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Assessment of Smallholder Rice Farmers' Adaptation Strategies to Climate Change in Kebbi State, Nigeria.

Sodipe Oluwaseun **Solaja**[abc], Ayorinde **Kolawole**[ac], Toluwalase Eniola **Awe**[bc], Opeyemi Abosede **Oriade**[ac], Wale **Ayojimi**[bc], Ibukun Elizabeth **Ojo**[bc], Gideon **Nayan**[d], Ruth Adefunke **Adedayo**[c], Stephen Otu **Etta-Oyong**[c], Faithfulness Fehintola **Olasehinde**[c], Oluwatosin Alexsandra **Asemokhai**[c], Isibietmfon Asuquo **Nsikak**[c]

[a]Landmark University SDG 2 (Zero Hunger Research Group)

[b]Landmark University SDG 13 (Climate Action Group)

[c]Department of Agricultural Economics and Extension Landmark University, Kwara State, Nigeria.

[d]Teaching and Research Farm Landmark University, Kwara State, Nigeria.

Corresponding Author: Solaja Sodipe Oluwaseun, solaja.sodipe@lmu.edu.ng

Department of Agricultural Economics and Extension Landmark University, Kwara State, Nigeria.

Abstract

The future of food production in Nigeria where smallholding agriculture is prevalent is threatened by climate change. Despite the threats, Nigeria has no specific plan or policy to combat it. Therefore, understanding how smallholder farmers adjust to the changing climate and the factors that influence their adaptation choices will facilitate developing a policy to tackle climate change. This study therefore evaluates climate change adaptation techniques among smallholder rice farmers in Kebbi state, Nigeria. The study employs a simple random sampling technique to select 345 respondents. The data was analysed using multivariate probit and ordered probit regression.

The findings revealed that marital status, literacy, farm size, farming experience, major occupation, extension visits, amount of credit, and access to climate information influenced adaptation strategy choice. Furthermore, marital status, literacy, household size, farm size, extension visits, and access to climate information are crucial drivers of adoption intensity. This study concludes that smallholder rice farmers in the study area adopt several practices to cope with climate change, however, farmers' intensity of adoption is low. This study recommends that stakeholders in the food systems in the study area should consider literacy, farm size, extension service, credits, and climate information in designing viable policies toward combating the vagaries of climate.

Keywords; Climate change; Adaptations; Intensity; Smallholder; Rice farmer; Nigeria.

Introduction

Climate change is an enormous challenge confronting humankind, impacting different regions at various levels [1]. Climate change can be described as an imbalance in the weather that typically occurs for a long period, characterized by variations in the intensity of weather elements [2-4]. Researchers around the world have noticed that the mean global temperature has risen by 0.74 degrees Celsius over the last century. If no urgent action is taken, the temperature of the planet will increase to a point that it will be practically impossible to cope with, thereby threatening the survival of countries worldwide. In the coming decades, climatic alteration is predicted to have a great effect on global food production and in turn on world food security [5, 6].

Sub-Saharan Africa is likely to experience intense drying and heating [7-9]. This is because of its geographical location, poverty, poor technological and infrastructural advancement, and over-reliance on rainfall to carry out agricultural production [10-15]. Furthermore, [7, 16, 17] opined that over 95 percent of agrarian ventures in sub-Saharan Africa are rain-dependent, which results in low food output and availability. Jones and Thornton [18] projected that crop yield in sub-Saharan Africa may plummet by 20 percent in 2050 because of climate change. According to Ayoola et al. [19] and Ifeanyi-Obi and Nnadi [20] there has been a significant drop in animal and crop production due to climatic shocks. This is worrisome as over 90 percent of the population of Africa lives in low-income countries where agriculture plays an even stronger role.

These debilitating effects of climate change are most likely felt by smallholder farmers who are dominant in rural areas and are trying to cope with climate change using their limited income and the little knowledge at their disposal [21, 22]. Nevertheless, sustained climate resilience in production is key to addressing the problem of food insecurity in developing countries [23].

Agriculture is an integral part of the Nigerian economy, and it employs about 70 percent of the nation's workforce and contributes massively to national income [24]. Nigeria’s vulnerability to climate change is pronounced by its population, which is the largest in Africa, making it rank as the 10th most susceptible nation to climate alterations [25]. Empirical evidence has proven that Nigeria is beset by several environmental issues that are climate-related [26, 27], and because agriculture employs about 70 percent of the population, adaptations to climate threats is very crucial to growth in the agricultural sector in Nigeria. As such, the country risks losing 6-30 percent of its gross domestic product by 2050 if nothing is done to control the climate-related environmental problems that beset it [28]. Fluctuations in agricultural outputs in the Nigerian agrarian sector is due to over-dependence on rainfall coupled with the dominance of smallholder farmers who cultivate between 0.1– 5.9 hectares of land utilising crude tools with archaic production techniques for their farm operations [17]. Nigeria's agricultural sector can dominate export as it was before the oil discovery; however, only about 30 percent of the agricultural potential is being realized [29, 17]. Nigeria's agricultural sector is besieged by a lot of problems ranging from underutilization of assets, infrastructural decay, and climatic shocks which are worsening the above-stated problem [17].

Climate change has been observed to impair water availability resulting in serious effects on rice production [22, 30]. Rice constitutes one of the most consumed staple foods around the globe and forms the diets of over half of the global population, especially inhabitants of Africa and Asia [31, 32]. The earth's population is predicted to attain about 10 billion and Nigeria’s population is projected to reach about 500 million by 2050 [33]. This population explosion forecast will likely increase the demand for rice and this raises a compelling duty to bring about measures to expand rice production in Nigeria in the face of climatic shocks. Rice is among Nigeria's top staple foods [17] and according to [34, 35] rice supply and demand is a pathway to economic growth and poverty reduction. Nigeria's consumption of rice is around 5 million metric tons per annum while the local production is about 2.7 million metric tons per annum. The remainder of the annual consumption is supplemented by importation, even though the country is third among rice importing nations of the world [22, 36] with about 8.2 percent share of worldwide imports [37]. There is, therefore, an imminent need to find a solution to curb the effect of climate change on rice production. The policy of the federal government [38] to increase the quantity of rice produced in Nigeria by setting up integrated rice mills has not yielded the expected result because the mills are operating below capacity [37]. This is the result of the incapacity of the local rice producers to supply paddy rice to the mills. This further suggests climate change is likely one of the problems hampering production [39, 40]. Rice production in Nigeria is faced with severe climate change events because rice is highly sensitive to climate shocks, which are responsible for low rice production in the country [23]. There is a need to assess the adaptation methods employed by rice farmers to mitigate climate change in Nigeria. This will help map out initiatives and policies geared toward fostering robust climate change adaptation in the food sector of the economy.

Climate change adaptation strategies refer to conscious responses aimed at combating the negative effects of climate change, especially in the agricultural system [4]. According to World Bank [28], farmers in Africa have implemented adaptation strategies to continue production in the face of climate change. Individual farmers adapt to climate change differently based on their ability and capability. The techniques utilized may be influenced by the farmers' skills, resource accessibility, and other socioeconomic qualities as well as their access to information and climatic forecasts [13, 22].

The negative impact of climate change on agricultural production could be reduced by adopting adaptation strategies such as alternative tillage, changing planting dates, planting drought-tolerant varieties mixed cropping, and income diversification [25, 30, 41]. Climate change effects such as drought, flooding, and erosion reduce soil fertility [22, 25]. Alternative tillage practices such as cover cropping, composting, mulching, etc. lessen climate change effects and increase soil quality and yield [21, 24]. Furthermore, many farmers have employed growing drought-tolerant plants, mixed cropping, and multiple planting dates to reduce climatic hazards and increase their ability to buffer the harsh effects of climate change [1, 30]. Given that production and income risks are spread by growing several crops, farmers' fragility is reduced, which aids the adaptation of rice farmers to climate change [1, 25]. Farmers' resilience to climate change is increased by livelihood diversification by dispersing their financial and production risks [17, 25]. The timing of rice planting and harvesting is impacted by the shifting rainfall patterns seen in sub-Saharan Africa. To manage shifting rainfall patterns, length, and distribution, farmers have turned to modifying their planting dates as an adaptation technique [1, 23, 30].

In Nigeria, extreme weather occurrences are responsible for Nigeria's low rice output; this requires climate change adaptation to maintain optimum rice production levels [23]. The research therefore fills the gap in knowledge by providing a deeper grasp of the joint adaptation strategies and the determinant of adaptation intensity of smallholder rice farmers in Kebbi state, Nigeria. It addresses the following research questions: What are farmers' adaptation techniques to climate change? What factors influence rice farmers' adoption of adaptation measures? What factors drive rice farmers' adaptation intensity? Answers to these questions will advance policies and initiatives that enable climate-adaptive farming, thus in increasing food production and security.

There is a plethora of research on climate change adaptation strategies among smallholder farmers in Nigeria, however, only a few have specifically examined smallholder rice farmers. For example, [1, 15, 17, 20, 17] considered crop farmers in their climate change adaptation study, while [22, 26] considered rice farmers in their research carried out in southwestern and southeastern states respectively but none, to the best of the authors' knowledge, have performed research on smallholder rice farmers' adaptations to climate change in northern Nigeria, especially Kebbi State, which has the largest rice producers in Nigeria. Moreover, what makes this study unique is the estimation of the intensity of adoption of climate change adaptation strategies in the study area.

Literature Review

Theoretical framework

Farm households make decisions in an attempt to maximize utility. Utility maximization theory describes how households allocate their resources to get the maximum satisfaction feasible from their production or consumption decisions, given certain constraints [42, 43]. The theory of utility maximization assumes that households make rational choices based on the information at their disposal and the constraints they face. The satisfaction or utility derived from adopting innovation is determined by the costs and revenue of embracing innovation coupled with household choices that are shaped by several variables. The theory of utility was used in this research conceptualisation of changing climate adaptation measures. The benefit of employing a strategy could increase yield as a result of minimizing the effects of climate change. A risk-averse farmer optimises their satisfaction or utility by opting for an adaptation strategy where the income that is accrued from using an adaptation outweighs the income realised without adaptation [22]. The farm household utility function is described in Eq. (1) below:

Eq. (1): $U_J = N_J - \beta\alpha_J$

where U_J is the satisfaction or utility attained from the adaptation technique j used; N_J is the non-stochastic component; β is the coefficient that accounts for the risk aversion of each farm household which affects the degree of variation in yield α_J. α_J is the stochastic term representing variations in yields of the farm households.

The coefficient β is expressed in Eq. (2) as:

Eq. (2): $\beta = \frac{\frac{du}{d\alpha_J}}{\frac{du}{d_J}}$

When β < 0 this shows that a farm household dislikes risk (risk aversion) and, hence, has more likelihood of adopting a climate change adaptation strategy, β = 0 indicates a risk-neutral household while at β > 0 suggests a farm household is willing to take risks of non-adoption of a climate change adaptation strategy.

The satisfaction or utility derived from using a climate change mitigation strategy U_J is given by the revenues accrued through the use of an adaptation strategy less the costs incurred in carrying out the strategy. A risk-averse farm household will select an adaptation method J_x that generates a greater satisfaction or utility than other J_y as shown in Eq. (3) below:

Eq. (3): E (U_{J_X}) - C_x > E (U_{J_y}) - C_y

where E (U_{J_X}) is the expected satisfaction or utility of using technique J_x and C_x is the cost of carrying out the strategy while E (U_{J_y}) is the expected satisfaction or utility of adopting measure J_y and C_y is the cost of the strategy.

Conceptual framework

This study conceptualizes the relationship between climate change and adaptation strategies based on the causal relationships among the variables shown in Figure 1 below. Climate change negatively affects agricultural production and productivity and to cushion the adverse effects of climate change on agricultural production and become resilient, farmers adopt several strategies to cope and adapt to changing climate. The type and intensity of strategies adopted by the farmers are a function of the farmers' socioeconomic characteristics and other resources at the disposal of the farmers. Strategies or measures adopted to cope and adapt to climate change will further improve farmers' production outcomes such as soil quality, productivity, yield, income, and food security.

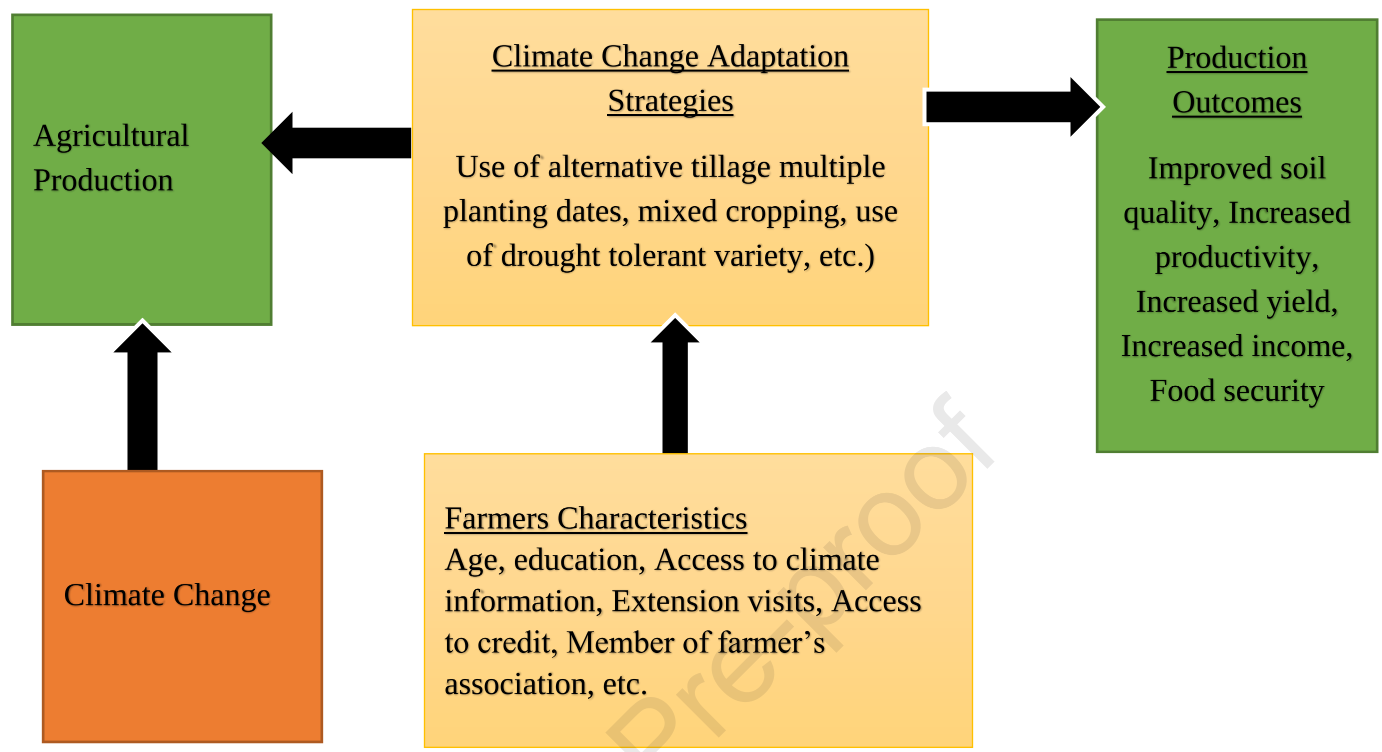

Figure 1: Conceptual framework of smallholder rice farmers' adaptations to climate change. Source: Authors' construct (September 2022).

Empirical Literature Review

The global scope of climate change adaptation to farm production research is extensive, with studies such as those by [13, 16, 21, 30, 44-57] investigating climate change adaptation strategies across diverse regions. In Nigeria specifically, [1, 15, 20, 22, 23, 25, 56, 57] have studied the determinants of climate change adaptation strategies adopted by smallholder farmers.

Notably, the impact of various factors on farmers' adoption of climate change adaptation measures differs across all the adaptation research. For instance, age, as noted by [22, 25, 30, 46, 48, 57] has a negative influence on the decision to adopt adaptation strategies. This is anticipated since younger farmers tend to be creative and innovative. They experiment with procedures and technology that would improve their capacity for adaptation and buffering. Older farmers also have less knowledge of better climate change adaptation. However, [1, 30] found a positive relationship between age and adopting climate change adaptation practices. Moreover, [49, 56] noted that age positively correlated with manure adoption, this is linked to the probability that older farmers have assessed the long-term advantages of using manure. [22, 25, 30, 45, 49, 53] observed that household size had a significantly positive influence on the choice of adaptation strategies to climate change. This is attributable to the household's capacity to provide extra family labour. In contrast, [47, 51] reported that household size negatively determines climate change adaptation practices adoption.

Ojo et al. [22] posited that farm size also positively influences the choice of adaptation strategies, probably because farmers with larger farm sizes may be able to invest in techniques for adapting to climate change. Onyeneke [25] noted that farm size has a negative significant relationship with adopting livelihood diversification. Moreover, Chete [57] posited that farm size has a negative and significant association with the probability of using disease-resistant varieties, intercropping, and planting of trees, as adaptation measures to climate change. Ojo et al. [22] and Chete [57] opined that farming experience has a significant negative influence on the choice of adaptation strategy. Experienced farmers could be inclined more to stick with tried-and-true traditional farming practices than to implement new ones. Onyeneke [25] found out that farming experience yielded a positive effect on the adoption of minimum tillage, fertilizer, nursery, and pesticide. Experienced farmers have over time acquired superior knowledge of managing climate hazards, as adaptation is a learning process.

Zakaria et al. [48] revealed that farmers' contact with research scientists significantly increased the probability of adopting early-maturity varieties, changing planting periods, bunding, and irrigation among farmers. Musafiri et al. [49] opined that there was a significant positive influence of contact with extension agents on soil water conservation and crop diversification, while animal manure was negative. Contact with extension agents plays a crucial role in providing farmers with practical knowledge about climate change adaptation measures; extension service delivery helps smallholders obtain greater insights into using agricultural technologies. Education has a positive and significant effect on adoption of climate adaptation strategies [25, 57]. Farmers with education tend to be more imaginative and experimental than farmers without education. Farmers who are educated are therefore better positioned to adopt technology that will increase climate resilience [45, 46, 49, 50]. Zakaria et al. [48] revealed that access to mass media significantly increases the probability of farmers' adoption of early-maturing varieties, drought tolerance varieties, and changing planting periods but has a significant negative effect on the probability of farmers' adoption of irrigation. Access to climate information is likely to have a positive effect on the adoption of climate adaptation options [58]. In fact, having access to information about climate change increases farmers' awareness and understanding of the issue and their propensity for adaptation.

In conclusion, while climate change adaptation strategies are crucial for smallholder farmers, their adoption is influenced by multitude of factors. Understanding the nuanced relationships between these factors and adaptation practices is essential for developing targeted and effective strategies to enhance climate resilience in agricultural systems. Researchers and policymakers must consider these diverse determinants when designing interventions to support smallholder farmers in adapting to a changing climate.

Methodology

Study Area

This research was carried out in Kebbi State, North West Nigeria. Kebbi has a total land area of 36,129 km2 and is positioned between latitudes 10°8' N and 13°15' N, as well as longitudes 3°30' E and 6°02' E. According to Usman [57], Zamfara State, Sokoto State, and a section of the Republic of Niger border the state to the north and east, Niger State to the south, and the Benin Republic to the west. Kebbi is composed of 21 Local Government Areas [57]. About 36.46% of its landmass is used for agriculture and a third of the state is a desert-prone area, making it one of the major states in Nigeria under threat of desertification and drought [58]. Kebbi State has a semi-arid climate and less than 750mm of mean annual rainfall with average yearly temperature ranging from 28 to 38 degrees Celsius [59]. It has a population of over three million and is blessed with vast agricultural land and economically viable rivers [57, 60]. The mainstay of the economy of Kebbi State is agriculture [58]. About 80 percent of the inhabitants of the state reside in rural areas, and more than 90% of those people earn their living in agriculture [61].

Research Design

The research utilises a non-experimental design which is a cross-sectional survey method because the researchers are interested in how smallholder rice farmers are adapting to climate change in the Kebbi state**.** This method measures the behaviour of farmers in response to adaptation choices adopted by the respondents in order to generalise the results across the study population (rice farmers in the study area). Data for this study was collected in 2020.

Sampling Techniques

The population of this study is smallholder rice farmers in Kebbi state, Nigeria. A list of smallholder rice farmers was obtained from the Agricultural Development Programmes' office in the state. We therefore employed a sample size determination formula, which is given as;

n = $\frac{N}{1+N(e^2)}$, where n is the sample size, N is the population size (registered rice farmers in Kebbi state (56,367) and e is the level of precision (0.05). n = $\frac{56367}{1+56367(0.05^2)}$ = 397.18. This gives us approximately 400 farmers.

A simple random sampling technique was thereafter employed to select a total of 400 smallholder rice farmers from the list. Unfortunately, on getting back from the field, some questionnaires contained incomplete information which rendered them unsuitable for analysis and were therefore excluded from the study.

Type of Data and Method of Data Collection

This study used primary data. A structured questionnaire was employed to elicit information from respondents. The authors developed the questionnaire with input from crop scientists, extensionists, and environmental economists. The experts checked how relevant the questionnaire's content was to the respondents and assessed the questions' presentation in terms of feasibility, readability, consistency in style and formatting, and the use of clear language. The data collection was done by experienced and trained enumerators in Kebbi state. Data were collected on respondents' socio-economic characteristics, climate change awareness, and adaptation strategies adopted.

Econometric Modeling

Multivariate Probit (MVP)

A multivariate probit regression was used to assess the determinant of adaptation techniques adopted by the farmers. The advantage of this model as opined by [22, 62] is that it analyses the influence of a series of covariates on each strategy adopted to minimise the impact of climate change concurrently while still accounting for correlation among unobserved factor. The association between the strategies may be complimentary, suggesting a positive correlation or substitutable, signifying a negative association between the various techniques [22, 63]. According to [64], estimating multiple adoptions of adaptation strategies without cognisance of the trade-off and cumulative interaction of adaptation strategies result in inaccurate and biased projections of the exogenous variables driving adoption options. This will further lead to wrong policy interventions as univariate regression will not account for complementary and substitutability features of the adoption of the adaptation measures [45, 64]. Smallholders may adopt more than one strategy because they are not mutually exclusive when faced with climate shocks [22]. Following [26, 46 - 49] the multivariate probit model can be represented as follows:

$let\ U_x$ indicate the utility of adoption of j^{it}strategy and U_y otherwise. Rice farmers can adopt the j^{it}measure if y_{ij} = U_x- U_0 > 0. Consequently, the net utility y_{ij}^* a rice farmer practicing j^{it}strategy is a predictive hidden variable and the error term (ε_i) which is distributed normally, this is represented in Eq. (4).

Eq. (4): $y_{ij}^* = \alpha_j x_i + \varepsilon_i$

where x_i is a vector of explanatory factors, y_{ij}^* represents a set of adaptation measures, while α_j is the vector coefficient, and ε_i is the error term. Following utility maximization theory, farmers could use any strategy if the anticipated utility (satisfaction) is greater than non-adopting. This is shown as a clear binary choice for each of the mitigation strategies embraced by the rice farmers, this is represented in Eq. (5) as:

Eq. (5): $y_{ij}^* = \begin{bmatrix} 1 \text{ if } y_{ij}^* \\ 0 \quad \text{otherwise} \end{bmatrix}$

Where j's are a set of adaptation strategies, which ranges from j_1 to j_6

j_1 = land fragmentation

j_2 = Use of alternative tillage

j_3 = multiple planting dates

j_4 = mixed cropping

j_5 = planting drought tolerant

j_6 = diversifying household income.

Where y_{ij}^* is a binate visible factor for using a jth method by the ith respondent. Since the use of these practices can occur simultaneously, the error term can be written as a matrix of variance-covariance as shown in Eq. (6)

Eq. (6):
$$\Pi = \begin{bmatrix} 1 & \delta j_1 j_2 & \delta j_1 j_3 & \delta j_1 j_4 & \delta j_1 j_5 & \delta j_1 j_6 \\ \delta j_2 j_1 & 1 & \delta j_2 j_3 & \delta j_2 j_4 & \delta j_2 j_5 & \delta j_2 j_6 \\ \delta j_3 j_1 & \delta j_3 j_2 & 1 & \delta j_3 j_4 & \delta j_3 j_5 & \delta j_3 j_6 \\ \delta j_4 j_1 & \delta j_4 j_2 & \delta j_4 j_3 & 1 & \delta j_4 j_5 & \delta j_4 j_6 \\ \delta j_5 j_1 & \delta j_5 j_2 & \delta j_5 j_3 & \delta j_5 j_4 & 1 & \delta j_5 j_6 \\ \delta j_6 j_1 & \delta j_6 j_2 & \delta j_6 j_3 & \delta j_6 j_4 & \delta j_6 j_1 & 1 \end{bmatrix}$$

Where δ is a paired association between any two strategies the sign of δ shows the direction of the association. A positive sign implies complements while a negative sign signifies substitutes.

Ordered Probit Model

The Ordered Probit was used to estimate the drivers of the intensity of response to climate variability. The dependent variable can take values of 0, 1, 2, 3, 4, or 6 which depend on whether a farmer utilized any climate change adaptation strategies. The MVP model described above is incapable of distinguishing how many adaptation strategies rice farmers employ. When farmers embrace numerous adaptation strategies, it is difficult to ascertain a cutoff line between adopters and nonadopters when analyzing the intensity of adaptation strategies usage among farmers [65]. Because the usage of adaptation techniques is a count parameter, a Poisson regression model would have been appropriate. However, it posits that each possibility has an equal chance of being adopted. This assumption is untrue in this study because the possibility of embracing any of the adaptation methods have varied probability [26, 45, 49, 50] which seems to be due to farmers' awareness of adaptation strategies [26]. However, rice farmers integrate several adaptation strategies to maximize utility over those who use one or no technique [47]. Adoption intensity was treated as an ordered parameter that might be estimated with the ordered regression. The ordered estimates range from 0 to 1, 2, 3, 4, 5, and 6. The ordered result could be termed a latent factor Y*, where Y* denotes a non-observable metric of rice farmers' adaptation strategies adoption intensity [43,50, 62] as described in Eq. (7).

Eq. (7). $y_i^* = x_j\alpha + \varepsilon_i$

$\varepsilon_i \sim N(0, 1)$

$where\ y_i^*$ are ordered as 1, 2, 3, 5, and 6 which represent the intensity of adoption of strategy as explained by x_j, together with a normally distributed disturbance term ε_i .

The likelihood of observing outcome j is explained by Eq. (8)

Eq. (8). Pr (outcome i=j) = Pr (mj-1 < $x_j\alpha + \varepsilon_i \leq \mu_j$

The coefficient $\alpha_1, \alpha_2, \ldots.. \alpha_j$-1, were jointly analysed with the cut-off values $\mu_1, \mu_2 \ldots... \mu_j$ where j is the number of possibilities. The pooled ordered probit assumes that latent heterogeneity is uncorrelated with the covariates [49].

Result and Discussions

Smallholder Rice Farmers' Descriptive Statistics

The socioeconomic profile of rice farmers is presented in Table 1. The result shows that the age of the respondents ranges from 29 to 80 years. The mean age is 51 years which indicates that majority of rice farmers in Kebbi State are still within the economically active age bracket which is between 15 - 64 [66] but are beyond the youthful age which according to [67] are people within the 18-35 age bracket. This suggests that fewer youths participate in rice farming in the state. Additionally, most of the farmers (95%) are married with an average family size of about 10 members. This indicates that family labour is readily available to the farmers. Furthermore, the sampled farmers (75%) have at least six years of primary education which means they are literate, thus implying that most smallholder rice farmers in Kebbi State understand and use new agricultural inventions [52].

The farmers have an average farm size of 1.55 hectares which suggests that rice farming in Kebbi State is practised on a small scale. Rice farmers have a wealth of rice farming experience (21.36 years) which implies that they have been in rice production for an ample time and can provide accurate responses on rice farming. The primary income source of many of the farmers (81%) is farming and most of them (95 percent) belong to farmers' associations where they share information on rice production. The mean of extension visits per production cycle stood at 5.39 which indicates that farmers have access to extension services. Moreover, 48 percent have access to climate information which can be improved upon to increase farmers' response to climate change. The mean amount of credit received by the farmers is about ₦80,000. This implies that rice farmers in Kebbi State have access to credit for improving production.

Table 1. Smallholder Rice Farmers' Descriptive Statistics

Variable	**Description**	**Mean**	**Standard Deviation**
Age	Age of the farmers in years	51.11	8.54
Marital status	1 if the farmer is married and 0 otherwise		
Household size	Number of persons in the household	10.32	5.32
Education status	1 if the farmer is educated and 0 otherwise		
Farm size	Total farm size in hectares	1.55	1.11
Farming experience	Years of farming experience	21.36	11.82
Major occupation	1 if the major occupation is farming and 0 otherwise		
Membership in farmers' association	1 if the farmer belongs to a farmers' association and 0 otherwise		
Number of extension visits	Number of extension visitation in the growing season	5.39	3.43
Access to climate information	1 if the farmer has access to climate information and 0 otherwise		
Amount of credit received	Amount of credit received in (₦)	79509.25	106526

Source: Author's analysis (2022)

Smallholder Rice Farmers' Climate Change Adaptation Practices

Table 2 below shows the smallholder rice farmers adoption rate. The adoption level of individual strategy ranged from 19 percent for diversification of income to 79 percent for multiple planting dates. Many of the farmers practise multiple planting dates to suit the present distribution and pattern of rainfall which is erratic. Farmers claimed that the length of the growing seasons had decreased considerably. According to [1], farmers in Sub-Saharan Africa now routinely employ this technique to manage the unpredictable nature of rainfall in the region. This finding implies that adaptation strategies vary among rice farmers in Kebbi State, Nigeria. The result agrees with [49, 68] who found a wide range of adoption rates of climate change adaptation measures in their study.

Table 2. Smallholder Rice's Climate Change Adaptation Practices

Climate change adaptation practices	Description	Mean	Standard Deviation
Land fragmentation	1 if the farmer adopted and 0 otherwise	0.47	0.50
Use of alternative tillage	1 if the farmer adopted and 0 otherwise	0.59	0.49
Multiple planting dates	1 if the farmer adopted and 0 otherwise	0.79	0.41
Mixed cropping	1 if the farmer adopted and 0 otherwise	0.49	0.50
Plng drought tolerant	1 if the farmer adopted and 0 otherwise	0.29	0.46
Diversifying household income	1 if the farmer adopted and 0 otherwise	0.19	0.39

Source: Author’s analysis (2022)

The Intensity of Adoption of Climate Change Adaptation Practices

The adoption intensity of adaptation techniques ranges from zero to six as presented in Table 3. The analysis reveals that about 3 percent of the farmers do not employ any of the methods while almost 97 percent utilize at least one adaptation measure. The finding is confirmed by [48, 52, 69] who found a high prevalence of uptake of at least one adaptation measure among farmers in their research. However, adoption and intensity vary greatly across the specific adaptation activities and across farm households. About 30 percent adopt just one of the strategies while less than 5 percent adopt five of the six practices. This could be because the farmers are smallholders and the effect of their small farm size on adaptation strategies adoption is dependent on the fixed costs inherent in the strategies adopted. According to [22], farm size has a positive influence on the adoption of adaptation strategies since small farms have high fixed costs and are more likely not to implement joint adaptation strategies. This result further proves that farmers' intensity of adoption is low and there is room for improved intensity of use of climate change adaptation methods among farmers. This result is consistent with [49] who opined that despite policymakers and researchers advocating greater adoption to minimise the influence of climate change on agricultural productivity, the intensity of climate change adaptation strategies adoption remains low.

Table 3. The Intensity of Adoption of Climate Change Adaptation Practices

Number of climate change adaptation practices	Frequency	Percentage
0	11	3.19
1	102	29.57
2	70	20.29
3	26	7.54
4	74	21.45
5	16	4.64
6	46	13.33
Total	345	100.00

Source: Author's analysis (2022)

Factors that Determine Smallholder Rice Farmers' Adoption of Climate Change Adaptation Measures

Factors that determined the simultaneous adoption of adaptation techniques were assessed as depicted in Table 4. The Wald chi2 of 367.22 and Prob > chi2 at 0.000 was significant, this justifies the use and acceptability of multivariate probit analysis.

Land fragmentation

Land fragmentation is a situation where a single farmer owns more than one spatially separate plot which is usually a small size(s). This decreases crop loss in the face of climatic shock because it offers a greater variety of plant growth environments [70, 71]. Farm size and farming experience are negatively related to the adoption of land fragmentation as shown in Table 4 below. This implies that farmers with large farm sizes and high farming experience are less likely to use land fragmentation as a mitigation strategy to climatic shocks. This may be because experienced farmers have gained a better knowledge and understanding of climate change adaptation over time and would rather adopt positive adaptation strategies than use land fragmentation as a cure for climate risk. According to [25], experienced farmers have a vast understanding of adjusting rice production to climatic threats since adaptation is a learning process. Furthermore, farmers with bigger farmlands would explore resilient practices.

Moreover, climate information access is negative and significant at 10 percent which suggests that farmers that have access to climate information have a greater probability of not adopting land fragmentation. However, major occupation and literacy level have a positive relationship with land fragmentation. This means that respondents that rice farming is their main occupation as well as farmers who can read and write have a higher chance of adopting land fragmentation as a measure to cope with climate risks.

Alternative tillage practice

Major occupation, extension visits, and amount of credit received have a positive relationship with the use of alternative tillage, it follows that farmers whose major occupation is rice farming have a higher likelihood of adopting alternative tillage practices likewise the more the extension visits and credit amount received, the higher the probability of adopting alternative tillage practices. Farmers whose major occupation is farming are likely to adopt alternative tillage practices because they have more time to face their farm operations and prepare materials for alternative tillage compared to their counterparts who have divided time and attention. After all, they have alternative occupations. The amount of credit received by farmers aids the acquisition of inputs and resources needed to practice alternative tillage. This result is supported by [57] who opined that access to credit is positively related to the adoption of the range of adaptation approaches. They argued that reliable credit empowers smallholders to utilize climate change adaptation methods. Adoption of adaptation strategies invariably involves committing financial resources to purchase inputs. On the other hand, inadequate funds constrain the use of adaptation options available to the farmer. Moreover, access to extension service provides hands-on knowledge exchange between the farmers and the extension officers.

Farming experience and marital status negatively influenced the adoption of the use of alternative tillage among sampled rice farmers in the study area. This insinuates that the more the farming experience of the farmers, the lower the adoption of alternative tillage practices. This could be attributed to the fact that farmers' year of experience is likely related to their age, and older people find it difficult to adopt new technology as it involves taking risks [72]. The marital status of the rice farming household was found to negatively impact the adoption of the use of alternative tillage. This suggests that married farmers are less likely to adopt the use of alternative tillage compared to their unmarried counterparts since married household heads do not have enough resources required to practice alternative tillage due to family responsibilities. This is in line with the findings of [73] who opined that marital status negatively impacts the adoption of alternative tillage and irrigation.

Multiple planting dates

Farmers adopt multiple planting dates due to the irregularities in weather conditions. The result shows that farm size, farming experience, extension contacts, and credit amount are positive and significant with the adoption of multiple planting dates. This implies that the more the farm size, the greater the possibility of practising multiple planting dates. Likewise, the higher the experience of farmers, the more they are likely to engage in multiple planting dates. Farmers with large farm sizes are likely to adopt multiple planting dates to guide against the impact of climate change because of the large expanse at their disposal. They have enough land area to experiment with different planting dates unlike farmers who have a meagre area of land. The amount of credit available to farmers also positively influences the adoption of the use of multiple planting dates. This implies that the more the amount of credit available to rice farmers, the higher the probability of engaging in multiple planting dates practice. Farmers with sufficient credit have the financial strength to purchase necessary inputs that will enable them to engage in the practice on time. However, membership association negatively influences the farmers' engagement in multiple planting dates. This implies that farmers who are not members of farmers' associations are more inclined to practice multiple planting methods, unlike their counterparts. This could be due to the time required to carry out multiple planting dates activities which might not be available to farmers who are members of the farmers' association because of the time spent on association activities.

Planting of drought tolerant varieties

Extension contact, amount of credit received, and access to climate information have a positive and significant relationship with the adoption of drought tolerant varieties by rice farmers. This means that an increase in extension contact leads to greater adoption of drought tolerant varieties. Extension workers in Nigeria are knowledgeable about climate change, therefore incorporate climate information into training and equally distribute materials such as drought tolerant varieties to farmers to fight the changing climate. Farmers in turn leverage on this information and materials provided by extension service to minimise the effect of climate change. According to [22, 30], agricultural extension service boost farmer's adoption of innovation to combat climate change.

The higher the credit available to rice farmers, the higher the probability of planting drought tolerant rice varieties because farmers with sufficient credit will have the financial strength to acquire this variety. Credit is crucial in this situation because it costs money to buy this drought tolerant variety. Farmers typically have limited financial resources and may not have enough money to purchase this particular type of seeds. According to [69], credit has a positive influence on the adoption of planting of drought resistant tolerance rice seed.

Access to climate information increases the use of adaptation options because it heightens farmers' awareness of climate risks and raises the likelihood of adaptation. Previous research has also demonstrated that farmers who have information engage more in adaptation. Information exposes farmers to better management techniques and technology and equips them to respond to climate threats. This finding is corroborated by [57, 74], who concluded that information reinforces climate change mindset and triggers the adoption of new adaptation technologies to deal with it. However, the use of drought tolerant rice varieties among farmers is negatively and significantly influenced by marital status and major occupation. This shows that farmers who have rice farming as their main occupation and are married are less likely to adopt drought tolerant rice varieties.

Mixed cropping practices

Adoption of mixed cropping practices is positively influenced by literacy and credit amount, this implies that adoption of mixed cropping practices increases with credit amount, and also literate farmers have more chance of adopting mixed cropping as a mitigation strategy to climate shock. Literate farmers are equipped with basic intelligence to appraise various options and make informed innovation choices. Chete [57], Tasie et al [75] corroborate this finding in their studies in Nigeria. Literate farmers tend to be more creative and adventurous than illiterate farmers. As a result, literate farmers are better positioned to adopt technology that will increase climate resilience. This outcome emphasizes the significance of education in the adoption of climate change adaptation strategies. Farmers with credit access are empowered to engage in mixed cropping as a practice to cope with climate shock. This result agrees with [76] who indicate that credit access enhances farmers' ability to adopt mixed cropping practices. Marital status, farm size, and major occupation are factors that negatively influence the use of mixed cropping strategy. This follows that unmarried farmers with small farm sizes are less likely to practice mixed cropping which might be a result of the labour required to carry out mixed cropping activities that may not be available to unmarried farmers.

Diversifying household income

Extension contact has a positive relationship with the adoption of diversification of household income. This portends that the more the extension visits, the more the likelihood of the farmers diversifying household income. This result is consistent with [47] who believed that farmers who had access to extension had higher odds of diversifying their household income. Although diversification of household income mitigates the impact of climate change-induced crop failures on the household, it erodes the time that is required for implementing climate adaptation measures. Additionally, the amount of credit received has a positive relationship with household diversification of income which suggests that the more credit a household has access to, the more the probability of diversification of household income.

Table 4: The Determining Factors of Smallholder Rice Farmers' Adoption of Climate Change Adaptation Strategies

Variable	Multivariate estimates					
	Land fragmentation Coeff. (S.E)	Alternative tillage practices Coeff. (S.E)	Multiple planting dates Coeff. (S.E)	Drought tolerant Coeff. (S.E)	Mixed cropping Coeff. (S.E)	Diversifying household income Coeff. (S.E)
Age	0.015588 (0.011578)	-0.0136 (0.011754)	-0.01263 (0.011536)	0.007803 (0.013027)	-0.00838 (0.011337)	0.012401 (0.014324)
Marital status	-0.55825 (0.361783)	-0.91409** (0.425266)	-0.67089 (0.416572)	-0.77327** (0.327626)	-1.58926*** (0.572151)	-0.35043 (0.386803)
Literacy	0.872421*** (0.187647)	0.180831 (0.185068)	0.223452 (0.176519)	0.010526 (0.184465)	0.333697** (0.167013)	0.225944 (0.197679)
Farm size	-0.3145*** (0.091368)	0.040478 (0.084998)	0.347045** (0.14495)	-0.00465 (0.069085)	-0.18599* (0.095312)	-0.07582 (0.08402)
Farming experience	-0.03034*** (0.009047)	-0.02243*** (0.009485)	0.033542*** (0.009686)	-0.01364 (0.011042)	0.004192 (0.00944)	-0.01574 (0.012095)
Major occupation	0.479697*** (0.231488)	0.923082*** (0.253831)	0.372924 (0.261639)	-0.76537*** (0.22328)	-0.66953*** (0.228256)	-0.03162 (0.223915)
Extension visits	-0.02147 (0.033285)	0.151311*** (0.037993)	0.065939*** (0.039584)	0.067059** (0.032832)	0.012642 (0.030163)	0.090936*** (0.034314)
Farmers association	1.319427 (0.374692)	-0.64317 (0.415076)	-1.81999*** (0.560071)	0.135473 (0.317074)	0.24094 (0.304622	0.570394 (0.463592)
Amount of credit	0.069064 (0.196042)	3.41E-06*** (1.24E-06)	2.34E-06* (1.30E-06)	2.96E-06*** (1.09E-06)	2.30E-06** (1.04E-06)	2.71E-06*** (1.06E-06)
Access to Climate information	-1.36717** (0.699328)	-0.0368 (0.195753)	0.094541 (0.188276)	0.515004*** (0.18223)	0.237119 (0.163799)	0.245921 (0.198346)
Cons	-1.36717* (0.699328)	1.021336 (0.7604584)	1.684275* (0.873759)	-0.35925 (0.667359)	1.910129** (0.830125)	-2.2888*** (0.830615)

Number of observations = 345   Wald chi2 = 367.22   Prob > chi2=0.000
Log likelihood = -717.56802

Source: Author’s analysis (2022)

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Drivers of Climate Change Adaptation Strategy Adoption Intensity

Rice farmers in the study area adopted multiple climate change adaptation practices. However, the intensity of adoption ranges from 1 to 6 from sampled rice farmers in Kebbi State, Nigeria. The intensity of adoption was assessed with ordered probit following [46, 47], the result is presented in Table 5. The Wald Chi-square is 104.73 and significant at 1 percent, implying that the predictor variables in the ordered probit regression collectively predict adoption decisions of climate change adaptation strategies. Therefore, the null hypothesis that the joint test of all slope coefficients is zero is rejected. The analysis reveals that marital status, household size, education, farm size extension, and access to climate information are the major determinants of the adoption intensity of climate mitigation strategies.

Marital status is negative and significant at 5 percent which means that unmarried farmers are likely to adopt more climate change adaptation practices than their married counterparts which might be a result of unmarried farmers having less responsibilities and more time to prepare the materials needed for adaptation to climate change. However, the household size is positive and significant at 10 percent, indicating that rice farmers with larger household sizes have a higher chance of embracing more climate change adaptation techniques. The number of people in a household has a favorable and significant impact on the adoption intensity of climate change adaptation as household members are sometimes used as labour on the farm. Labour is important to adopting adaptation strategies, and farm family members typically provide this labour. This result agrees with the finding of [53] who claimed that the probability of intensity of adoption of climate change adaptation techniques is higher with farmers that have larger households. However, [55] believed that the probability of adopting more climate change adaptation practices is expected to diminish if the number of household members to support grows due to low per capita income. Low income limits the possibility of investing in adaptation methods.

Education is significant at 5% and it is positively related to the intensity of climate change adaptation methods. This implies that educated rice farmers have a higher probability of using more climate mitigation practices which might be a result of the level of awareness and knowledge of climate change. Education could also motivate farmers to adjust and reduce the adverse impacts of the climate threat [54]. This result conforms with [53-55] who confirmed that educated farmers are likely to have a higher intensity of adoption of climate change adaptation strategies than uneducated ones. Farm size is negatively related to the intensity of adoption of climate change adaptation measures and is significant at 10 percent. This indicates that the higher the farm size, the less likely the farmer will adopt more climate change adaptation practices. This may be due to the tedious nature of administering the adaptation practices and the high cost involved in the adoption of more practices on larger hectares of land. Farmers who have large farm sizes may be unable to bear the cost of adopting climate change adaptation practices. This result supports the findings of [48, 54]. Zakaria et al. [48] opined that the marginal effect of adopting climate smart agricultural technologies declines by 5% when the size of the farm is raised by one acre. The farmers interviewed in their study confirmed that they could not adopt climate change adaptation technologies owing to the high expense of adoption. They would rather raise the size of their farm to increase overall output instead of increasing yield/acre. However, the result negates the findings of [46, 49, 53, 54] whose results show that farmers with larger plots are more likely to adopt more climate change adaptation strategies. Luu [55] argued that farmers with large production sizes are more financially capable and so, have a higher adoption intensity.

Extension visits positively predict the intensity of adoption of climate change adaptation practices and it is significant at 1%. This follows that farmers with more extension visits are likely to have a higher intensity of adoption of climate change adaptation strategies. This may be due to the training and demonstration received from extension officers which boost rice farmers' level of knowledge of climate change and mitigation measures. This result agrees with [46, 53-56] who affirm that extension service has a crucial role in increasing the intensity of climate change adaptations. Access to climatic information is positively related to the adoption intensity of climate change adaptation strategies and it is significant at 10%. The implication is that farmers who have access to climate information have a higher probability of adopting more climate mitigation practices. The result agrees with [48, 49, 54] who believe that farmers who have access to information regarding climate change adopt more climate change adaptation measures than their counterparts who do not have access to information.

Table 5: Intensity of Adoption of Climate Change Adaptation Strategies

Variable	Coefficient	Standard error	P-value
Age	-.0096211	.0092463	0.298
Marital status	-.6189055**	.2725318	0.023
Household size	.0245064*	.0141381	0.083
Literacy	.2683017**	.1371626	0.050
Farm size	-.1033912*	.0555474	0.063
Farming experience	-.0005563	0068572	0.935
Major occupation	.1083735	.1911134	0.571
Number of extension visits	.0724061***	.0255306	0.005
Farmers association	.0062656	.2636766	0.981
Amount of credit	1.26e-06	8.42e-07	0.136
Access to climate information	.3286954**	.1461702	0.025
Number of observations = 345	LR chi2(11) = 83.03		Prob > chi2 = 0.0000
Log likelihood = -555.29757	Pseudo R2 = 0.0696		

Source: Author's analysis (2022)
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Conclusion and Policy Recommendation

The study assessed the drivers of climate change adaptation strategies and the intensity of the use of mitigation methods among smallholder rice farmers in Kebbi State, Nigeria. The result of the analysis showed that multiple planting dates is the most used while income diversification is the least adopted adaptation measure. The result of the adoption intensity suggests that about 30 percent of the farmers adopted at least one of the adaptation strategies. The determinants of the adoption of climate change adaptation show that literacy, extension visits, credits, and information have the likelihood of boosting the adoption of climate mitigation strategies. The intensity of adoption reveals that household size, literacy or education, extension visits, and information have the probability of increasing the intensity of adoption.

This study concludes that farmers adopt several practices to cope with climate change in Kebbi State, Nigeria. However, farmers' intensity of adoption is low and there is room for improved intensity of use of climate change adaptation methods among farmers.

This study, therefore, recommends that policymakers and players in the food system in Nigeria, Kebbi State in particular, should formulate policies that will be all-inclusive of the factors (literacy, extension visits amount of credit received, and access to climate information) that increase adaptation and intensity of adaptation to climate threats. Taking cognisance of these factors in farm policy formulation will help smallholder rice farmers in Nigeria, especially in Kebbi state, adapt to the burden of climate risks and reduce low productivity and food insecurity in Nigeria.

Limitations of the Study

Although this research is among the few that provide empirical evidence on climate adaptation strategies among smallholder rice farmers in Kebbi State, Nigeria, it has the following limitations. First, the sample is not representative of all smallholder rice farmers in Nigeria, thus, generalization is limited to Kebbi State. Secondly, this research utilizes a cross-sectional design rather than a longitudinal design which establishes relationships over a period of time. Despite these limitations, this study provides insight into the factors that influence the adoption of climate adaptation measures among smallholder rice farmers in Kebbi State, Nigeria. It therefore conveys findings that are relevant to policy formulation on climate change adaptation strategies. Future research on climate adaptation strategies in Nigeria should consider drawing respondents from all the major rice producing states in Nigeria. This will produce a national representative sample allowing generalization of results across Nigeria. This will inform how best to formulate a national policy to address climate change challenges among rice farmers in Nigeria.

Data availability

Data available on request

Ethical approval

Participation in this research was voluntary. Before the questionnaire was administered, participants' verbal consent was obtained. Participants declined to give written consent due to cultural, literacy and education reasons, therefore, only verbal consent was collected. Additionally, participants permitted sharing of their anonymized information/data

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The authors declared no conflicts of interest.

CRediT authorship contribution statement

Sodipe Oluwaseun **Solaja**: conceptualization, methodology, data analysis and interpretation, supervision, writing original draft and review. Ayorinde **Kolawole**; supervision, data organisation, investigation, writing review, editing, and assisting with logistics. Toluwalase Eniola **Awe**: data organisation, methodology, data analysis, writing the original draft. Opeyemi Abosede **Oriade**: data collection, organisation, and writing original draft. Wale **Ayojimi**; Supervising; writing reviews, editing, and assisting with logistics. Ibukun Elizabeth **Ojo**; data collection/organization, and writing the original draft. Gideon **Nayan** data collection/organisation and assisted with logistics. Ruth **Adedayo** data collection/organisation and assisted with logistics. Isibiet **Nsikak**; data collection/organisation and assisted with logistics. Faithfulness **Olasehinde**; data collection/organisation and assisted with logistics. Oluwatosin **Asemokhai**; data collection/organisation and assisted with logistics. Stephen Otu **Etta-Oyong;** data collection/organisation and assisted with logistics.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: