ige I.O., Adebayo K.E. (2024): Analysis of consumers' preference and willingness to pay for orange-fleshed sweet potato in Osun state, Nigeria. International Journal of Agricultural Research, Innovation and Technology, 14: 53–61.

Kassie M., Zikhali P., Manjur K., Edwards S. (2009): Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia. Natural Resources Forum, 33: 189–198.

Kassie M., Marenya P., Tessema Y., Jaleta M., Zeng D., Erenstein O., Rahut D. (2018): Measuring farm and market level economic impacts of improved maize production technologies in Ethiopia: Evidence from panel data. Journal of Agricultural Economics, 69: 76–95.

Kassie M., Teklewold H., Marenya P., Jaleta M., Erenstein O. (2015): Production risks and food security under alternative technology choices in Malawi: Application of a multinomial endogenous switching regression. Journal of Agricultural Economics, 66: 640–659.

Knowler D., Bradshaw B. (2007): Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy, 32: 25–48.

Kolapo A., Kolapo A.J. (2023): Implementation of conservation agricultural practices as an effective response to mitigate climate change impact and boost crop productivity in Nigeria. Journal of Agriculture and Food Research, 12: 1–9.

Läpple D., Kelley H. (2013): Understanding the uptake of organic farming: Accounting for heterogeneities among Irish farmers. Ecological Economics, 88: 11–19.

Lin S. (2013): The gap between global issues and personal behaviours: Pro-environmental behaviours of citizens toward climate change in Kaohsiung, Taiwan. Mitigation and Adaptation Strategies for Global Change, 18: 773–783.

Lynne G.D., Shonkwiler J.S., Rola L.R. (1988): Attitudes and farmer conservation behaviour. American Journal of Agricultural Economics, 70: 12.

Mare F., Bahta Y.T., Van Niekerk W. (2018): The impact of drought on commercial livestock farmers in South Africa. Development in Practice, 28: 884–898.

Marie M., Yirga F., Haile M., Tquabo F. (2020): Farmers' choices and factors affecting adoption of climate change adaptation strategies: Evidence from northwestern Ethiopia. Heliyon, 6: 1–10.

Mutyasira V., Hoag D., Pendell D. (2018): The adoption of sustainable agricultural practices by smallholder farmers in Ethiopian highlands: An integrative approach. Cogent Food & Agriculture, 4: 1–17.

Mutyasira V., Hoag D., Pendell D., Manning D. (2018b): Is sustainable intensification possible? Evidence from Ethiopia. Sustainability, 10: 4174.

Ogunleye A.S., Kehinde A.D., Kolapo A. (2020): Effects of social capital dimensions on income of cocoa farming households in Osun state. Tanzanian Journal of Agricultural Sciences, 19: 131–137.

Ojo T.O., Baiyegunhi L.J.S., Adetoro A.A., Ogundeji A.A. (2021): Adoption of soil and water conservation technology and its effect on the productivity of smallholder rice farmers in southwest Nigeria. Heliyon, 7: e06433.

Oyetunde-Usman Z., Olagunju K.O., Ogunpaimo O.R. (2021): Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria. International Soil and Water Conservation Research, 9: 241–248.

Quinn C., Burbach M.E. (2008): Personal characteristics preceding pro-environmental behaviours that improve surface water quality. Great Plains Research (University of Nebraska Press), 18: 103–114.

Rabirou K., Kolapo A., Lasisi A.L. (2022): Competitiveness of broiler production in Nigeria: A policy analysis matrix approach. Heliyon (Elsevier), 8: e09298.

Sarstedt M., Ringle C.M., Smith D., Reams R., Hair J.F. (2014): Partial least squares structural equation modelling (PLS-SEM): A useful tool for family business researchers. Journal of Family Business Strategy, 5: 105–115.

Solis D., Bravo-Ureta B., Quiroga R. (2007): Soil conservation and technical efficiency among hillside farmers in Central America: A switching regression model. Australian Journal of Agricultural and Resource Economics, 51: 491–510.

Stern P. (2000): Toward a coherent theory of environmentally significant behaviour. The Journal of Social Issues, 56: 407–424.

Tambo J.A., Abdoulaye T. (2012): Climate change and agricultural technology adoption: The case of drought tolerant maize in rural Nigeria. Mitigation and Adaptation Strategies for Global Change, 17: 277–292.

Tatlidil F.F., Boz İ., Tatlidil H. (2009): Farmers' perception of sustainable agriculture and its determinants: A case study in Kahramanmaras province of Turkey. Environment, Development and Sustainability, 11: 1091–1106.

Teklewold H., Kassie M., Shiferaw B., Köhlin G. (2013): Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. Ecological Economics, 93: 85–93.

https://doi.org/10.17221/87/2024-AGRICECON

Teklu A., Simane B., Bezabih M. (2023): Effect of climate smart agriculture innovations on climate resilience among smallholder farmers: Empirical evidence from the choke mountain watershed of the Blue Nile Highlands of Ethiopia. Sustainability, 15: 4331.

Thinda K.T., Ogundeji A.A., Belle J.A., Ojo T.O. (2020): Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. Land Use Policy, 99: 104858.

Toluwase S.O.W., Adejumo J.A., Kolapo A. (2017): Determinants of yam minisett technology adoption among rural farmers in Ekiti State, Nigeria. Journal of Agricultural Economics, Extension and Rural Development, 5: 606–611.

Wooldridge, J.M. (2002) Econometric Analysis of Cross Section and Panel Data. Cambridge, The MIT Press, 551–644.

Wollni M., Lee D.R., Thies J.E. (2010): Conservation agriculture, organic marketing, and collective action in the Honduran hillsides. Agricultural Economics, 41: 373–384.

Wong K. (2013): Partial least squares structural equation modelling (PLS-SEM) techniques using Smart PLS. Marketing Bulletin. Available at http://www.academia.edu/download/43l89928/ Smartpls.pdf (accessed Aug 7, 2017).

Received: March 6, 2024
Accepted: February 13, 2025
Published online: April 28, 2025