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Does Adoption of Climate Change Adaptation Strategy Improve Food Security? A Case of Rice Farmers in Ogun State, Nigeria

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Abstract: The southwestern part of Nigeria, particularly Ogun State, is more vulnerable to the vagaries of climate change due to the high dependence on rain-fed agriculture and limited capacities to respond to climate change. In this study, factors influencing climate change adaptation strategies and its impacts on household food security of smallholder rice farmers in Ogun State were estimated. A multistage sampling technique was employed to select 120 smallholder rice farmers in the study area. The factors influencing the adoption of climate change adaptation practices and their impacts on household food security among smallholder rice farmers in Ogun State were examined using a probit model and an endogenous switching probit model (ESPM). According to the results of household dietary diversity score (HDDS), adopters of climate change adaptation techniques have higher levels of food security than non-adopters. The outcome of the ESPM shows that access to market information, access to extension agents, gender, off-farm income, and membership in cooperatives all contribute to the variations in food security experienced by both adopters and non-adopters of climate change adaptation strategies. A unit increase in adoption of climate change adaptation measures will increase household food security by about 3 units while decreasing severity in food insecurity by about 3.2 units. Therefore, it is recommended that policies that would support smallholder farmers' decisions to embrace measures for coping with climate change should be encouraged in order to stimulate their adaptive capacity. Additionally, in order to secure the inclusive sustainability of the agricultural sector, stakeholders and NGOs must collaborate with each other to enhance the circumstances under which farmers may receive climate change information, timely agricultural loans, and policy incentives.

Keywords: rice; HDDS; climate change; adaptation strategies; ESPM; AIPW

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1. Introduction

The primary staple crop and the source of half the calories for nearly 50% of the world's population is rice (*Oryza sativa L.*). The global demand for rice is anticipated to increase by 28% by 2050 [1]. However, global rice production is stagnated by 35% in all rice-growing regions [1,2]. Rice production in African nations, especially Nigeria, relies largely on the natural weather conditions of the locality. Vagaries in the climatic condition of Nigeria are evident in increased desert encroachment and extreme droughts in the Northern region [2] and the problem of persistent flood and erosion occurrence in the Southern region. Climate change is a significant global phenomenon that poses a threat to the sustainability of the environment and all facets of human development, making it a matter of urgent political and social concern. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) confirms and affirms the idea that global economic, social, and environmental hazards are significantly increased by climate change and variability [3]. Climate variability and changes have been linked to erosion, increased flooding, environmental degradation [3], and decreases in agricultural productivity [3,4].

Due to limited food production, constrained land, and limited resources, frequent and extreme weather events resulting from climate change are expected to have effects on the welfare and food security status of both rural and urban populations [4]. In addition to a number of other factors, inadequate storage, improved agricultural facilities, and adverse natural conditions like erosion and flooding contribute to increased food insecurity among farm households [3,5]. Even though food security involves food and its production, trade, and nutrition, as well as how people and nations sustain access to food across time in the face of various challenges, the interconnections between food security and climate change are intricate [6]. The relationships between climate change and the other aspects of food security, such as access, availability, stability, and utilization, have not yet been well explored, despite the recent focus on the potential significant impact of climate change on food production.

Food security depends not only on the availability of food but also its nutritional quality. Several factors which contribute to food security must be thoroughly examined, and action plans need to be targeted at ensuring that these factors are well considered in designing a sustainable food security framework. Other factors include increased population growth, a heavier reliance on imported food [4], and fewer household incomes required for food purchases necessary to achieve food security [1]. Understanding the reasons for the low rice growth and output as a result of climate change is vital. Khanal et al. [3] claim that the substantial decline in rice output because of rising temperatures has exacerbated the nation's already severe food insecurity. The ability of the world to provide and distribute rice is necessary for the food security of more than half of the world's population [4]. In accordance with the 2020 global food security index, Nigeria's food insecurity status is considered serious in the severity chart [6].

The Federal Ministry of Agriculture of Nigeria in 2014 estimated that 65% of the population is food insecure despite having more than half of all employments dependent on agriculture [5]. Rice distribution is influenced by distance between farms and markets and by transportation infrastructure and systems. Changes in land and water resources caused by increases in temperature, rising seas, and expected altered rainfall patterns and distribution as a result of global climate change may have a considerable impact on the productivity of rice crops grown around the world [6,7]. The level of short-term climatic variability is anticipated to increase globally. This worsens the situation of food insecurity, and the future is anticipated to see an increase in the areas that are sensitive to high climate variability [7]. Droughts and floods are the principal causes of short-term fluctuations of food production in semi-arid and sub-humid areas of the world.

The challenges, such as climate variability, faced by smallholder farmers in Africa, including Nigeria, have contributed to the low productivity of farmers due to the inefficient combination of inputs. The average yield of rice in Nigeria is 1.6 mt/ha, which is sharply low, compared with other rice-producing countries such as Egypt (9.8 mt/ha), the USA (7 mt/ha), Senegal (4.10 mt/ha), Benin (4.07 mt/ha), Vietnam (4 mt/ha), Japan (4 mt/ha), Mali (3.36 mt/ha), and Ghana (2.71 mt/ha) [7]. Ogun State in Nigeria is one of the major rice-producing states in the nation with heavy reliance on rain-fed agriculture. This is evident as some areas in Lagos and Ogun States were said to have experienced an uncommon rainfall with thunderstorms in the early days of 2021, drawing attention to the fact that these regions record the highest number of industries in Nigeria. The challenge of climate unpredictability makes subsistence farming difficult [8]. Empirical studies have shown that the leading cause of environmental disruptions is the continuously rising CO_2 levels from emitting biomass, concrete production, and desertification, which are the major causes of CO_2.

In a bid to reduce the negative effect of climate change and variability, farmers use climate change adaptation strategies as management practices to improve household food security. Some of the most widely used adaptation options include altering cropping timing or location, improving pest, disease, and weed management practices through expanded use of integrated pest and pathogen management, improved varieties, and improving water management through the use of water harvest technologies and soil and water conservation [7]. However, the ability of smallholder farmers to adapt to climate change may be influenced by their access to information, knowledge, resources (including funding), and social networks [7]. The farmers' individual experiences and access to more accurate weather forecasts are other factors affecting climate change adaptation. Additionally, while accurate weather predictions can benefit households, inaccurate forecasts can potentially hurt small farmers [9,10]. The regulatory and institutional context, as well as the socio-economic standing of the farmer's household, determines the capacity to respond to climate forecasts and the benefits received from their utilization [11–13].

Adeagbo et al. [14] and Oduniyi et al. [15] observe the issues that made it difficult for farmers to adapt to climate change [16]. The main challenges are institutional factors and credit access [16,17]. Farmers adopting more climate change adaptation practices had higher food security levels compared to the non-adopters [18–20]. In a similar study, Gebrehiwot and van der Veen [21] examined the food security package program which Tigray regional state launched as a climate adaptation measure; it was revealed that the program significantly increased household food calorie intake.

According to Ojo and Baiyegunhi [13], the adoption of climate change adaptation practices in the southwestern part of Nigeria has positive and significant impacts on rice productivity. Similarly, Adeagbo et al. [14] examine factors influencing the extent to which the techniques for adapting to climate change were used in the southwestern area of Nigeria. The study does not, however, take into account the persistent problems with food insecurity in the area. As a result of this, the purpose of this study is to estimate the factors that influence the adoption of climate change adaptation strategies, as well as to assess the impact of adoption of adaptation strategies on the food security of smallholder rice farmers in Ogun State.

2. Research Methodology

2.1. Study Area

There are a number of Local Government Areas (LGAs) in Ogun State of Nigeria, which are research areas producing rice. Ogun State, one of Nigeria's 36 states, was established on 3 January 1976 and is situated in the South-West Geopolitical Zone (6.9980° N, 3.4737° E). It shares borders with the Republic of Benin to the west, Lagos State to the south, Oyo and Osun States to the north, Ondo State to the east, and Lagos State to the east. Figure 1 shows a map of Ogun State that highlights the local government areas (LGAs) that produce rice. The State's capital and largest city is Abeokuta. Other well-known towns and cities in Ogun State include Ijebu Ode, Sagamu, Ijebu Igbo, Ilaro Ayetoro, and Ota. According to the figures that are currently available, there are roughly 3 million people residing in the rural parts of Ogun State, where the majority of agricultural operations are conducted. About 360,000 people live in farming families, making up an average family of 5 people. Ogun State has 1,204,000 hectares of arable land in total, or roughly 74% of the state's total land area. Approximately 350,000 hectares of the total arable land mentioned above are now under cultivation, making up 29.07% of the total arable land area. The primary types of vegetation are derived savanna, swamp forest, and rain forest.

The wet season which starts in March and lasts until November is immediately followed by the dry season, which starts from December to February. The weather and climate normally follow this tropical pattern. The yearly average rainfall in the state's northern region ranges from 105 cm to 128 cm (in the southern areas of the state). The principal products grown in the state are therefore not surprising, including cashew, cassava, citrus species, cocoa, yam, coco-yam, cotton, kola nut, maize, oil palm, pineapple, rice, rubber, sugar cane, and vegetables. These are the main sources of reliable foods and of raw materials for food production companies [22]. According to Figure 1, eight of Ogun State's twenty LGAs, or 40% of them, are involved in rice farming. Some of these LGAs are Abeokuta North, Egbado North, Ewekoro, Ifo, Ijebu-North, Ikenne, Obafemi Owode, and Ogun Waterside.

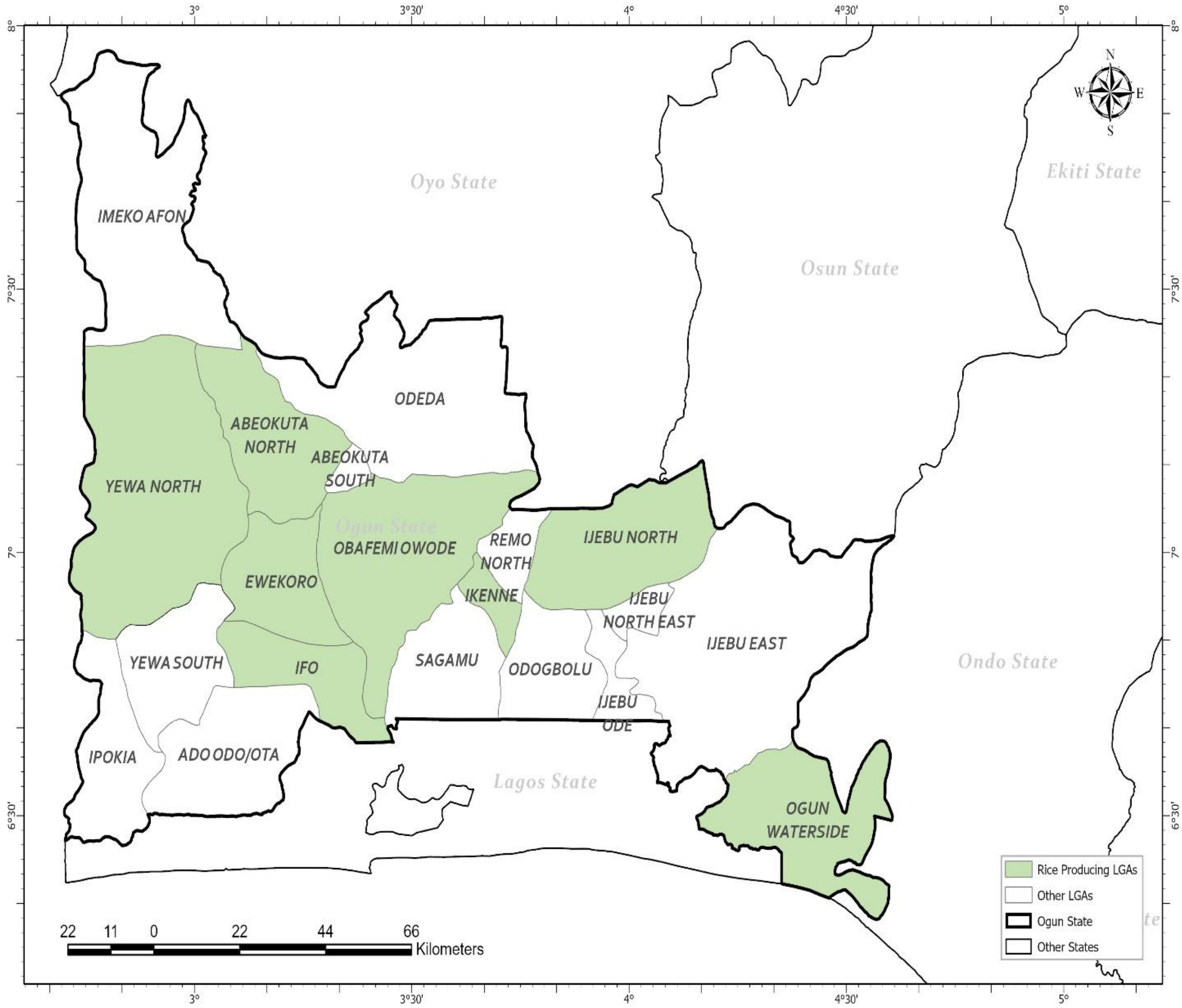

Figure 1. The map showing rice producing local government areas in Ogun State.

For data collection, a multistage sampling technique was employed. In the first stage, four Local government areas (LGAs) were selected based on their agricultural production. They include: Obafemi Owode, Ifo, Ijebu North, and Yewa North. This specific criterion was used because of the purpose of this study, which is to study the determinants of climate change adaptation strategy adoption on food security. In the second stage, six villages per LGA were selected based on the predominance of rice production. In the last stage, five farmers per village were selected for interviews. A total of 120 respondents were interviewed and used for the analysis.

2.2. Conceptual Framework

Households make decisions to optimize their desired satisfaction. The predicted costs and advantages of adopting a technology, as well as household choices that are influenced by numerous factors determine household utility. This study conceptualizes the adoption of climate change adaptation methods using the theory of utility satisfaction.

The improvement in food security (with an underlying reduction in the impact of climate change), may result from adopting a strategy. Benefiting from the adoption of climate change adaptation measures is a random utility framework [13,23]. $AdoptAdapstr_i^*$ indicates the change between the utility derived from adopters of climate change adaptation strategies and $AdoptAdapstr_{0i}^*$, derived for the non-adopters such that a household i will benefit from climate change adaptation strategies if $AdoptAdapstr_i^* = AdoptAdapstr1_i^* - AdoptAdapstr_{i0}^* > 0$. Although this difference cannot be observed, a latent variable model can express it as follows:

$$AdoptAdapstr_i^* = \alpha F_i + \varepsilon_i > 0 \; with \; AdoptAdapstr = 1 \; if \; AdoptAdapstr_i^* > 0, \quad (1)$$

where $AdoptAdapstr_i$ = 1 if a smallholder farmer adopts climate change adaptation strategies and $AdoptAdapstr_i$ = 0 otherwise; F_i refers to a vector of variables that may influence adoption of adaptation strategies; α is a vector of estimated parameters; and ε_i is an error term that is hypothesized to have a normal distribution with a mean of zero.

Since households' adoption capacity is non-random, if adopters have systematically different features than non-adopters, ordinary least square (OLS) regression would be biased in estimating the impact of adaptation approaches on food security. Those with managerial characteristics, such as stronger individual skills, ability, and drive, may have better access to climate knowledge than households with inadequate networks, which are more likely to not adapt. Such unobservable variables may influence both the adoption of adaptation methods and the state of food security, which results in inaccurate estimations of the impact of adaptation strategy adoption on household food security. In this situation, taking potential selection bias into consideration is necessary for a viable model of analysis. While controlling endogeneity, assessing the effect of implementing climate change adaption techniques on household food security:

$$FS_i^* = \beta H_i + \lambda AdoptAdapstr_i + \Psi_i \; with \; FS_i = 1 \; if \; FS_i^* > 0 \quad (2)$$

where FS_i^* is a latent variable that represents household food security for household i, which gives the value of 1, and 0 otherwise; H_i is a vector of observable characteristics that are assumed to influence household food security; FS_i^* is an indicator representing the farmer's binary choice of adaptation strategies; β_1 and λ are parameters to be estimated; and Ψ_i is a random error.

Impact of Adoption of Climate Change Adaptation Strategies on Household Food Security

This study used endogenous switching probit regression to estimate the effect of climate change adaptation techniques on household food security. This has two stages. In the initial stage, factors affecting smallholder farmers' adoption of adaptive techniques were modeled. In the second stage, a probit model was used to estimate the connection between adopting a climate change adaptation strategy and a collection of explanatory factors that are dependent on household food security. The model specification is written as Equations (3) and (4) in accordance with [13,24,25]:

$$FS_{1i}^* = \beta_1 H_{1i} + \psi_{1i} \; with \; FS_{1i} = \begin{cases} 1 & if \; FS_{1i}^* > 0, FS_{1i}^* \leq 0 \\ 0 & \end{cases} \quad (3)$$

$$FS_{0i}^* = \beta_0 H_{0i} + \psi_{1i} \; with \; FS_{0i} = \begin{cases} 1 & if \; FS_{0i}^* > 0, FS_{0i}^* \leq 0 \\ 0 & \end{cases} \quad (4)$$

where FS_{1i}^* and FS_{0i}^* are two food security status variables for adopters and non- adopters of adaptation strategies, respectively; FS_{1i} and FS_{0i} are observed adoption choices, which take the value of 1 if food secure and food insecure and 0 otherwise; H_i is a vector of socio-demographic and institutional factors that affect the level of food security; β_1 and β_0 are the estimated parameters; and ψ_{1i} and ψ_{0i} are two error terms that, respectively, represent unobservable aspects linked to the food security of both those who adopt and those who do not adopt climate change adaptation measures. The full information maximum likelihood (FIML) approach simultaneously estimates the outcome Equations (3) and (4) and the selection Equation (2) [13,26].

3. Results and Discussion

3.1. The Sociodemographic Characteristics of Smallholder Rice Farmers in Ogun State, Nigeria

This section describes the dependent and explanatory variables used in the model estimations. Table 1 presents the sociodemographic characteristics of smallholder rice farmers in Ogun State, Nigeria.

Table 1. Definitions and summary statistics of variables used in the model.

Variables	*Description of Variables*	*Mean*	*Std. Dev.*
Outcome variables			
Food security	*1 = food secure, 0 = food insecure*	0.42	
Adopters of climate change adaptation strategies	*1 = adopter, 0 = non-adopter*	0.60	
Independent variables			
Age of the household head	*Age of HH head (years)*	43.51	11.40
Gender	*1 if HH head is male, 0 if female*	0.80	
Household's Marital status	*1 if married, 0 if unmarried*	0.89	
Level of educational	*Years of education of HH head*	5.99	4.67
Experience in farming	*Years of household experience in farming*	18.54	8.94
Number in the Household	*Number of household (Number)*	7.192	2.30
Plot size	*Farm size (Ha)*	7.62	4.92
Primary activity	*1 if farming is the primary activity, 0 otherwise*	0.89	
Access to extension	*1 if HH has access to extension, 0 otherwise*	0.78	
Non-farm income	*1 = if HH engages in any off-farm activity*	0.52	
Access to credit	*1 if HH has access to credit, 0 otherwise*	0.66	
Access to cooperative	*1 if HH has cooperative, 0 otherwise*	0.68	
Access to information	*1 if HH has access to information, 0 otherwise*	0.48	
Access to market	*1 if HH has access to market, 0 otherwise*	0.80	
Access to government funding	*1 if HH has access to government funding, 0 otherwise*	0.18	

Age is a significant factor in agricultural output because it affects the family head's level of farming experience [27]. The mean age of the sampled household heads is 43 years old. As depicted in Table 1, the average life expectancy in Nigeria is 51.9 years, this indicates that the respondents are still within the productive age. This complements the study of Musemwa et al. [28], who opined that the older the household head, the more sustainable the household economy, since the older people have a comparatively richer experience in the social and physical environment, as well as greater farming experience. According to the gender analysis, men make up 80% of the house heads. This suggests that rice production in the study area is male dominated. The result also shows that roughly 90% of household heads are married. This shows that if farmers have sufficient responsibilities, they would be committed to the solutions for adapting with climate change, which eventually alleviates their food insecurity situation. Pierotti [29] alludes to these findings by stating that married households benefit from having partners who can work and help them in agricultural operations.

The results show that respondents spent an average of 14 years in school. This is in line with the Nigerian Universal Basic Education Programme's recommendation for a minimum of nine years of basic education. Within the research areas, some households claimed to have one primary source of income (89%), while others claimed to have many sources of income (52%). Zhang [30] claims that rural households turn to various income sources to improve their household income, and those rural communities can diversify their revenue. Credit was available to about 66% of the smallholder rice producers, which is a key factor in the decision to adapt. The ease of access to information, however, varied noticeably. For instance, around 48% of farmers who used at least one technique had access to climate-change-related information. This shows that there is a relationship between access to information and level of education. Those with basic education (9 years) may not respond to information awareness in the same way as people who are more educated. Hence, inability to have access to information could be consciously and unconsciously driven due to the level of exposure to education.

3.2. Climate Change Adaptation Strategies Used by Rice Farmers

Table 2 represents the distribution of the adaptation strategy used by the rice farmers. It is observed that about 22.50% of the farmers adopted soil and water conservation as a climate change adaptation strategy; 0.83% were involved in mulching and sales of crops; 2.50% engaged to livestock rearing; 5.83% of the farmers adopted mixed cropping; 1.67% were involved in no adaptation; 13.33% engaged the use of agrochemicals; 27.50% of the farmers adopted use of improved varieties; and 25.50% engaged in varying the planting and harvesting. This implies that the three most prevailing adopted adaptation strategies available in the study area are: the use of improved varieties, varying the planting and harvesting, and soil and water conservation.

Table 2. Distribution of climate change adaptation strategies.

Adaptation Strategies	Frequency	Percent
Soil and water conversation	27	22.50
Mulching	1	0.83
Livestock rearing	3	2.50
Mixed cropping	7	5.83
No adaptation	2	1.67
Sales of crops	1	0.83
Use of agrochemicals	16	13.33
Use of improved varieties	33	27.50
Varying the planting and harvesting	30	25.00
Total	**120**	**100.00**

3.3. The Distribution of Household Food Security Status by Adoption of Climate Change Adaptation Strategies

The HDDS score was categorised as food secure and food insecure. According to the findings shown in Figure 2, adopters of climate change adaptation strategies were more food secure compared to non-adopters. About 72% of the adopters had reliable access to food varieties, whereas 28% did not. When compared to households that did not adopt climate change adaptation strategies, about 34.45% of those households are food secure, while 65.55 are food insecure. The implications of these findings suggest that the adopters of climate change adaptation strategies have distinct advantages over the non-adopters. Therefore, compared to smallholders who did not implement adaptation techniques, the adopters were in a better position in terms of their level of food security. This is consistent with the study of Ogundeji [20], who found a positive influence of climate change adoption on household food security in South Africa.

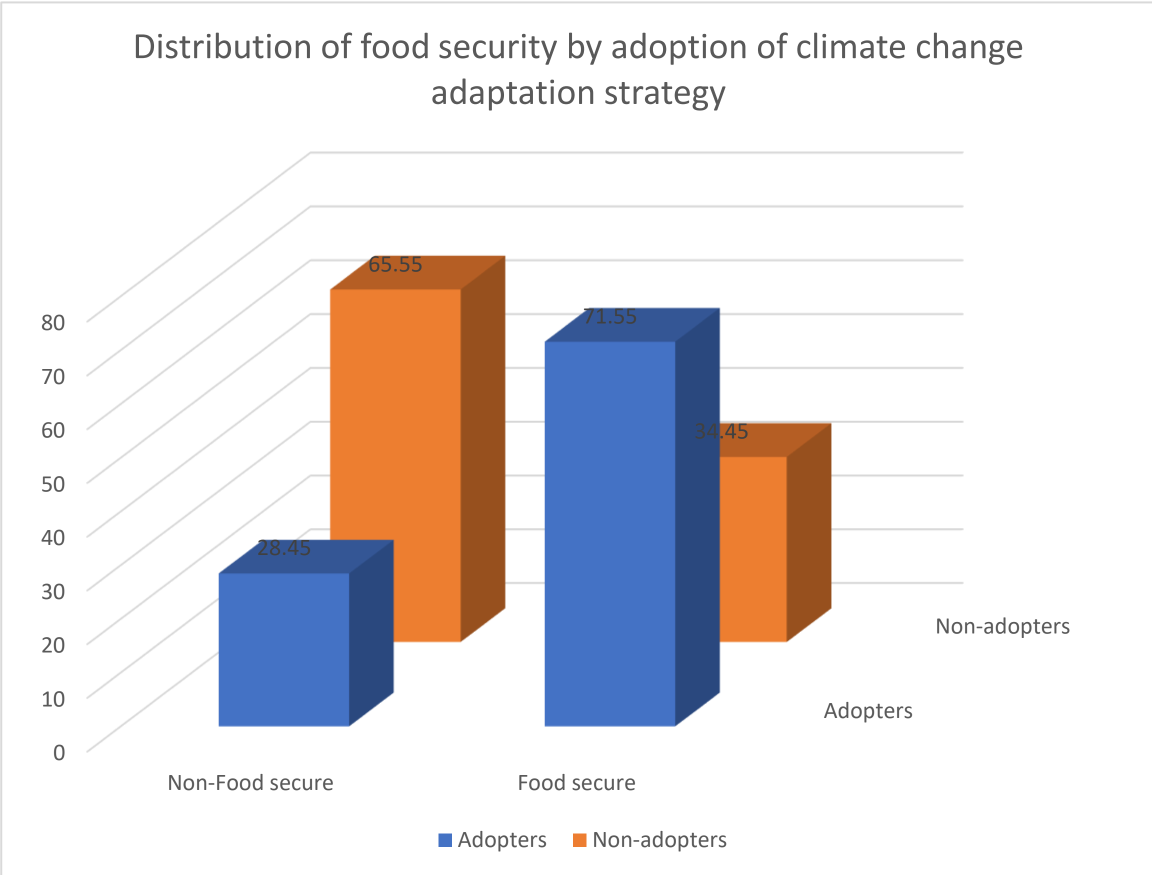

Figure 2. Household food security status in relation to adoption of climate change adaptation strategies.

3.4. Factors Determining the Adoption of Climate Change Adaptation Strategies

The result of the factors determining the rice farmers' probability of adopting climate change adaptation strategies in the study area is presented in Table 3.

According to the probit results, the primary activity of the household had a positive coefficient and was statistically significant in influencing the adoption of adaptation measures to climate change. As shown in the results of the marginal analysis, adoption of climate change adaptation strategies rises by about 11% for every unit increase in farmers' involvement in farming activities. This shows that the higher the involvement of rice farmers in farming activity, the higher the propensity to adopt climate change adaptation strategies in the study areas.

The coefficient of gender of household head indicates a positive and significant impact on the likelihood of rice farmers to adopt climate change adaptation techniques. Interestingly, the results show the tendency of a male-headed households to adopt adaptation strategies. This is evident in the result of marginal analysis where the probability of adopting increases by 26% the heads of households are men. This implies that a male-headed household is likely to increase the adoption of an adaptation strategy. This is because male household farmers have access to farmland and participate more in farming activities as compared to their female counterparts. This is supported by Ojo and Bayegunhi [13,24], who examined the impact of the adoption of climate change on rice productivity in Southwestern Nigeria and Danso-Abbeam et al. [31] on gender differentials in cocoa production. According to their findings, gender differences between families with male and female heads are more prominent at mid-levels of output.

Table 3. Factors influencing the adoption of climate change adaptation strategies—Probit model.

Adoption of CCAS	*Coef.*	*St.Err.*	*Dydx*	*St.Err.*
Primary activity	*0.314 ****	*0.160*	*0.106 ****	*0.052*
Gender	*0.768 ***	*0.362*	*0.260 ***	*0.116*
Age of the respondent	*0.036 ***	*0.015*	*0.012 ****	*0.005*
Years of farming experience	*−0.062*	*0.037*	*−0.021 ***	*0.012*
Access to information	*−0.226*	*0.307*	*−0.076*	*0.104*
Access to market	*0.262*	*0.314*	*0.089*	*0.105*
Off-farm activity	*0.278 **	*0.159*	*0.094 ****	*0.052*
Highest level of education	*0.250 **	*0.128*	*0.085*	*0.041*
Membership in cooperative	*0.510 **	*0.293*	*0.173*	*0.096*
Access to extension	*0.273*	*0.299*	*0.093*	*0.100*
Access to climate information	*0.032*	*0.036*	*0.110*	*0.120*
Constant	*−0.295*	*1.230*		
Pseudo r-squared	*0.115*			
Chi-square	*18.351*			
Akaike crit. (AIC)	*165.32*			
Prob > chi2	*0.074*			
Bayesian crit. (BIC)	*198.67*			
Mean VIF	*1.638*			
Breuschâ€ "Pagan/Cookâ€" Weisberg test for heteroskedasticity (H_0)	*0.114*			

***, **, and * represent significance level at 1%, 5%, and 10%, respectively.

The findings show that cooperative membership had a positive coefficient and statistically significant impact on rice farmers' likelihood of implementing adaption strategies to climate change. The positive and significant impact of membership in a cooperative on the adoption of adaptation strategies indicates how such informal gatherings may support farmers who lack a direct connection to agricultural experts (such as agricultural extensionists) and who even have a limited understanding of cutting-edge farming techniques. Informal interactions and social networks may make it easier to receive support and guidance from other farmers. This finding is consistent with the works of Aryal et al. [32] and Mahmood et al. [33] that show farmers' interactions had a positive and significant impact on their capacity to reduce the risks associated with climate change.

The results show that the age of the respondents had a positive and significant impact on rice farmers. Age is a proxy for agricultural experience, suggesting that older farmers with more experience are more aware of the significance of climate change adaptation. Younger farmers with less agricultural experience, on the other hand, have little or no awareness of climate change and are consequently less likely to explore implementing climate change solutions. The marginal analysis shows that a unit increase in the household head's age results in a 1.2% rise in the adoption of the climate change adaptation strategies. This suggests that older farmers, as opposed to their younger colleagues, are more likely to enhance the adoption of climate change adaptation techniques. This is consistent with a study by Oduniyi et al. [15], who also found a connection between respondents' ages and sustainable land management techniques used in South Africa.

The length of time a farmer has been farming indicates how much experience he or she has. Subsequent to the rice farmers' decisions to adopt measures for coping with climate change, the coefficient of years of experience is statistically significant and negatively signed. For rice farmers in the study area, every additional year of agricultural experience reduces their propensity to use adaptive measures by 2.1%. The reasonable inference might be drawn from the fact that farmers with a lot of experience are typically risk-averse to adopt a new technology that demands more technical expertise and capital intensive. This result is consistent with research by Adeagbo et al. [14] and Ogundeji [20], which shows that the tendency to use techniques of coping with climate change declines as agricultural experience grows. This is contrary to the studies of Thinda et al. [19] and Ojo et al. [13], which indicate that agricultural experience has a significant positive impact on adopting a climate change adaptation approach.

The acceptance of the adaptation option by smallholder rice farmers in the research area was significantly influenced by the coefficient of off-farm income, which was statistically positive. According to the marginal analysis, there is a 9.4% chance that farmers will employ more climate change adaptation measures for every unit rise in their off-farm income. This shows that in order to increase income and establish sustainable livelihoods, smallholder farmers are urged to devote greater effort to non-farm activities to offset the effect of climate change-induced losses. These findings are in line with those of some studies that found that off-farm income had a positive influence on climate change adaption because of the income effect [34,35]. This finding, however, conflicts with the study of Shahzad and Abdulai [36], which claim that the lost labor effect outweighs the income effect and has a negative impact on the adoption process. Diiro [37] posited that farmers without off-farm income use all the family labor that is readily available intensively to implement various farm management practices. They also adopt adaptation strategies in order to achieve the maximum yield of a particular crop, which is in contrast with the findings of the present study.

Understanding the dangers of climate change, making wise plans, and finally adapting critically depend on the level of education. Farmers that have received education want to explore their options and strive to stay current on advancements. Years spent in school had a positive and significant effect on adaptive capabilities. The marginal analysis shows that an increase of one unit in the number of years spent in school leads to an increase of 8.5% in the use of climate change adaptation strategies. This implies that a farmer who has a higher level of education is more likely to plan and carry out an adaptation to mitigate the negative effect of climate change. This is not unexpected because farmers with a higher level of education are more likely to have better access to information on climate change adaptation strategies. This finding is consistent with a study by Ojo et al. [13], which found that education is crucial for smallholder farmers in South Africa to adopt adaptation techniques. Similar findings were reported by Aryal et al. [32], who made a compelling case for the importance of farmers' education in changing their behavior and coming up with effective adaptation techniques for climatic hazards. Education can also help farmers become more aware of potential hazards and shift their attention to climate-smart agriculture in response to climate change [32,33].

3.5. Impact of Climate Change Adaptation Strategies on Household Food Security: Endogenous Switching Probit Model

The result of impact of climate change adaptation strategies on household food security is as presented in Table 4.

An ESPM was used to estimate the effect of adopting climate change adaption practices on the food security status of smallholder rice producers. The model takes into account any biases that can skew the estimated parameters. The correlation coefficients, rho 1 and rho 0, of ESPM were both positive; however, they were only statistically significant for the correlation between the non-adopter of climate change adaptation strategies and food security status. Thus, self-selection occurred in the adoption of climate change adaptation strategies but might not have the same effect on adopters should they choose not to adopt. This result compliments those of Khanal et al. [3] and Ojo et al. [13]. The statistical significance of the likelihood ratio test at 1% for the joint independence of the three equations indicated that they should not be estimated separately.

Evidence has revealed that one of the key drivers of adopting climate change adaptation strategies is off-farm income [19]. The coefficient of off-farm income of non-adopters is positive and statistically significant. The availability of off-farm income is still a crucial factor that may influence farmers' decisions to use climate change adaptation measures as they increase agricultural production. The result implied the likelihood of households with access to off-farm income to invest in climate change adaptation strategies. Smallholder farmers who engage in off-farm activities could acquire some adaptation strategies such as chemical inputs or investing in the conservation of soil. Some of the strategies are capital-intensive.

Table 4. Impact of climate change adaptation strategies on household food security—endogenous switching probit model.

Impact of Climate Variability	*Coefficient*	*Std. Err.*
Primary activity	*0.373 ** *	*0.160*
Gender	*0.786 ** *	*0.360*
Age of the respondent	*0.038 ** *	*0.016*
Years of farming experience	*−0.064 * *	*0.038*
Access to information	*−0.255*	*0.308*
Access to market	*0.226*	*0.309*
Off-farm activity	*0.287 * *	*0.157*
Highest level of education	*−0.261 * *	*0.135*
Membership in cooperative	*−0.501 * *	*0.292*
Access to extension	*0.334*	*0.297*
Access to climate information	*0.033*	*0.037*
Constant	*−0.394*	*1.273*
HDDS2_02_1		
Access to funds from government	*0.535*	*0.557*
Gender	*0.238*	*0.536*
Age of the respondent	*−0.020*	*0.021*
Years of farming experience	*0.051*	*0.052*
Access to information	*1.073 ** *	*0.493*
Access to market	*1.727 * *	*1.017*
Off-farm income	*0.102*	*0.226*
Highest level of education	*−0.184*	*0.238*
Membership in cooperative	*0.154*	*0.425*
Access to extension	*0.797 * *	*0.446*
Years of farming experience	*−0.027*	*0.047*
Constant	*0.123*	*1.755*
HDDS2_02_0		
Access to funds from government	*−0.191*	*0.392*
Gender	*2.176 *** *	*0.803*
Age of the respondent	*0.034*	*0.027*
Years of farming experience	*0.005*	*0.069*
Access to information	*1.147*	*0.791*
Access to market	*0.750 * *	*0.445*
Off-farm income	*0.442 * *	*0.267*
Highest level of education	*0.252*	*0.207*
Membership in cooperative	*−0.648 * *	*0.386*
Access to extension	*0.555*	*0.380*
Years of farming experience	*−0.132*	*0.098*
Constant	*−4.556*	*1.918*
/athrho1	*−0.482*	*1.052*
/athrho0	*16.481*	*2755.165*
rho1	*−0.448*	*0.841*
rho0	*0.890*	*0.005*
LR test of indep. eqns. (rho1 = rho0 = 0): chi2(2)	*4.9200*	
Prob > chi2	*0.0853*	
Log likelihood	*127.570*	
Prob > chi2	*0.0699*	
Wald chi2(11)	*18.5400*	

***, **, and * represent significance level at 1%, 5%, and 10%, respectively.

Both the adopters and non-adopters of climate change adaptation techniques experienced a positive and significant impact on their food security, according to the coefficient of market access. This suggests that the more market access smallholder farmers have, the better their ability to increase food security. This is in line with a study by Maddison [38], who argued that farmers in Africa are more likely to adopt climate change practices as markets become more accessible to them. In Africa, markets serve as the primary means for farmers to exchange information and products. According to Marie et al. [39], market access is a crucial element that profoundly affects farmers' adoption of technology.

As argued by Ojo et al. [13], Oduniyi et al. [15], and Adeagbo et al. [14], climate information such as updated weather forecasts is one of the services provided to the farmers as it significantly contributes to farmers' likelihood of adopting climate change adaptation strategies. The coefficient of access to climate information is positive and statistically significant in explaining the variations in the food security status of only the adopters of climate change adaptation strategies. The results suggest that farmers who have access to climate information are more likely to implement techniques for coping with climate change, which ultimately raises their level of food security. The findings of this study are in line with those of Belay et al. [40] and Ogundeji [20], who posit that when farmers have access to up-to-date weather information and better irrigation schedules, they can make informed decisions about early or late planting dates and improve water use efficiency.

The coefficient of access to extension is positive and statistically significant in explaining the variations in food security status of only the adopters and not of non-adopters of climate change adaptation strategies in the study area. This implies that having contacts with the extension agents provides farmers with information on the adaptation strategies required for mitigating climate risks. This is in line with the study of Ojo et al. [13], who posit that farmers who experience difficulties in accessing extension services could have a low probability to adopt. The result is also in tandem with the findings of Ogundeji [20] on adaptation to climate change and its impact on smallholder farmers' food security in South Africa. Although the non-adopters may have access to extension, the ease of access could be a contributing factor as farmers whose farms are located far from home and near markets are hard to reach by extension agents [13]. Thus, this contributes to the reduced adoption of improved production technologies. This result is consistent with Musafiri et al. [41] regarding farmers' adoption of multiple climate-smart agricultural practices in Kenya.

The membership of rice farmers in cooperatives is positively and statistically significant in explaining the variations in the food security status of both adopters and non-adopter of climate change adaptation strategies in the study area. Therefore, membership in a farm-based cooperative increases the food security status of both adopters and non-adopters of climate change adaptation strategies. According to Kassie et al. [42], cooperative associations of farmers share a wealth of information concerning climate change adaptation strategies. Agbenyo et al. [43] claim that this positive relationship can be due to the fact that members of farmer groups routinely come together to exchange experiences and discover new technologies. Farmers' perceptions are improved through their participation in farm-based organizations [44].

3.6. Estimated Impact of Climate Change Adaptation Strategies on Food Security

This study determines the impact of climate change adaptation strategies on household food security among smallholder rice farmers in Ogun State. To achieve this, three approaches were used. In the first approach, the impact of adopting strategies for coping with climate change on food security was examined using FIML estimates of an endogenous switching probit model. The results show that adopting strategies for coping with climate change has a favorable and significant effect on food security. Since impact evaluation studies frequently neglect to take into account potential differences in the characteristics between the two groups, a simple significant difference in the average number of adaptation strategies between adopters and non-adopters of climate change adaptation strategies in impact evaluation studies could be ambiguous. Direct coefficients from the model cannot be taken into account as ATT due to concerns with missing data (counterfactual scenario) if not accounted for. In a similar vein, even if endogeneity is taken into account, the estimate from the ESPM may still be inconsistent, if not misleading.

To proffer a remedy to these inconsistencies, this study thus turned to the results of the causal effects of the farmers' adaptation strategies on food security using ATE and ATT. This is where the endogenous switching probit with treatment was used and then complemented with AIPW (third approach) as a robustness check. As a result, the ESPM was estimated. After fitting the switching probit regression with endogenous treatment effects, the ATE and ATT were estimated. As shown in Table 5, the estimated average treatment effect (ATE) of the adopters of adaptation techniques on the food security of smallholder rice farmers is about 2.3 and statistically significant at 1%. According to the ATE results, a unit increase in the adoption of adaptation strategies increases the food security status of smallholder farmers by 2.3 units. Similar to this, the conditional treatment effects, which assess the ATT, reveal that as the adoption of adaptation techniques increases, the food security status increases by 3.1 units.

Table 5. Treatment effects for the adoption of climate change adaptation strategies on household food security of rice farmers.

Treatment Effects	*Coefficient*	*Std. Err.*
ATE	*2.268 ****	*0.0359*
ATT	*3.143 ****	*0.0653*

*** represent significance level at 1%.

AIPW generates considerable improvements in the adoption of food security as a result of benefiting from the adoption of climate change adaptation techniques, which is consistent with the switching probit regression. According to Table 6, the ATE and POM are approximately three (3) and two (2), respectively. Therefore, if all of the sampled farmers employed adaptation strategies, the average household food security would increase three times as opposed to the average increase of two that would take place if none of the farmers adopt adaptation strategies. The treated adopters group also increased their food security status by 3.143 over what they would have achieved if they had not adopted adaptation methods.

Table 6. Augmented inverse probability-weighted treatment effects on the adoption of climate change adaptation strategies.

Treatment Effects	*Coefficient*	*Std. Err.*
ATE	*2.903 ****	*0.243*
ATT	*3.428 ****	*0.235*
POM	*2.198 ****	*0.328*

*** represent significance level at 1%.

The results of the two estimation methodologies show a considerable improvement in household food security when farmers implement adaptation techniques to reduce the negative effects of climate change. In line with studies conducted in Kenya and South Africa by Ndiritu et al. [45] and Ogundeji [20], respectively, climate change adaptation measures have a favorable influence on food security. The findings imply that farming households' access to adaptation practices may encourage smallholder farmers to employ adaptation strategies and hence become robust to the whims of the climate.

4. Conclusions and Policy Recommendations

Agriculture is still affected by climate change, and adaptations are required to minimize the impact on household food security. Designing policies that facilitate effective adaptation in agriculture requires careful consideration of the factors that affect farmers' decisions to adopt adaptation strategies. This study examined the determinants of the adoption of climate change adaptation strategies and their impact on household food security among 120 sampled smallholder rice farmers in Ogun State, Nigeria. According to the findings of the HDDS, adopters of climate change adaptation strategies were more food secure compared to non-adopters. In line with the estimated probit model results, the decisions of smallholder rice farmers in the study area to adopt climate change adaptation strategies were influenced by factors such as farming as their primary activity, gender, age, years of farming experience, off-farm activity, highest level of education, and cooperative membership. Turning to the ESPM, access to market information, access to extension agents, gender, off-farm income, and participation in cooperatives explained the differences in food security between adopters and non-adopters of climate change adaptation strategies. Adopting adaptation measures to climate change has a tendency to boost food security in households by about 3 units while lowering severe food insecurity by about 3.2 units. Therefore, it is advised that policies that would support smallholder farmers' decisions to embrace measures for coping with climate change should be encouraged in order to increase their adaptive capacity. Government investment plans and regulations should be developed with a focus on delivering knowledge on climate change, credit options, and education. Furthermore, in order to secure the inclusive sustainability of the agricultural sector, stakeholders and NGOs must collaborate with each other to enhance the circumstances under which farmers may receive climate change information, timely agricultural loans, and policy incentives. The relationship between the age and attitude of farmers towards the adoption of climate change adaptation strategies could be a panacea for precision and transformational agriculture; this, meanwhile, enhances economic output at a early stage in developing countries. Therefore, while future studies should consider the effects of various adaptation strategies on welfare, this study only looked at adaptation as a binary variable (i.e., adopters versus non-adopters) on food security.

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References

1. Zhu, Q.; Liu, X.; Hao, T.; Zeng, M.; Shen, J.; Zhang, F.; De Vries, W. Modelling soil acidification in typical Chinese cropping systems. *Sci. Total Environ.* **2018**, *613*, 1339–1348. [CrossRef]
2. Rice Almanac. *Global Rice Science Partnership*, 4th ed.; International Rice Research Institute: Los Baños, Philippines, 2013.
3. Khanal, U.; Wilson, C.; Hoang, V.N.; Lee, B. Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. *Ecol. Econ.* **2018**, *144*, 139–147. [CrossRef]
4. Wang, L.C.; Hoang, D.V.; Liou, Y.A. Quantifying the Impacts of the 2020 Flood on Crop Production and Food Security in the Middle Reaches of the Yangtze River, China. *Remote Sens.* **2022**, *14*, 3140. [CrossRef]
5. Kandegama, W.M.; Rathnayake, R.M.P.J.; Baig, M.B.; Behnassi, M. Impacts of Climate Change on Horticultural Crop Production in Sri Lanka and the Potential of Climate-Smart Agriculture in Enhancing Food Security and Resilience. In *Food Security and Climate-Smart Food Systems*; Springer: Cham, Switzerland, 2022; pp. 67–97.
6. Ziervogel, G.; Ericksen, P.J. Adapting to climate change to sustain food security. *Wiley Interdiscip. Rev. Clim. Change* **2010**, *1*, 525–540. [CrossRef]
7. Ogunpaimo, O.R.; Oyetunde-Usman, Z.; Surajudeen, J. Impact of Climate Change Adaptation on Household Food Security in Nigeria—A Difference-in-Difference Approach. *Sustainability* **2021**, *13*, 1444. [CrossRef]
8. Etim, M.A.; Babaremu, K.; Lazarus, J.; Omole, D. Health risk and environmental assessment of cement production in Nigeria. *Atmosphere* **2021**, *12*, 1111. [CrossRef]
9. Yiridomoh, G.Y.; Bonye, S.Z.; Derbile, E.K.; Owusu, V. Women farmers' perceived indices of occurrence and severity of observed climate extremes in rural Savannah, Ghana. *Environ. Dev. Sustain.* **2022**, *24*, 810–831. [CrossRef]

10. Chiputwa, B.; Blundo-Canto, G.; Steward, P.; Andrieu, N.; Ndiaye, O. Co-production, uptake of weather and climate services, and welfare impacts on farmers in Senegal: A panel data approach. *Agric. Syst.* **2022**, *195*, 103309. [CrossRef]
11. Behailu, G.; Ayal, D.Y.; Zeleke, T.T.; Ture, K.; Bantider, A. Comparative Analysis of Meteorological Records of Climate Variability and Farmers' Perceptions in Sekota Woreda, Ethiopia. *Clim. Serv.* **2021**, *23*, 100239. [CrossRef]
12. Asgari, A.; Darzi-Naftchali, A.; Saberali, S.F.; Nadi, M. Assessing DSSAT performance for predicting yield and water productivity of rainfed canola in a subsurface-drained field. *Theor. Appl. Climatol.* **2022**, *149*, 1659–1670. [CrossRef]
13. Ojo, T.O.; Baiyegunhi, L.J.S. Climate change perception and its impact on net farm income of smallholder rice farmers in South-West, Nigeria. *J. Clean. Prod.* **2021**, *310*, 127373. [CrossRef]
14. Adeagbo, O.A.; Ojo, T.O.; Adetoro, A.A. Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. *Heliyon* **2021**, *7*, e06231. [CrossRef] [PubMed]
15. Oduniyi, O.S.; Ojo, T.O.; Nyam, Y.S. Awareness and adoption of sustainable land management practices among smallholder maize farmers in Mpumalanga province of South Africa. *Afr. Geogr. Rev.* **2022**, 1–15. [CrossRef]
16. Ojo, T.O.; Baiyegunhi, L.J.S. Impact of climate change adaptation strategies on rice productivity in South-west, Nigeria: An endogeneity corrected stochastic frontier model. *Sci. Total Environ.* **2020**, *745*, 141151. [CrossRef]
17. Adegnandjou, M.R.F.; Dominique, B. Farmers adaptation strategies to climate change and their implications in the zou department of south Benin. *Environments* **2018**, *5*, 15.
18. Ali, A.; Erenstein, O. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Clim. Risk Manag.* **2017**, *16*, 183–194. [CrossRef]
19. Thinda, K.T.; Ogundeji, A.A.; Belle, J.A.; Ojo, T.O. Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. *Land Use Policy* **2020**, *99*, 104858. [CrossRef]
20. Ogundeji, A.A. Adaptation to Climate Change and Impact on Smallholder Farmers' Food Security in South Africa. *Agriculture* **2022**, *12*, 589. [CrossRef]
21. Gebrehiwot, T.; van der Veen, A. Farmers' drought experience, risk perceptions, and behavioural intentions for adaptation: Evidence from Ethiopia. *Clim. Dev.* **2021**, *13*, 493–502. [CrossRef]
22. Adeleye, N.; Osabuohien, E.S.; Adeogun, S.; Fashola, S.; Tasie, O.; Adeyemi, G. Access to land and food security: Analysis of 'priority crops' production in Ogun State, Nigeria. In *The Palgrave Handbook of Agricultural and Rural Development in Africa*; Palgrave Macmillan: Cham, Switzerland, 2020; pp. 291–311.
23. Asfaw, S.; McCarthy, N.; Lipper, L.; Arslan, A.; Cattaneo, A.; Kachulu, M. Climate Variability, Adaptation Strategies and Food Security in Malawi (No. 1008-2016-80228). In Proceedings of the 29th International Conference of the International Association of Agricultural Economists, Milan, Italy, 8–14 August 2015.
24. Abdulai, A.; Huffman, W. The adoption and impact of soil and water conservation technology: An endogenous switching regression application. *Land Econ.* **2014**, *90*, 26–43. [CrossRef]
25. Lokshin, M.; Sajaia, Z. Impact of interventions on discrete outcomes: Maximum likelihood estimation of the binary choice models with binary endogenous regressors. *Stata J.* **2011**, *11*, 368–385. [CrossRef]
26. Ojo, T.O.; Adetoro, A.A.; Ogundeji, A.A.; Belle, J.A. Quantifying the determinants of climate change adaptation strategies and farmers' access to credit in South Africa. *Sci. Total Environ.* **2021**, *792*, 148499. [CrossRef] [PubMed]
27. Ahmad, D.; Afzal, M. Flood hazards and agricultural production risks management practices in flood-prone areas of Punjab, Pakistan. *Environ. Sci. Pollut. Res.* **2022**, *29*, 20768–20783. [CrossRef]
28. Musemwa, L.; Chagwiza, C.; Sikuka, W.; Fraser, G.; Chimonyo, M.; Mzileni, N. Analysis of cattle marketing channels used by small scale farmers in the Eastern Cape Province, South Africa. *Livest. Res. Rural. Dev.* **2007**, *19*, 131.
29. Pierotti, R.S.; Friedson-Ridenour, S.; Olayiwola, O. Women farm what they can manage: How time constraints affect the quantity and quality of labour for married women's agricultural production in southwestern Nigeria. *World Dev.* **2022**, *152*, 105800. [CrossRef] [PubMed]
30. Zhang, Q.; Bilsborrow, R.E.; Song, C.; Tao, S.; Huang, Q. Rural household income distribution and inequality in China: Effects of payments for ecosystem services policies and other factors. *Ecol. Econ.* **2019**, *160*, 114–127. [CrossRef]
31. Danso-Abbeam, G.; Baiyegunhi, L.J.; Ojo, T.O. Gender differentials in technical efficiency of Ghanaian cocoa farms. *Heliyon* **2020**, *6*, e04012. [CrossRef]
32. Aryal, J.P.; Sapkota, T.B.; Khurana, R.; Khatri-Chhetri, A.; Rahut, D.B.; Jat, M.L. Climate change and agriculture in South Asia: Adaptation options in smallholder production systems. *Environ. Dev. Sustain.* **2020**, *22*, 5045–5075. [CrossRef]
33. Mahmood, N.; Arshad, M.; Mehmood, Y.; Shahzad, M.F.; Kächele, H. Farmers' perceptions and role of institutional arrangements in climate change adaptation: Insights from rainfed Pakistan. *Clim. Risk Manag.* **2021**, *32*, 100288. [CrossRef]
34. Fernandez-Cornejo, J.; Mishra, A.K.; Nehring, R.F.; Hendricks, C.; Southern, M.; Gregory, A. *Off-Farm Income, Technology Adoption, and Farm Economic Performance (No. 1477-2016-121070)*; United States Department of Agriculture (USDA): Washington, DC, USA, 2007.
35. Ojo, T.O.; Baiyegunhi, L.J.S.; Salami, A.O. Impact of credit demand on the productivity of rice farmers in South West Nigeria. *J. Econ. Behav. Stud.* **2019**, *11*, 166–180. [CrossRef]
36. Shahzad, M.F.; Abdulai, A. Adaptation to extreme weather conditions and farm performance in rural Pakistan. *Agric. Syst.* **2020**, *180*, 102772. [CrossRef]
37. Diiro, G.M. Impact of off-farm income on agricultural technology adoption intensity and productivity. *Agric. Econ.* **2013**, *11*, 1–15, Uganda Support Programme IFPRI Working Papers.

38. Maddison, D. *The Perception of an Adaptation to Climate Change in Africa*; World Bank Policy Research Working Paper, 4308; The World Bank: Washington, DC, USA, 2007; Volume 4308.
39. Marie, M.; Yirga, F.; Haile, M.; Tquabo, F. Farmers' choices and factors affecting adoption of climate change adaptation strategies: Evidence from northwestern Ethiopia. *Heliyon* **2020**, *6*, e03867. [CrossRef]
40. Belay, A.; Recha, J.W.; Woldeamanuel, T.; Morton, J.F. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agric. Food Secur.* **2017**, *6*, 1–13. [CrossRef]
41. Musafiri, C.M.; Kiboi, M.; Macharia, J.; Ng'etich, O.K.; Kosgei, D.K.; Mulianga, B.; Ngetich, F.K. Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: Do socioeconomic, institutional, and biophysical factors matter? *Heliyon* **2022**, *8*, e08677. [CrossRef]
42. Kassie, M.; Jaleta, M.; Shiferaw, B.; Mmbando, F.; Mekuria, M. Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technol. Forecast. Soc. Change* **2013**, *80*, 525–540. [CrossRef]
43. Agbenyo, W.; Jiang, Y.; Jia, X.; Wang, J.; Ntim-Amo, G.; Dunya, R.; Twumasi, M.A. Does the Adoption of Climate-Smart Agricultural Practices Impact Farmers' Income? Evidence from Ghana. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3804. [CrossRef]
44. Singh, S. Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand Region, India. *Ecol. Indic.* **2020**, *116*, 106475. [CrossRef]
45. Ndiritu, S.W. Drought responses and adaptation strategies to climate change by pastoralists in the semi-arid area, Laikipia County, Kenya. *Mitig. Adapt. Strateg. Glob. Change* **2021**, *26*, 1–18. [CrossRef]