



PERCEIVED EFFECTS OF CLIMATE CHANGE AND ADAPTATION STRATEGIES AMONG RICE FARMERS IN NIGER STATE, NIGERIA

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ABSTRACT

Climate change poses a major threat to rice production, though evidence on rice farmers' adaptation actions remains limited in Niger State, especially concerning the interdependence of adaptation strategies. This study assessed rice farmers' perceptions of climate change and examined the determinants of farmers' adaptation decisions in Niger State, Nigeria. A multistage sampling procedure was used to select farmers from six Local Government Areas across the State's three agricultural zones based on their dominance in rice production. Data were analysed using descriptive statistics and a multivariate probit model. The multivariate probit model was chosen because previous studies have paid limited attention to the simultaneous influence of socioeconomic, farm-specific, and institutional factors on farmers' multiple adaptation strategies. The study showed that farmers observed climate change through increased soil erosion, decreased crop yields, and increased flood incidence, all of which adversely affected rice production. The most commonly adopted coping strategies were early planting (94.2%), diversification to off-farm activities (71.8%), use of organic/inorganic fertilizers (64.4%), and diversification to farming other crops (64.4%). The multivariate probit model showed that farmers' age, household size, education, farming experience, off-farm employment, farm size, farm labour, access to credit, cooperative membership, access to climate information, extension contact, and climate change awareness significantly influenced adaptation decisions. The study provides a broad understanding of how socioeconomic, farm-specific, and institutional factors jointly shape farmers' adaptation decisions by explicitly modelling interdependence among multiple adaptation strategies. The findings provide evidence for designing coordinated climate adaptation policies that strengthen extension services, improve access to climate information and credit, and improve institutional support for climate-resilient rice production.

Keywords: Climate change, Off-farm employment, Farm labour, Multivariate Probit model, Cooperative membership

INTRODUCTION

Rice (*Oryza sativa*) is a staple crop for most households and a major source of livelihood for small-scale farmers (Obot *et al.*, 2022). In Nigeria, small-scale farmers predominantly undertake rice farming, highlighting their critical role in the agricultural sector (Klynleld Peat Marwick Goerdeler [KPMG], 2019). However, rice production in Niger State, and by extension Nigeria, has not reached its full production potential to meet ever-increasing demand, despite the policy banning its importation (Orunyomi *et al.*, 2024). This can be attributed to numerous problems faced by rice farmers, including low capital to invest in rice or expand production, inefficient resource use, low yields, and the prevailing negative effects of climatic factors on rice production.

Globally, climate change is altering agricultural production through floods, persistent temperature increases, drought, and rainfall variability. These changes have considerable influence on the rural communities' livelihoods, such as increased food insecurity, reduction in yield, alteration of pest and disease dynamics, drop in water availability, reduction of farmers' profit margin, and gradual decrease of the sustainability of subsistence farming (Karienyne and Macharia, 2020; Aderinoye-Abdulwahab and Abdulbaki, 2021). Rice is a water-loving crop and is highly sensitive to climatic changes because its growth relies on well-distributed rainfall and/or water throughout the production cycle. Therefore, variations in rainfall patterns, drought, and rising temperatures have reduced water availability, lowering yields and heightening rice production risks (Solaja *et al.*, 2024). Rice farmers in Niger State, and more broadly in Nigeria, are increasingly experiencing the negative effects of climate variability. For instance, Egunsola *et al.* (2022) reported that rice farmers in Taraba State, Nigeria, perceived reduced rice yields and floods as the main impacts of climate on rice production. Farmers have observed rising temperatures and more frequent, intense rains as effects of climate change (Hussain *et al.*, 2020). Likinaw *et al.* (2022) reported that households perceived delayed onset of rainfall, food insecurity, early termination of rainfall, and persistent drought as the main climate change risks.

Hence, how rice farmers in Niger State perceive climate change and adapt or respond to its adverse effects depends on climatic variations.

Perception consequently plays a crucial role in influencing farmers' adaptation decisions. Thus, understanding how rice farmers perceive climate change is important because their responses to these climatic variations are largely shaped by how they perceive climate change and the negative effects it poses to their farming activities. Thus, adaptation offers farmers practical methods to reduce the negative effects of climate change. Africa has limited adaptive capacity to address the challenges posed by climate change. In terms of climate change vulnerability, Nigeria ranked the 53rd most susceptible nation and the sixth least prepared to adapt to a changing climate (Osuji *et al.*, 2023). Thus, farmers must adopt various techniques and strategies to lessen the negative effects of climate change by finding local methods to adapt and carry out activities that address current and unpredictable future impacts. Adaptation constitutes a critical component of the long-term rejoinder to climate change, aimed at safeguarding human populations, livelihoods, and natural ecosystems (United Nations Framework Convention on Climate Change [UNFCCC], 2022). It refers to gradual changes in response to current or anticipated climate conditions, their unpredictability, and associated effects (Dumba *et al.*, 2021). Adaptation in this context refers to the farming practices small-scale farmers use to minimize the impact of climate change on food security (Zamasiya *et al.*, 2021). The ultimate objective of employing adaptation activities is to lessen the risk and/or uncertainty from the adverse effects of climate change. To adapt to climate change, rice farmers have used improved varieties, livelihood diversification, alternative crops, and insurance (Osuji *et al.*, 2023).

To adapt effectively to the adverse effects of climate change, studies (Adisa *et al.*, 2024; Ajibade *et al.*, 2023; Ebenehi *et al.*, 2024) have found that rice farmers in Niger State adopt various adaptation strategies. However, significant differences linger in adaptation decisions by the farmers even when they face the same climatic conditions. This indicates that adaptation is influenced not only by farmers' exposure to climate change but also by differences in their socioeconomic, farm-specific, and institutional characteristics. However, empirical evidence on the joint influence of socioeconomic, farm-specific, and institutional factors on rice farmers' climate change adaptation decisions in this context remains limited. This calls for a deeper investigation of how these factors jointly influence farmers' adaptation decisions. Moreover, recent studies (Abou *et al.*, 2023; Idu *et al.*, 2023; Abubakar *et al.*, 2025; Chete *et al.*, 2025) have

examined rice farmers' perception of climate change, access to climate information, and the effect of climate-smart adaptation practices on farmers' income independently instead of considering how socioeconomic, farm-specific, and institutional factors collectively shape farmers' adaptation decisions. The study also used a Multivariate Probit (MVP) model because previous studies have paid limited attention to using MVP to examine the simultaneous influence of socioeconomic, farm-specific, and institutional factors on farmers' multiple adaptation strategies. This knowledge gap limits the development of suitable climate adaptation policies and interventions tailored to rice farmers' needs. Therefore, this study seeks to address this contextual and empirical gap by examining factors influencing rice farmers' adaptation decisions and assessing rice farmers' perceptions of climate change and the adaptation strategies they employ.

RESEARCH METHODOLOGY

The Study Area

The study was carried out in Niger State, Nigeria. The State lies between latitudes 11°30'N and longitude 7°18'E in the North Central region, with a landmass of 74,108.58 square kilometres (Niger State Bureau of Statistics (NSBS), 2014). The State's population was estimated at 6,783,300 inhabitants, based on an annual growth rate of 3.4% (City Population, 2022). The State experiences two distinct seasons, dry and wet, with a yearly average rainfall of 1,219mm (World data, 2022). Niger State has two soil types: Ku soil, which has low erosion risk, and Ya soil, which has better water-holding capacity (NSBS, 2014). Farmers cultivated crops such as yam, maize, millet, groundnut, cowpea, cassava, melon, sugarcane, cotton, beniseed, and rice in the State.

Data and Sampling Technique

Primary data were sourced using a structured interview schedule via the online KoboCollect toolbox. Rice farmers and research locations were selected using a multi-stage sampling procedure and purposive selection. In the first step, two (2) Local Government Areas (LGAs) from each of the three agricultural zones (I, II, and III) that are dominant in rice production were purposively selected, for a total of six (6) LGAs. The LGAs were Lavun, Katcha, Gurara, Bosso, Wushishi, and Borgu. The second stage involved selecting three (3) farming communities from each selected LGA. In the third stage, 20% of farmers from each selected farming community

were randomly selected from the rice farmers' list obtained from the Niger State Agricultural and Mechanization Development Authority (NAMDA) branch office in each selected LGA. A total of 365 rice farmers were randomly selected. The rice farmers in the sampled communities totalled 1,825.

The study used Cochran's (1977) sample size formula, along with the finite population correction, to determine the sample size for this study. Following Khan et al. (2022), assuming a 95% confidence interval ($z = 1.96$), 50% population variability ($p = 0.5$), and a 4.59% ($e = 0.0459$) customized margin of error, the initial baseline or unadjusted sample size (n_0) was calculated as 456 farmers. However, since the population of this study is known ($N = 1825$) from the sampled farming communities. The sample size was determined using finite population correction for a known population as delineated by Cochran (1977) and Israel (1992). The sample size was calculated to be 365 rice farmers. This represents a robust 20% sample of the whole target population.

METHOD OF DATA ANALYSIS

Descriptive statistics

Descriptive statistics, including frequencies, charts, means, and percentages, were used. To gauge farmers' perceptions of climate change's negative effects on rice production, a Likert-type scale was used.

Multivariate Probit model

The multivariate probit model (MVP) was used to analyse factors determining farmers' adaptation decisions. Aryal *et al.* (2021), Ali (2021), and Onyeneke (2021) adopted a similar model; the model assumes that rice farmers may adopt more than one coping strategy to reduce the adverse effects of climate change. This is because farmers usually select climate adaptation practices as a complementary package rather than separate options. Hence, the MVP model is needed to capture interdependencies among coping strategies. This study preferred the multivariate probit model over binary logistic regression because it accounts for interdependence and correlations among multiple simultaneous adoption decisions made by a farmer (Mpinda *et al.*, 2025). Unlike binary logistic regression, which runs isolated models for each adaptation strategy and erases complex decision pathways. Furthermore, the MVP model was chosen over

the Multinomial probit (MNP) model because MNP is designed for mutually exclusive choices, while the MVP model accommodates non-mutually exclusive decisions (Mpinda *et al.*, 2025). MVP allows the error terms of each coping strategy to correlate freely while estimating the impact of exogenous factors on strategy adoption (Mulwa *et al.*, 2017; Arun and Yeo, 2020). The eleven (11) adaptation strategies used by rice farmers formed the endogenous variables in the Multivariate Probit model. The explicit form of the model is expressed in eqn. (1) and (2), following Mulwa *et al.* (2017) and Onyeneke (2021)

$$Y_n = 1 \text{ if } \beta_i x' + \varepsilon_i > 0 \dots\dots\dots (1)$$

and

$$Y_n = 1 \text{ if } \beta_i x' + \varepsilon_i \leq 0 \text{ } n = 1, 2, 3, 4, 5, 6 \dots\dots\dots, 11 \dots\dots\dots (2)$$

Where;

Y_n = n^{th} farmers' climate change coping strategies

X = vector of the explanatory variables

$n = 1, 2, 3, 4, 5, 6 \dots\dots\dots, 11$ are numbers of coping strategies employed by the rice farmers

$\beta_0, \beta_1, \beta_3 \dots\dots\dots \beta_{11}$ = regression coefficients of the MVP model

$\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4 \dots\dots\dots \varepsilon_{11}$ = random error term distributed as a multivariate normal distribution with zero mean, unitary variance and an $n \times n$ correlation matrix.

The resultant covariance matrix (ω) is presented in eqn. (3):

$$\omega = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} & \rho_{15} & \rho_{16} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} & \rho_{25} & \rho_{26} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} & \rho_{35} & \rho_{36} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 & \rho_{45} & \rho_{46} \\ \rho_{51} & \rho_{52} & \rho_{53} & \rho_{54} & 1 & \rho_{56} \\ \rho_{61} & \rho_{62} & \rho_{63} & \rho_{64} & \rho_{65} & 1 \end{pmatrix} \dots\dots\dots (3)$$

The pairwise correlation coefficient of the error terms that fit any two coping techniques is represented by the symbol ρ . The use of a multivariate probit rather than a univariate probit for each farm-level coping strategy is justified by the non-zero in the off-diagonal elements in the covariance matrix.

Table 1: Summary of variables measurement of MVP model and a prior expectation

Variables	Measurement	Expected sign
Dependent variables		
Climate adaptation practices	$Y_i = 1$ (use coping strategies), $Y_i = 0$ (otherwise)	
Independent variables		
Farmers' age	Years (continuous)	+
Farmers' sex	Male = 1, Female = 0	+
Household size	Number of family members (continuous)	+
Farming experience	Years (continuous)	+
Off-farm employment	Yes = 1, No = 0	+
Educational level	Years of acquiring formal education (continuous)	+
Farm size	Ha/acre	-
Farm labour	Number of farm labourers (Continuous)	+
Access to credit services	1 = if farmer availed, 0 = No	+
Cooperative membership	Member = 1, otherwise = 0	+
Access to climate information	1 = if farmer access, 0 = No	+
Contact with extension service	1 = if farmer received, 0 = No	+
Climate change awareness	Aware = 1, Not aware = 0	+

Source: Authors computation, 2023.

RESULTS AND DISCUSSION

Rice farmers' perception of climate change

Table 2 shows rice farming households' perceived effects of climate change on rice production. The decision rule indicates that a mean rating of 2.5 and above shows that farmers perceive the climatic event as negatively affecting rice production. Farmers need to perceive current trends in climate change as a threat to adapt sufficiently to a changing climate. Thus, perceiving climate change as a problem is the first step toward adapting to climatic changes (Yakubu *et al.*, 2021). Table 2 shows that an increase in the rate of soil erosion (Mean = 3.52, Rank = 1st) is seen as the most significant effect of climate on rice farming. This could be due to heavy downpours that

erode the soil. Farmers strongly believe that increased rainfall intensity and poor soil cover due to climate variations are accelerating soil degradation. Rice farmers observed a decrease in rice crop yield (Mean = 3.45, Rank = 2nd). Climate change is clearly perceived to lower yields, possibly because erratic rainfall, heat stress, or flooding affects crop performance. Gbemavo *et al.* (2022) and Egunsola *et al.* (2022) reported that rice farmers in the Republic of Benin and Taraba State, Nigeria, perceived reduced rice yields and floods as the main impacts of climate change on rice production. Farmers also noted that increased flood incidence (Mean = 3.45, Rank = 3rd) is a major concern, washing away planted fields and reducing output.

Farmers have noticed that climate change has increased food insecurity (Mean = 3.41, Rank = 4th). Farmers associate climate change with reduced food availability, likely tied to reduced production and income. This could result from extreme weather events and changes in rainfall patterns, which can lead to low rice yields. Thus, it may hinder the attainment of food sufficiency. Rising temperatures, changing precipitation patterns, and more extreme weather due to climate change have contributed to increased food insecurity in Africa (World Meteorological Organization, 2021). Likinaw *et al.* (2022) reported that smallholder farmers perceived food insecurity as one of the major impacts of climate change.

Table 2 also shows that farmers perceived an increased incidence of pests and diseases (Mean = 3.39, Rank = 5th) due to climate change. Farmers notice that warmer, wetter, or more unpredictable weather encourages pest and disease outbreaks that further affect yield. This result corroborates the findings of Egunsola *et al.* (2022), who found that rice farmers noticed an increase in crop pest populations and more disease infestation as a result of climate change.

Similarly, Pickson and He (2021) found that farmers have observed new diseases in rice crops due to climate change. Yakubu *et al.* (2021) also reported that rice farmers perceived pest infestation on rice farms as common due to climatic changes. A significant majority of farmers perceived a decrease in agricultural incomes and food availability (Mean = 3.35, Rank = 6th) as a result of climate change. Reduced yields translate into reduced income and lower food security for households. This result aligns with Adekunmi (2022), who reported that rice farmers observed that climate change has led to low income due to poor yield. Farmers also observed an increase in farmland destruction (Mean = 3.32, Rank = 7th) due to grazing activities by herders. Soil degradation, flooding, or drought-related cracking may be damaging arable land.

Table 2: Perceived effects of climate change on rice production by rice farming households

Impacts	SA	A	D	SD	Mean Rating	Rank
Climate change increase the rate of soil erosion	223 (61.1)	110 (30.1)	31 (8.5)	1 (0.3)	3.52	1 st
Climate change result to decrease in rice crop yield	212 (58.1)	120 (32.9)	25 (6.8)	8 (2.2)	3.47	2 nd
Increased incidence of flood	174 (47.7)	147 (40.3)	41 (11.2)	3 (0.8)	3.45	3 rd
Food insecurity	183 (50.1)	149 (40.8)	31 (8.5)	2 (0.5)	3.41	4 th
Increased incidence of pest and diseases	197 (54.0)	116 (31.8)	50 (13.7)	2 (0.5)	3.39	5 th
Decrease in agricultural income and food availability	161 (44.1)	175 (47.9)	25 (6.8)	4 (1.1)	3.35	6 th
Climate change leads to farmland destruction	151 (41.4)	182 (49.9)	31 (8.5)	1 (0.3)	3.32	7 th
Wilting of crop due to drought	130 (35.6)	197 (54.0)	38 (10.4)	0 (0)	3.25	8 th
Resource based conflict	112 (30.7)	182 (49.9)	69 (18.9)	2 (0.5)	3.11	9 th
Reduction of soil moisture	127 (34.8)	139 (38.1)	92 (25.2)	7 (1.9)	3.06	10 th
Decrease availability of water	110 (30.1)	143 (39.2)	109 (29.9)	3 (0.8)	2.99	11 th

N.B: SA =strongly agree, A=agree, D = disagree, SD =strongly disagree. Decision rule 2.5 and above perceived each climatic event as risk/have negative impact on them, < 2.5 perceived climatic event not having any negative impact on the farmers. n= 365, figures in parentheses are percentages.

The results further revealed that farmers perceived an increase in crop wilting due to drought (Mean = 3.25, Rank = 8th). Drought may adversely affect crops' physiological ability and yield

potential. This is because when plants do not receive enough water, they lose turgor pressure, causing leaves and stems to wilt. Rice is one crop facing significant yield decline because of rising temperatures (Khan *et al.*, 2022). Furthermore, rice farmers perceived negative impacts of climate change, including increased resource-based conflict (Mean = 3.11, Rank = 9th). Resource-based conflict between crop farmers and herders may result from competition for natural resources. Farmers perceived a reduction in soil moisture (Mean = 3.06, Rank = 10th) due to climate change. Reduced soil moisture, possibly due to rising temperature and irregular rainfall, affects crop establishment and growth. Farmers also reported decreased water availability (Mean = 2.99, Rank = 11th) due to climate change. This is the lowest-ranked perceived impact but still above the mean threshold of 2.5, indicating that farmers still consider it a problem. Orifah *et al.* (2021) reported that rising temperatures influenced the availability of water sources.

Farmers' coping strategies against climate change

Figure 1 shows rice farmers' coping strategies against the adverse effects of climate change. The findings revealed that most (94.2%) rice farmers practice early planting as a coping strategy against climate change. This aligns with Yakubu and Oladele (2021), who found that 97% of rice farmers in Kebbi State adopted early planting to cope with climate change. In contrast, 71.8% of rice farmers in the study area adopted diversification into off-farm activities. In this context, diversification to off-farm activities refers to farmers' ability to venture into non-farm business activities to improve their livelihoods. Rice farmers use livelihood diversification as an adaptation strategy, according to Onyeneke (2021). The author stated that farmers may mitigate climate change risks by diversifying their income sources. 64.4% of rice farmers acknowledged the usage of organic and/or inorganic fertilizer as a climate change management technique. Proper fertilizer use ensures plants receive essential nutrients, improving growth and their ability to withstand stresses like drought, heat, or pests exacerbated by climate change. According to research by Khan *et al.* (2022) and Khanal and Wilson (2019), rice farmers in Nepal use a balanced mix of chemical and organic fertilizers as a climate change management strategy. Efficient fertilizer management enriches soil fertility and reduces climate shocks (Khan *et al.*, 2022).

The practice of diversifying into other crop farming was adopted by 64.4% of farmers. This result corroborates the finding of Egunsola *et al.* (2022), who found that rice farmers in Taraba State practice crop diversification as a coping strategy against climate change. To cope with climate change, 61.6% of farmers adopted irrigation as a climate change management strategy. Egunsola *et al.* (2022) and Yakubu and Oladele (2021) reported the adoption of irrigation methods among rice farmers as a coping strategy.

The study recorded significant adoption of improved varieties among farmers (49.3%) in the study area. Yakubu and Oladele (2021) reported that farmers carefully select varieties that are superior in yield, drought tolerance, early maturity, and resistance to pests and diseases. This finding is consistent with the findings of Zama *et al.* (2021), Moksia *et al.* (2023) and Onyeneke (2021). Figure 1 further showed that 49.3% of farmers adopted changes in planting dates as a climate change management practice. Gahatraj *et al.* (2018) and Zama *et al.* (2021) also reported changing planting dates among rice farmers. Several farmers (44.9%) adopted efficient use of agrochemicals to cope with the changing climate, which aligns with the findings of Yakubu and Oladele (2021).

Furthermore, 37.5% of farmers adopted cultivation of short-duration crops. To address climate change, rice farmers are cultivating short-duration crops, according to a study by Khan *et al.* (2022). Because short-duration rice farming reflects risk aversion rather than a climate-smart variety, it is considered a distinct climate change adaptation strategy (Khan *et al.*, 2022). To adapt to climate change, about 31.5% of farmers used minimum tillage. Minimum tillage offers advantages such as reduced soil erosion, environmental preservation, enhanced soil fertility, decreased susceptibility to climate change, and higher yields (Onyeneke, 2021). The least-adopted climate-change management strategy among the 30.4% of rice farmers in the study area was reliance on climate information and forecasts. A similar finding that rice farmers avail weather forecast services to adapt to climate change was reported by Egunsola *et al.* (2022).

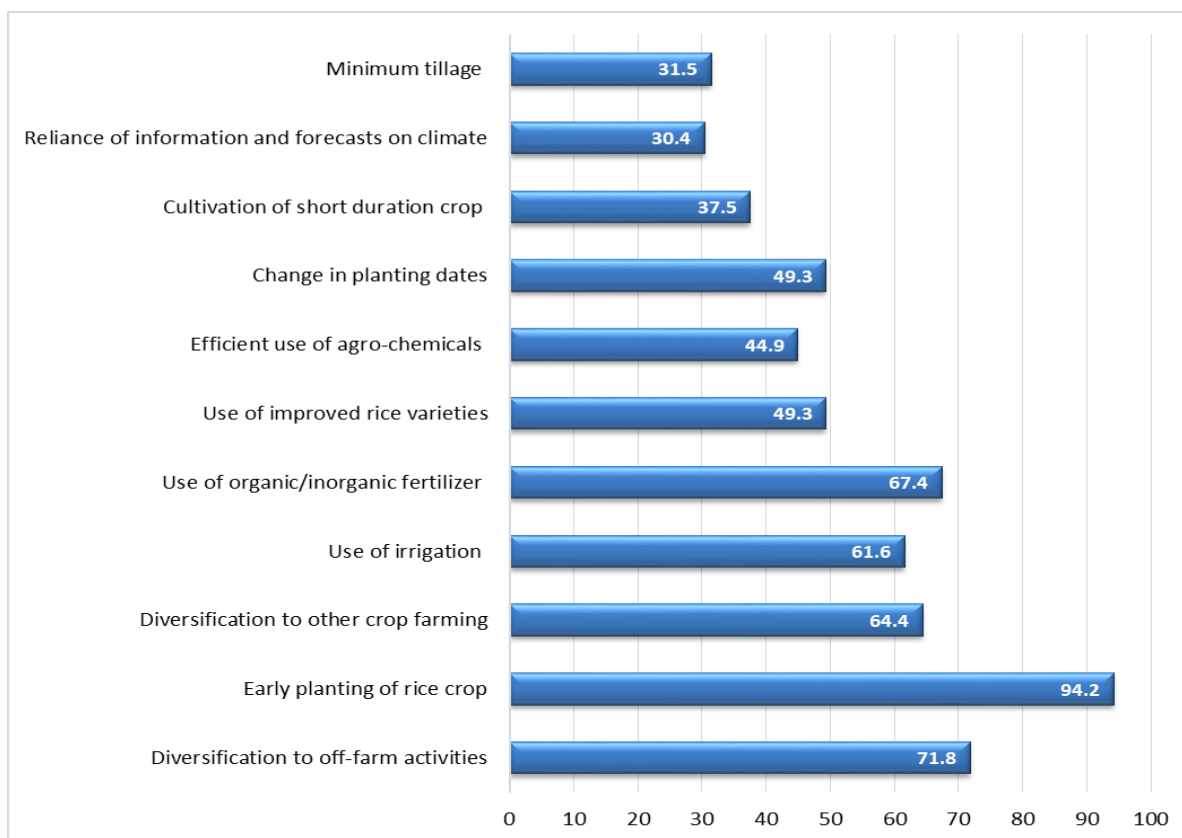


Figure 1: Rice farmer's coping strategies to climate change.

Source: Field survey, 2023.

Determinants of climate change adaptation decisions among rice farmers

Table 3 presents the Multivariate Probit (MVP) model results 3. Age was statistically significant and had an inverse relationship across two climate management strategies (changes in planting dates ($p < 0.05$) and minimum tillage ($p < 0.05$)). This shows that, as farmers' age increases, the likelihood of adopting any of these strategies to mitigate the effects of climate change decreases.

This also suggests that older farmers may be less likely to adapt to a changing climate than younger farmers, possibly because of factors such as readiness to experiment with new farming practices, adherence to traditional methods, and risk aversion. Older farmers may lack the ability to engage in activities that require physical strength and may be inclined to traditional farming practices that they are familiar with rather than adopting modern methods that are resilient to climate change (Zama *et al.*, 2021). This aligns with findings from Gameda *et al.* (2023), Aryal *et al.* (2021), Zama *et al.* (2021), and Onyeneke (2021), who found a negative relationship between farmers' age and climate change adaptation decisions.

Household size was associated with early rice planting as a coping strategy, and this association was statistically significant at the $p < 0.1$ level. This indicates that as the size of the rice farmer's household increases, the intensity of adopting early rice planting as an adaptation option increases. Farmers with larger households have more family members to help adopt labour-intensive coping strategies, which can reduce climate-change-related risks. This agrees with the findings of Gbemavo *et al.* (2021) and Onyeneke (2021), who found a positive relationship between rice farmers' household size and climate coping strategies. Conversely, household size was negatively associated with rice farmers' adoption of efficient agrochemical use to cope with climate change. Thus, as farmers' household size increases, they are less likely to adopt efficient agrochemical use as a climate change coping option. Larger households may need to allocate resources to immediate family needs, such as health and education, rather than investing in potentially costly climate-coping measures. Thus, they may adopt a less costly coping strategy rather than using agrochemicals, which involve costs. Khan *et al.* (2022) reported a negative correlation between household size and farmers' adaptation decisions.

Educational level had a significant negative relationship with rice farmers' use of early planting of rice crops ($p < 0.05$), diversification to off-farm activities ($p < 0.05$), and irrigation ($p < 0.05$). The magnitude of the correlation shows that as the farmers' educational level increases, the probability of adopting these climate strategies decreases. Educated farmers may have alternative income sources, may not view these coping strategies as important, and may feel more confident in their ability to cope with climate change without adopting them. Changes in cultivation date ($p < 0.05$), cultivation of short-duration crops ($p < 0.01$), and minimum tillage ($p < 0.05$) are significantly and positively associated with the farmer's educational level. This implies that more years of schooling increase the likelihood that farmers adopt these coping strategies. Education

increases rice farmers' use of climate change coping measures and is often postulated to increase the likelihood of farmers using novel technologies (Yakubu and Oladele, 2021). This finding is consistent with Aryal *et al.* (2021) and Yakubu and Oladele (2021), who found a positive correlation between rice farmers' educational level and the use of climate coping strategies.

Farming experience had significant and positive association in determining farmers' adopting reliance of information and forecast on climate ($p < 0.01$), diversification to other crop farming ($p < 0.05$), use of improved varieties ($p < 0.01$), changes in planting dates ($p < 0.05$), efficient use of agrochemicals ($p < 0.05$), and cultivation of short duration crop ($p < 0.01$). This implies that a one-year increase in farmers' experience would increase adoption of these coping strategies. Experiences gained by farmers over the years on climate patterns, climate coping techniques, and knowledge of farming practices may shape and/or influence the farmers' adaptation decision. Experienced farmers have better knowledge of adapting to climate risk in rice farming than less experienced farmers (Onyeneke, 2021). This result is consistent with Onyeneke (2021), who found that farming experience was significant and positively related to the rate of rice farmers' utilization of climate change coping strategies. Off-farm employment has a significant, positive impact on farmers' diversification into off-farm activities ($p < 0.05$), irrigation ($p < 0.05$), reliance on climate information and forecasts ($p < 0.1$), and diversification into other crop farming ($p < 0.05$). The positive relationship infers that the more farmers are engaged in off-farm employment, the more likely they are to adopt these strategies. Farmers with diversified income sources may have a stronger financial pool to invest in these coping strategies. This is consistent with Zama *et al.* (2021), who reported that supplementary income from other sources increases farmers' likelihood of adopting climate change management practices. Off-farm employment is negatively correlated with the cultivation of short-duration rice crops, and this relationship is statistically significant at the $p < 0.1$ level. This indicates that farmers engaged in off-farm employment are less likely to adopt this as a coping strategy against climate change. Compared with the average rural households, farmers with access to non-farm income may be less exposed to production risks (Mulwa *et al.* 2017).

Farm size had a significant but negative relationship with farmers' adoption of diversification to off-farm activities ($p < 0.1$), efficient use of agrochemicals ($p < 0.05$), and minimum tillage ($p < 0.1$). This implies that as the farm size increases, the probability of adopting these strategies decreases. Larger farm sizes may provide sufficient income to reduce the need for farmers to

seek off-farm employment. The negative correlation between farm size and efficient agrochemical use contradicts the expectation that farmers are likely to adopt practices that improve efficient agrochemical use. Farmers with larger farms may be less disposed to adopt minimum tillage practices and may prioritize conventional tillage methods for efficiency in covering extensive areas.

Furthermore, farm size was positively associated with changes in planting dates ($p < 0.1$). This indicates that farmers operating on a large scale may adjust rice planting dates to better suit their operations in response to climate shocks. The positive association between farm size and the adoption of climate coping strategies aligns with the findings of Khan *et al.* (2022) and Onyeneke (2021).

Diversification to off-farm activities, irrigation, and use of improved varieties have significant but negative impacts on farm labour at $p < 0.05$, $p < 0.05$, and $p < 0.1$, respectively. This indicates that higher labour availability reduces the likelihood of farmers diversifying into off-farm activities, adopting irrigation, and using improved varieties. Farmers with more farm labour mobility may focus on maximizing rice output to attain food sufficiency rather than engaging in off-farm activities. Farm labour availability does not significantly affect the adoption of improved varieties by rice farmers, suggesting that other factors, such as access to improved seed and farmers' literacy level, play a bigger role. Farm labour also showed a significant positive correlation with reliance on climate information and forecasts ($p < 0.05$), diversification to other crop farming ($p < 0.05$), cultivation of short-duration crops ($p < 0.1$), and minimum tillage ($p < 0.05$). This implies that a one-labourer increase increases the likelihood of adopting these coping strategies. Khan *et al.* (2022) found that farm labour significantly determined farmers' adoption of coping strategies to climate change. Access to credit services has a negative and significant relationship with early planting of rice crops ($p < 0.1$) and irrigation ($p < 0.05$). These findings showed that the more farmers access credit, the less likely farmers are to rely on early planting of rice crops and irrigation. Farmers with access to credit can prioritize modern farming practices to cope with a changing climate over traditional water management techniques (irrigation) and reliance on early planting, which is more reactive. Minimum tillage is positively correlated with farmers' access to credit services and is statistically significant at the $p < 0.01$ level. Rice farmers with access to credit are more likely to adopt minimum tillage, a practice that may require credit to finance specialized equipment. This finding aligns with Ateka *et al.* (2021),

Mulwa *et al.* (2017), Khan *et al.* (2022), and Zama *et al.* (2021), who underscore the importance of access to credit in farmers' ability to adopt climate change coping strategies.

Cooperative membership was significantly and positively associated with farmers' adoption of diversification into off-farm activities ($p < 0.1$), irrigation ($p < 0.05$), and rice farmers' efficient use of agrochemicals ($p < 0.1$). This indicates that the more farmers participate in cooperative associations, the more likely they are to adopt these coping strategies. This may be because cooperative associations give farmers access to timely, accurate climate change information. This would help farmers better select resilient farming practices that align with predicted climate conditions. Aryal *et al.* (2021) corroborate these findings, finding that farmers who are members of cooperative organizations are more likely to adopt changes in agricultural practices to cope with climate risks. Access to climate information significantly affects farmers' adoption of diversification into off-farm activities ($p < 0.01$) and diversification into other crop farming ($p < 0.05$). The results show that farmers who gain access to climate information are more likely to adopt these climate coping strategies. However, farmers' access to climate information was negatively related to the adoption of minimum tillage, and this was statistically significant at the $p < 0.01$ level. This implies that the more rice farmers access climate information, the less likely they are to adopt minimum tillage. Gameda *et al.* (2023) and Khan *et al.* (2022) reported similar findings of both positive and negative correlations between farmers' access to climate information and their coping strategies against climate change.

Contact with extension agent (as shown in Table 3 above) had positive relationship with rice farmers' adoption of reliance of information and forecast on climate ($p < 0.01$), use of improved varieties ($p < 0.01$), changes in planting date ($p < 0.01$), efficient use of agrochemicals ($p < 0.05$), cultivation of short duration crop ($p < 0.01$) and minimum tillage ($p < 0.01$). Thus, the more farmers contact extension agents, the more likely they are to rely on climate information and forecasts and to use improved varieties. Farmers are also more likely to adopt changes in planting dates, efficient agrochemical use, cultivation of short-duration crops, and minimum tillage. Extension services could strengthen farmers' ability to make informed decisions to adapt to climate change using climate forecasts. Gbemavo *et al.* (2021), Zama *et al.* (2021), and Khan *et al.* (2022) found that extension services are an important factor in influencing farmers to adopt coping strategies to adapt to climatic changes. Rice farmers' climate change awareness positively impacts farmers' adoption of irrigation, diversification to other crop farming, use of improved

varieties, and cultivation of short-duration crops; each was statistically significant at $p < 0.01$, $p < 0.05$, $p < 0.05$, and $p < 0.05$, respectively. This suggests that the more rice farmers are aware of climate change, the more likely they are to adopt these coping strategies to cushion its negative impacts. Farmers with access to climate change information are more likely to adapt to climate change than those without access to climate change information (Yakubu and Oladele, 2021).

Estimated pairwise correlation coefficients of rice farmers' adaptation strategies

Table 4 shows the estimated pairwise correlation coefficient of rice farmers' adaptation strategies. The result revealed statistical and significant correlations across 29 out of the 55 pairs. This indicates a complementarity and substitution association among the multiple coping strategies adopted by the rice farmers. Thus, suggesting that adoption of one climate adaptation strategy heightens the chances of adopting another, reflecting the coordinated nature of the rice farmer's responses to climate changes. A positive correlation between pairwise coefficients shows that the coping strategies are complementary. On the other hand, negative correlation coefficients imply that farmers considered the coping strategies as substitutes or one strategy is more fitting to adopt than the other. Early planting of rice crop (EPRC) was statistically significant and positively associated with irrigation for access to water ($\rho = 0.53$, $p < 0.01$). Implying that, adoption of early planting of rice crop is associated with higher chances of adopting irrigation for access to water. This complementarity indicates that investments in small-scale irrigation facilities would significantly improve the efficacy of early planting as a climate adaptation strategy. Irrigation will not only increase the water availability but also expedites timely planting and improved varieties adoption.

Diversification to other crop farming (DOCF) was positively correlated with diversification to off-farm activities (DOA) ($\rho = 0.67$, $p < 0.01$). This infers that rice farmers that utilized diversification to other crop farming to cope with climatic changes adopted it together with this coping strategy. Also, shows that farmers who diversify their incomes outside rice farming are more probable to diversify into farming of other crops. The two adaptation strategies mutually lessen climate-related production and income risks via risk diversification across various enterprises. This finding infers that adaptation policies should facilitates incorporated livelihood diversification instead of single-handedly promoting crop diversification. The positive association between minimum tillage (MNT) and efficient use of agrochemicals (EUA) ($\rho =$

Table 3: Determinants of farmers' climate change adaptation decisions

Explanatory variable	EPRC	UOIF	DOA	IAW	RIFC	DOCF	UIV	CPD	EUA	CSDC	MNT
Socio-economic characteristics											
Farmers age	-0.021 (0.019)	-0.009 (0.010)	-0.006 (0.113)	0.004 (0.010)	-0.013 (0.012)	-0.011 (0.010)	-0.013 (0.010)	-0.022** (0.010)	0.004 (0.010)	-0.018 (0.110)	-0.031** (0.011)
Farmers' sex	0.159 (0.459)	0.224 (0.264)	0.409 (0.293)	-0.166 (0.309)	0.090 (0.374)	0.039 (0.290)	-0.270 (0.287)	-0.319 (0.269)	0.042 (0.293)	0.094 (0.332)	0.053 (0.310)
Household size	0.062* (0.039)	0.004 (0.018)	-0.002 (0.019)	-0.003 (0.018)	-0.014 (0.023)	0.007 (0.017)	-0.018 (0.018)	0.016 (0.018)	-0.036* (0.019)	-0.003 (0.019)	0.024 (0.020)
Educational level	-0.054** (0.026)	-0.010 (0.014)	-0.043** (0.016)	-0.041** (0.015)	0.011 (0.017)	-0.031** (0.015)	0.004 (0.015)	0.029** (0.014)	0.013 (0.014)	0.028* (0.015)	0.041** (0.016)
Farm specific characteristics											
Farming experience	0.002 (0.018)	0.013 (0.010)	0.014 (0.011)	0.011 (0.011)	0.038*** (0.011)	0.024** (0.011)	0.048*** (0.011)	0.022** (0.010)	0.028** (0.010)	0.046*** (0.011)	-0.003 (0.012)
Off-farm employment	-0.318 (0.380)	0.035 (0.174)	0.380** (0.184)	0.454** (0.189)	0.449* (0.242)	0.442** (0.180)	-0.101 (0.187)	0.118 (0.183)	0.104 (0.193)	-0.360* (0.210)	0.010 (0.206)
Farm size	0.020 (0.120)	-0.01 (0.049)	-0.073* (0.046)	-0.045 (0.044)	0.001 (0.053)	-0.053 (0.049)	-0.023 (0.057)	0.131* (0.076)	-0.170** (0.077)	-0.056 (0.050)	-0.094* (0.056)
Farm labour	0.007 (0.019)	0.009 (0.106)	-0.021* (0.011)	-0.027** (0.011)	0.030** (0.133)	-0.030** (0.011)	-0.019* (0.011)	-0.012 (0.011)	-0.002 (0.011)	-0.024* (0.012)	0.035** (0.012)
Institutional characteristics											
Access to credit services	-1.023* (0.444)	0.310 (0.444)	-0.181 (0.444)	-0.786** (0.444)	0.444 (0.444)	-0.288 (0.444)	-0.162 (0.444)	-0.293 (0.444)	-0.080 (0.444)	0.443 (0.443)	1.514*** (0.443)

	(0.587)	(0.291)	(0.338)	(0.317)	(0.302)	(0.314)	(0.314)	(0.293)	(0.294)	(0.299)	(0.307)
Cooperative membership	0.028	0.239	0.591*	0.697**	0.206	0.331	0.256	0.276	0.481*	0.059	0.149
	(0.505)	(0.247)	(0.297)	(0.284)	(0.294)	(0.279)	(0.253)	(0.246)	(0.243)	(0.268)	(0.306)
Access to climate information	0.435	-0.322	0.847***	0.022	-0.033	0.478**	0.013 (0.209)	-0.133	0.126	0.091	-0.809***
	(0.492)	(0.203)	(0.239)	(0.227)	(0.233)	(0.224)		(0.206)	(0.202)	(0.212)	(0.256)
Contact with extension services	-0.014	0.013	0.071	0.170	1.087***	0.271	0.957***	0.876***	0.628**	0.972***	1.033***
	(0.535)	(0.265)	(0.316)	(0.297)	(0.298)	(0.298)	(0.286)	(0.271)	(0.267)	(0.277)	(0.311)
Climate change awareness	0.245	0.204	0.214	1.325***	0.135	0.513**	0.473**	0.101	0.257	0.489**	0.240
	(0.463)	(0.213)	(0.225)	(0.229)	(0.264)	(0.219)	(0.216)	(0.212)	(0.213)	(0.231)	(0.260)
Constant	2.222**	0.474	0.083	-0.486	-2.103***	0.136	-0.073	-0.008	-0.777*	-0.634	-0.458
	(0.889)	(0.435)	(0.478)	(0.477)	(0.568)	(0.457)	(0.452)	(0.440)	(0.462)	(0.498)	(0.501)
No. of observation	365										
Wald Chi ² (143)	632.99										
Prob>Chi ²	0.0000										
Log Likelihood	-1753.8272										

*P≤0.1; **P≤0.05; ***P≤0.01 Note: EPRC =Early planting of rice crop, UOIF=Use of organic/inorganic fertilizer, DOA=Diversification to off-farm activities, IAW=Irrigation, RIFC=Reliance on information and forecast on climate, DOCF=Diversification to other crop farming, UIV=Use of improved varieties, CPD=Changes in planting dates, EUA=Efficient use of agrochemicals, CSDC=Cultivation of short duration crop, MNT=Minimum tillage NB: Values in parentheses are standard errors; values outside parentheses are coefficients

Outstandingly, irrigation (IAW) was positively associated with diversification into off-farm activities (DOA) ($\rho = 0.45$, $p < 0.01$), as well as irrigation (IAW) and crop diversification (DOCF) ($\rho = 0.45$, $p < 0.01$). These associations infer that farmers with better financial capacity or diversified sources of income are more capable of investing in irrigation technologies. Off-farm income may therefore reduce liquidity restrictions that frequently limit farmers' investment in climate-resilient technologies. More so, positive relationships were found between changes in planting dates (CPD) and efficient agrochemical use (EUA) ($\rho = 0.32$, $p < 0.01$), and between changing planting dates and improved varieties (UIV) ($\rho = 0.32$, $p < 0.01$). These results suggest that agronomic management practices are implemented together to maximize productivity under changing climatic conditions. The positive correlation among the coping strategies shows that they should not be promoted independently. Therefore, promoting one complementary practice independently may likely lessen the general effectiveness of adaptation.

The findings of this study are consistent with the studies by Mulwa *et al.* (2017), Aryal *et al.* (2021), Onyeneke (2021) and Regmi *et al.* (2023). They found that rice farmers' adoption of diverse climate adaptation strategies simultaneously increases the chances of their selections being correlated. These studies (Mulwa *et al.*, 2017; Aryal *et al.*, 2021; Onyeneke 2021; and Regmi *et al.*, 2023) reported complementarities and substitutive relationships among climate coping strategies adopted by rice farmers.

Table 4: Pairwise correlation coefficients of rice farmers' climate adaptation strategies

Adaptation strategy	EPRC	UOIF	DOA	IAW	RIFC	DOCF	UIV	CPD	EUA	CSDC	MNT
EPRC	1.00										
UOIF	0.09(0.10)	1.00									
DOA	0.03(0.11)	0.09(0.08))	1.00								
IAW	0.53(0.10)***	0.18(0.09)**	0.45(0.08)***	1.00							
RIFC	0.08(0.13)	0.17(0.09)*	0.15(0.10)	0.22(0.09)**	1.00						
DOCF	0.22(0.12)*	0.06(0.08)	0.67(0.06)***	0.45(0.07)***	0.34(0.10)***	1.00					
UIV	0.16(0.10)	-0.03(0.08)	-0.03(0.09)	0.20(0.08)**	0.20(0.10)**	0.16(0.09)*	1.00				
CPD	0.10(0.11)	0.09(0.08)	0.19(0.08)**	0.04(0.08)	0.18(0.10)*	0.21(0.08)**	0.32(0.08)***	1.00			
JUA	0.10(0.11)	0.30(0.07)***	0.18(0.09)*	0.27(0.08)***	0.28(0.09)***	0.24(0.09)**	0.22(0.08)**	0.32(0.08)***	1.00		
CSDC	0.02(0.11)	0.09(0.08)	0.02(0.09)	0.11(0.08)	0.24(0.10)**	0.08(0.10)	0.41(0.08)***	0.42(0.08)***	0.48(0.77)***	1.00	
MNT	-0.39(0.12)***	0.12(0.10)	0.04(0.10)	-0.15(0.10)	0.19(0.11)*	-0.11(0.12)	0. .00(0.11)	-0.02(0.11)	-0.08(0.11)	0.00(0.11)	1.00

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{61} = \rho_{71} = \rho_{81} = \rho_{91} = \rho_{101} = \rho_{111} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{62} = \rho_{72} = \rho_{82} = \rho_{92} = \rho_{102} = \rho_{112} = \rho_{43} = \rho_{53} = \rho_{63} = \rho_{73} = \rho_{83} = \rho_{93} = \rho_{103} = \rho_{113} = \rho_{54} = \rho_{64} = \rho_{74} = \rho_{84} = \rho_{94} = \rho_{104} = \rho_{114} = \rho_{65} = \rho_{75} = \rho_{85} = \rho_{95} = \rho_{105} = \rho_{115} = \rho_{76} = \rho_{86} = \rho_{96} = \rho_{106} = \rho_{116} = \rho_{87} = \rho_{97} = \rho_{107} = \rho_{117} = \rho_{98} = \rho_{108} = \rho_{118} = \rho_{109} = \rho_{119} = \rho_{1110} = 0$: $\chi^2(55) = 282.055$. ***Prob > $\chi^2 = 0.0000$. ***P<0.01. Note: EPRC =Early planting of rice crop, UOIF=Use of organic/inorganic fertilizer, DOA=Diversification to off-farm activities, IAW=Irrigation for access water, RIFC=Reliance on information and forecast on climate, DOCF=Diversification to other crop farming, UIV=Use of improved varieties, CPD=Changes in planting dates, EUA=Efficient use of agrochemicals, CSDC=Cultivation of short duration crop, MNT=Minimum tillage

CONCLUSION

Rice farming households perceived climate change as a threat, negatively affecting rice yield and resulting in soil erosion, flooding, and food insecurity. Farmers in the study area have adopted multiple strategies to cope with climate change; however, they attached less importance to strategies like cultivation of short duration, minimum tillage and reliance of information on climate and weather forecast. This shows low adoption of coping strategies that could potentially lessen the susceptibility to climate effects. Notably, 94.2% of the rice farmers adopted early planting as a major adaptation strategy, while 71.8% diversified into off-farm income activities to lessen climate-related production risks. Adaptation to climate change is influenced by factors related to the farmers' socioeconomic, farm-specific and institutional characteristics. These factors influence farmer's decision to adapt or not adopt climate coping strategies to reduce the adverse effects of climate change.

RECOMMENDATION

The following recommendations were made based on the findings of the study;

- Efforts should be made by the stakeholders to strengthen adult literacy programmes or encourage farmers' enrolment into formal education as it is one of the factors that influence their decision to adapt to climate change.
- Stakeholders such as government, development partners and/or NGOs should design a policy that will focus on providing accessible and efficient extension services to facilitate farmer's adoption of farm-level climate coping strategies.
- Access to affordable credit facilities is important in enhancing the farmers' capability to access climate information. Financial institutions should provide ease procedures for accessing affordable agricultural credit schemes tailored to smallholder rice farmers.
- Farmers should form or be encouraged to join cooperative association to enhance their chances of accessing credit, improved access to agricultural inputs, market opportunities and information on climate-resilient farming practices.

REFERENCES

- Adekunmi, A. O. (2022). Rice farmers' awareness and perception of climate change in Ondo State, Nigeria. *European Journal of Agriculture and Food Sciences*, 4(1): 81-85. <http://dx.doi.org/10.24018/ejfood.2022.4.1.355>.
- Abuo, T.N., Rashid, S.A., Ifabiyi J.O., Mubarak O.A. & Kehinde L.O. (2023). Perceived effects of climate variability on the rice farmers in Niger State, Nigeria. *Diyala Agricultural Sciences Journal*, 15(2): 90-97.

- Ateka J.M., Mbeche, R.M., & Muendo K.M., (2021). Determinants of protected tomato production technologies among smallholder peri-urban producers Kiambu County, Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 122(1) 43-52. Ajibade, O., Yusuf, O. J., Olooto, F.M. and Adefalu, L.L. (2023). Factors influencing resilience building for climate change among rice farmers in Niger State, Nigeria. *Ondo University Journal of Agriculture and Social Sciences* 2023, 1(1): 8-14. <https://doi.org/10.52493/j.oujas.2023.2.89>
- Adisa, R.S., Abuo T.N., Ifabiyi, J.O., Abdulrahman, O.L., Oluwanisola, AM., (2024). Climate Variability Adaptation Strategies among Rice Farmers in Niger State, Nigeria. *Journal of Agriculture, Food, Environment and Animal Sciences*, 5(1): 13-21.
- Ali, E. (2021). Farm households' adoption of climate-smart practices in subsistence agriculture: Evidence from Northern Togo. *Environmental Management, Springer Science+Business Media, LLC part of Springer Nature* 2021. <https://doi.org/10.1007/s00267-021-01436-3>
- Abubakar, S., Bwala, M.A., & Sule, B.A. (2025). An analysis of access to climate information among smallholder rice farmers in Niger state, Nigeria. *International Journal of Agricultural Economics, Management and Development*, 13(1): 32 – 43.
- Aryal, J.P., Sapkota, T.B., Rahut, D.B., Marennya, P., & Stirling, C.M., (2021). Climate risks and adaptation strategies of farmers in East Africa and South Asia. *Scientific Report*, 11:10489, 1 – 14. <https://doi.org/10.1038/s41598-021-89391-1>
- Aderinoye-Abdulwahab, S. A., Abdulbaki, T. A. (2021). Climate change adaptation strategies among cereal farmers in Kwara state, Nigeria. In: Oguge, N., Ayal, D., Adeleke, L., da Silva, I. (eds), *African Handbook of Climate Change Adaptation* (pp. 509 – 522). Springer, Cham. Switzerland. https://doi.org/10.1007/978-3-030-45106-6_228
- Arun G.C. & Yeo, J., (2020). Perception to adaptation of climate change in Nepal: An empirical analysis using Multivariate Probit model. *Science* 2020, 2(87): 1 – 14. <https://doi.org/10.3390/sci2040087>. www.mdpi.com/journal/sci
- Chete, O.B., Louis, N. C. & Thomas, K.A. (2025). Climate change and livelihood outcomes of households in rice farming communities of Ebonyi and Niger states, Nigeria. *Discover Agriculture*, 3:217, 1 – 23. <https://doi.org/10.1007/s44279-025-00340-2>
- Cochran, W.G. (1977). *Sampling Techniques*, 3rd Edition, John Wiley & Sons, Inc. New York.
- City Population (2022). Statistics for Niger state, Nigeria. Retrieved from https://citypopulation.de/en/Nigeria/admin/NGA027_niger/
- Dumba, H., Danquah, J. A. & Pappinen, A. (2021). Rural farmer's approach to drought adaptation: Lessons from crop farmers in Ghana. In: Leal Filho, W., Oguge, N., Ayal, D., Adeleke, L., da Silva, I. (eds) *African Handbook of Climate Change Adaptation*, (pp. 1–19). Springer, Cham. Switzerland. https://doi.org/10.1007/978-3-030-42091-8_29-1
- Ebenehi, O., Fawole, B. F. and Musab, I. (2024). Effect of Usage of Climate Smart Agricultural Practices on Rice Farmers' Income in Niger and Kwara State. *Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)*, 4(4B), 58 – 70.
- Egunsola, A.O.E., Chiroma, Z.E., Sabo, I. M., & Hasuruna, A. (2022). Perception of farmers on climate change and adaptation strategies employed to enhance rice production in Taraba State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, 7(6); 163 – 173; <https://dx.doi.org/10.22161/ijeab.76.19>

- Gahatraj, S., Jha, R.K., & Singh, O.P., (2018). Impacts of climate change on rice production and strategies for adaptation in Chitwan, Nepal. *Journal of Agriculture and Natural Resources*, 1(1): 114-121.
- Gbemavo, C.J., Toffa, J., Tchakpa, C., Loko, Y.L.E., Djedatin, G., Ewedje, E., Orobiyi, A & Sedah, P., (2021). Rice farmers' perceptions and response to climate variability, and determinants of adaptation strategies in the Republic of Benin. *International Journal of Climate Change Strategies and Management* 14 (4), 332-353. Emerald Publishing Limited 1756-8692: <https://doi.org/10.1108/IJCCSM-06-2021-0059>
- Gemeda, D.O, Korecha, D., & Garedew, W., (2023). Determinants of climate change adaptation strategies and existing barriers in Southwestern parts of Ethiopia. *Climate Services* 2023, 11 (183) 2 – 19; <https://doi.org/10.3390/cli11090183>.
- Hussain, A., Memon, J. A., & Hanif, S. (2020). Weather shocks, coping strategies and farmers' income: A case of rural areas of district Multan, Punjab. *Weather and Climate Extremes*, 30(2020), 1 – 9. <https://doi.org/10.1016/j.wace.2020.100288>
- Idu, E. E., Fadiji, T. O., & Chimdi, A. (2023). Effect of climate variability on rice production in North-Central, Nigeria from 1980– 2020. *Direct Research Journal of Agriculture and Food Science*, 11(4), 78-89, <https://doi.org/10.26765/DRJAFS10759523>
- Israel, Glenn D. (1992). Sampling the evidence of extension program impact. Program evaluation and organizational development. *IFAS Extension*, University of Florida. PEOD-6. October. <https://doi.org/10.32473/EDIS-PD006-1992>
- Karienyee, D., Macharia, J. (2020). Adaptive capacity to mitigate climate variability and food insecurity of rural communities along River Tana Basin, Kenya. In: Leal Filho, W., Ogue, N., Ayal, D., Adeleke, L., da Silva, I. (eds) *African Handbook of Climate Change Adaptation*, (pp. 1–12). Springer, Cham. Switzerland. https://doi.org/10.1007/978-3-030-42091-8_57-1
- Khan, N.A., Shah, A.A., Chowdhury, A., Tariq, M. & Khanal, U., (2022). Rice farmers' perceptions about temperature and rainfall variations, respective adaptation measures, and determinants: Implications for sustainable farming systems. *Frontiers in Environmental Science*, 10:997673, 1 – 22. [10.3389/fenvs.2022.997673](https://doi.org/10.3389/fenvs.2022.997673)
- Khanal, U. & Wilson, C., (2019). Derivation of a climate change adaptation index and assessing determinants and barriers to adaptation among farming households in Nepal. *Environmental Science Policy* 101, 156–165. <https://doi.org/10.1016/j.envsci.2019.08.006>
- Klynleld, P. & Marwick G. [KMPG] (2019). Rice Industry Review. KPMG Advisory Services, October, 2019. home.kpmg/ng
- Likinaw, A., Bewket, W. & Alemayehu, A. (2022). Smallholder farmers' perceptions and adaptation strategies to climate change risks in northwest Ethiopia. *International Journal of Climate Change Strategies and Management*, 15(5) 1756 – 8692. [10.1108/IJCCSM-01-2022-0001](https://doi.org/10.1108/IJCCSM-01-2022-0001), <https://www.emerald.com/insight/1756-8692.htm>
- Mpinda, M.O., Bett, H.K. & Muluvi, A.S. (2025). Determinants of adoption of climate-smart agricultural practices among smallholder maize farmers in North East District, Botswana. *Discover Agriculture* 3(1114), 1 – 19. <https://doi.org/10.1007/s44279-025-00293-6>
- Moksia, J. J., Ibrahima, A., Stroia, C., Laminou, M.M. A., & Dancea, L. (2023). Farmer Perception of the Impact of Climate Change on Rice Production and Their

Adaptation Strategies in the Mayo-Danay, Far-North Cameroon. *Research Journal of Agricultural Science*, 55 (4), 121 – 134; ISSN: 2668-926X

- Mulwa, C., Marenja, P., Rahut D.B. & Kassie, M. (2017). Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. *Climate Risk Management* 16 (2017) 208–221.
- Niger State Bureau of Statistics (2014). Socio-economic Survey. Retrieved from www.nigerstats.ni.gov.ng.
- Obot A.; Okeke, C.; Precious C.; Onuoha F. (2022). Factors Influencing the Adoption FARO-44 Rice among Smallholder Farmers in Anambra State, Nigeria. *Canadian Journal of Agriculture and Crops*, 7(1): 30-37.
- Onyeneke, R. U. (2021). Does climate change adaptation lead to increased productivity of rice production? Lessons from Ebonyi State, Nigeria. *Renewable Agriculture and Food Systems* 36, 54–68. <https://doi.org/10.1017/S1742170519000486>
- Orifah M. O., Sani M. H., Nasiru M. & Ibrahim A. A. (2021). Perceived effectiveness of adaptation strategies to climate change among rice farmers in Jigawa State, Nigeria: Implication for rice production. *Agricultura Tropica Et Subtropica*, 54(2021), 122–135. <https://doi.org/10.2478/ats-2021-0013>
- Orunyomi, O., Odu, O.I., & John-Okon, M.E. (2024). Border Closure and Food Security in Nigeria: A Study of Domestic Rice Production in Ogun and Kebbi States, 2015 – 2023. *An African Journal of Arts and Humanities*. 10 (5), 62 – 75. <https://doi.org/10.13140/RG.2.2.33952.39688>
- Osuji, E.E., Igberi, C.O., & Ehirim, N.C. (2023). Climate Change Impacts and Adaptation Strategies of Cassava Farmers in Ebonyi State, Nigeria. *Journal of Agricultural Extension*, 27 (1) 35-48. <https://dx.doi.org/10.4314/jae.v27i1.4>
- Pickson, R.B. and He, G. (2021). Smallholder Farmers’ Perceptions, Adaptation Constraints, and Determinants of Adaptive Capacity to Climate Change in Chengdu. *Sage Open*, 11(3): 1–16. <https://doi.org/10.1177/21582440211032638>
- Regmi, H.P., Sreedhar Upendram, Seong-Hoon Cho & Christopher D. Clark (2023). Examining complementary relationships among climate change adaptation practices of rice producers in Chitwan, Nepal. *Climate and Development*, 15(6): 480-500, <https://doi.org/10.1080/17565529.2022.2107980>
- Solaja, S., Ayorinde, K., Toluwalase, A., Opeyemi, O., Wale, A., Ibukun, O., Gideon, N., Ruth, A., Stephen, E., Faithfulness, O., Oluwatosin, A. & Isibietmfon, N. (2024). Assessment of smallholder rice farmers’ adaptation strategies to climate change in Kebbi state, Nigeria. *Heliyon* 10 (2024) e35384, <https://doi.org/10.1016/j.heliyon.2024.e35384>
- United Nations Climate Change (2022). Conflict and climate change. Retrieved from <https://www.unfccc.int/news/conflictandclimate#:~:text=The%20evidence%20is%20clear%20that,climate%20change%20into%20conflict%20risks>
- World data (2022). Climate: Niger state, Nigeria. Retrieved from <https://www.worlddata.info/Africa/nigeria/climate-north-central.php>
- World Meteorological Organization (2021). Climate change triggers mounting food insecurity, poverty and displacement in Africa. Press release, 19 October 2021. Retrieved from <https://wmo.int/news/media-centre/climate-change-triggers-mounting>

- Yakubu, D.H. & Oladele, O.I. (2021). Determinants of Use of Climate Change Adaptation Practices by Rice Farmers in Kebbi State, North-West Nigeria. *Problems of World Agriculture*, 21(1), 52–69; <https://doi.org/10.22630/PRS.2021.21.1.4>
- Yakubu, D.H., Akpoko, J.G., Akinola, M.O. & Abdulsalam, Z. (2021). Assessment of perceived effects of climate change on rice production among farmers in North-west zone, Nigeria. *Ghana Journal of Agricultural Science*. 56 (1), 48 – 64: <https://dx.doi.org/10.4314/gjas.v56i1.484>
- Zama, N.I., Lan, F., & Zama, E.F. (2021). Drivers of adaptation to climate change in vulnerable farming communities: a micro analysis of rice farmers in Ndop, Cameroon. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 122 (2) 231–243. <https://doi.org/10.17170/kobra-202110274961>
- Zamasiya, B., Nyikahadzoi, K., Mukamuri, B. B. (2021). Drivers of level of adaptation to climate change in smallholder farming systems in Southern Africa: A multilevel modeling approach. In: Oguge, N., Ayal, D., Adeleke, L., da Silva, I. (eds), *African Handbook of Climate Change Adaptation*, (pp. 213–224). Springer, Cham. Switzerland. https://doi.org/10.1007/978-3-030-45106-6_52