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Heterogeneity of adaptation strategies to climate shocks: Evidence from the Niger Delta region of Nigeria

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Abstract. There is overwhelming evidence to suggest that climate shocks undermine food security and livelihood well-being of the climate-impacted Niger Delta region of Nigeria. Employing survey data collected from farming and fishing households in the Niger Delta region of Nigeria, the study investigated the range of adaptation practices prevalent in the region, as well as factors influencing the adoption of these adaptation strategies. Five hundred and three (503) households (252 fishing households and 251 farming households) were selected using multi-stage sampling techniques. Multinomial logit model was used to determine factors affecting the household choice of adaptation strategies. The results show that adaptation strategies adopted by farming households were livelihood diversification (78.5%), crop management (77.7%), and soil and water management (64.5%). Factors influencing their choice of adaptation strategies were age, gender, household size, education, extension, and farm size. The adaptation strategies employed by the fishing households were livelihood diversification (83.61%) and intensification [which include the use of improved fishing gears (80.33%), varying fishing locations (67.21%), and expanding area of fishing (40.98%)]. Uncovering the heterogeneity in adaptation and resilience aspects to climate shocks has immense practical significance, particularly in providing targeted assistance for the two livelihood groups' adoption.

Keywords: Climate shocks, crop farmers, Fish farming, Adaptation strategies, Developing nations.
JEL codes: Q13, Q22, Q54.

1. INTRODUCTION

Crop farming and fishing constitute the main economic activity of rural people especially in Sub-Saharan Africa (Giller, 2020). It is a source of livelihood for about 70-80% of the population and accounts for 30% of the GDP and 40% of the foreign exchange earnings of most nations in Sub-Saharan Africa (Bezner Kerr et al., 2019). As climate conditions change all over the

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world, there are increasingly multiple and uneven risks to societies (Arfini, 2021). In Nigeria for instance, farming and fishing constitute the main livelihood strategy for over 70% of the teaming rural population. In the Niger Delta region of Nigeria, despite the abundance of oil in the region, about 60% of the population of these rural people depend on farming for their life sustenance and livelihood (Fund World Life, 2018). Studies have also shown that the shock and impact are more on farmers in the Niger Delta region (Fund World Life, 2018; PEDI, 2020), as most of the areas in the Niger Delta region are coastal areas and as such are bedevilled with a number of environmental challenges and flood-related disasters. Also, like in most African countries, there is an over-dependence on rain-fed agriculture in the Niger Delta region of Nigeria, as well as limited adaptive capacity among the farmers (Ume, 2017). According to Akpoti et al. (2021), over-dependence on the natural environment in the face of climate change, without an adequate safety net, exposes these farmers to climate shocks, which negatively affect productivity and sustainable development. The future sustainability of the agricultural sector and food security in the region will depend on the adaptation strategies adopted by farming and fishing households (Bandara & Cai, 2014; Kahsay & Hansen, 2016). This study, therefore, seeks to investigate the range of adaptation practices prevalent in the region, as well as factors influencing the adoption of these adaptation strategies.

As developing countries have been projected to be more impacted by climate change, adaptation has been increasingly identified as the policy option to help cope with the negative impact of climate change (Ford et al., 2011; Lamonaca et al., 2021). According to the IPCC (2001), adaptation is the ability of a system to adjust in response to actual or expected climatic stimuli to reduce harm and cope with the resulting condition. The importance of mainstreaming climate change adaptation into farming activities for sustainable development is evident, and considerable research has investigated the determinants of adoption of climate change adaptation strategies among farmers in the global south, although reviews reveal mixed evidence thus far (Bezner Kerr et al., 2018; Fosu-Mensah et al., 2012; Ume et al., 2021; Zazu & Manderson, 2020). For instance, Ume et al. (2021) concluded from 14 studies in Southeast Nigeria that the gender of the farmer has a significant effect on adaptation, while Enete & Amusa (2010) found an indeterminate influence of socioeconomic factors such as age, education, and gender on adaptation. In Ghana Fosu-Mensah, Vlek, & MacCarthy (2012) found access to extension services, credit, soil fertility, and land tenure to be the major factors that influenced farmers' perception and adaptation. The authors suggested a need for more empirical investigations to establish coherence in the literature.

In contrast to the large literature on determinants of adaptation among crop farmers in the developing nations, research documenting the range of adaptation practices prevalent in the region is sparse: our literature search identified only three studies. Wetende et al., (2018) documented the different climate change adaptation strategies employed by smallholder dairy farmers in the Siaya Sub-County of Western Kenya. Sinharoy et al. (2018) assessed the determinants of crop farmers' choice of coping methods to climate change and variability in Ethiopia and usefully documented the adaptation method employed by highlands farmers. Onyeneke et al. (2018) presented the status of climate-smart agriculture in Nigeria, and categorized them into mobility and social networks, adjusting agricultural production systems, diversification on and beyond the farm, farm financial management, and knowledge management and regulations. We expand these available adaptation options in literature by documenting additional adaptation strategies and innovative agroecological farming and fishing methods that farmers in the Niger Delta region of Nigeria employ.

This paper contributes to the existing literature in three key ways. First, as highlighted above, very few studies have systematically examined the different adaptation options employed by farmers in developing nations, and these studies did not consider the peculiar vulnerabilities of riverine dwellers and fish farmers. According to the IPCC (2014), vulnerability describes a set of conditions derive from the prevailing cultural, historical, social, political, environmental, and economic contexts. For a long time, the Niger Delta region has been exposed to various degrees of environmental degradation and conflicts, hence can be referred to as a vulnerable region not only because they are exposed to climate hazards but because of everyday patterns of marginality and neglects experienced by farmers in this region.

Second, the determinants of adaptation have been extensively covered in the literature. However, empirical evidence in the context of the Niger Delta region is largely scarce. More so, the underlying drivers of adaptation are complex, and have not been fully understood (Bezner Kerr et al., 2018). Recent studies suggest that they differ from place to place according to location-specific factors (Komba & Muchapondwa, 2015; Meadows, 2008). Furthermore, there is variation in the level of influence of different determinants of adaptation, which makes it difficult to generalize findings (Ume et al., 2020). As stated by Fosu-Mensah et al. (2012) the determinants of adaptation to climate change among smallholder farmers in the developing economies are still contentious issues, thus, making further empirical study necessary to clarify uncertainties and establish a coherent scholarship.

Finally, we are not aware of any previous study that examined the different adaptation options for fish farmers in West Africa, though the fishery sector is widely acknowledged to have the potential of improving the nutritional status of the rural population. Previous research on climate change adaptation among farmers has mostly concerned with crop farmers (Amare & Simane, 2017; Onyeneke et al., 2018; Ume et al., 2022), with a few recent studies on dairy and livestock innovations (Apata, 2011; Wetende et al., 2018). We add another empirical point to this expanding literature with evidence on adaptation options for fish farmers. Importantly, the findings from this study can help guide development interventions, on the best way to frame an approach that will engender better climate change adaptation among farmers in the coastal regions in the developing nations and beyond.

The rest of the paper is structured as follows: Section 2 presents the theories underlying determinants of adaptation strategies, Section 3 describes the methodology used in the study, Section 4 presents the empirical results, followed by section 5 which details our conclusions and policy implications.

2. THEORY UNDERLYING DETERMINANTS OF ADAPTATION STRATEGIES: UTILITY MAXIMIZATION AND PROTECTION MOTIVATION

For explaining the choice of adaptation strategies adopted by households, the utility maximization theory is used. Households are assumed to be rational beings; hence they choose adaptation options that maximize their expected utility among the available options (Amare & Simane, 2017; Gebrehiwot & van der Veen, 2013; Menozzi et al., 2015). The limitation of this theory is that in the real world this may not always apply as there are other factors that may affect the behaviour of households. If U_i and U_j represent the household's utility for any two adaptation options. Following Greene (2000) the random utility model can be stated thus:

$$U_{it}=V_{it}+\varepsilon_{it},\ U_{jt}=V_{jt}+\varepsilon_{jt} \quad 2.1$$

where U_{it} and U_{jt} are the perceived utility from choosing adaptation options i and j at time t respectively; V_{it} and V_{jt} are the deterministic component and ε_{it} and ε_{jt} are the error terms of the utility function which are independently and identically distributed. Utility cannot be directly observed, it is rather indirectly observed from the choices that households make. Choice experiments assume that a household m chooses an option i at time period t, only if this adaptation option generates at least as much utility as any other option for example j, represented as:

$$U_{mit}>U_{mjt},\ j\neq i \quad 2.2$$

The probability of a household m choosing adaptation option i among the available adaptation strategies at time t can then be specified as:

$$P_{mit}=P(U_{mit})>U_{mjt}),\ j\neq i \quad 2.3$$

The second theory, which has been found to be valuable in explaining adaptive behaviours of individuals to climate change is the protection motivation theory (Cismaru et al., 2011). The theory of protection motivation was originally postulated by Rogers (1975) and applied in the field of health to explain how individuals are motivated to act in a protective manner toward a perceived health risk. However, it has since been adapted and applied in other contexts such as environmental risk and natural hazards. For instance, it has been applied to the studies of natural hazards such as earthquakes in the United States (Mulilis & Lippa, 1990), and flood in Germany and the Netherlands (Grothmann & Reusswig, 2006 and Bubeck, Botzen, Kreibich, & Aerts, 2013) and even studies on climate change adaptation (Grothmann & Patt, 2005; Keshavarz & Karami, 2016; Koerth, Vafeidis, Hinkel, & Sterr, 2013; Bockarjova & Steg, 2014). This theory postulates that individuals will act to protect themselves against a perceived risk if they perceive that the threat of that hazard, they are exposed to is severe (threat appraisal) and if the coping appraisal is high. Threat appraisal is composed of two main components: 'perceived vulnerability' (probability) and 'perceived severity' (consequences). Coping appraisal, on the other hand, consists of three components namely: 'response efficacy', 'self-efficacy' and 'response cost'. The coping appraisal is considered high if individuals perceive the protective measures available to be effective *i.e.*, able to mitigate the threat (high 'response efficacy'), easy i.e., the individuals perception of their ability to implement the required actions (high 'self-efficacy') and inexpensive (low 'response costs') (Floyd et al., 2000). The two appraisal processes influence an individual's protection motivation (Maddux & Rogers, 1983; Opata et al., 2021). However, Poussin et al. (2014) found that coping appraisal has a far-reaching effect on self-protective bahaviours by individuals than threat appraisal. Grothmann & Reusswig (2006) in their study concluded that it is just not enough to communicate the threat or risk individuals are exposed to (threat appraisal) but the benefits and cost of precautionary measures (coping appraisal) should also be included.

In this study, this theory can be adapted to explain the behaviour of households to act in a protective manner towards the perceived threat to their livelihoods occasioned by environmental and social factors (climate shock, environmental degradation, and conflict). There are two processes. In the first process, 'threat appraisal' the household assesses the threat probability for example climate shocks and the severity of the damage that will be done say to their food security or income should they choose not to act. The second process is the 'adaptation appraisal' that has three components. The first is the 'perceived adaptation efficacy', which is the perception of the effectiveness of the adaptive action in protecting one from the threat (e.g., a judgment that changing crop variety can protect one from climate shocks). The second component is the 'perceived self-efficacy which refers to the household's perceived ability to implement the adaptive action (e.g., a household might perceive that they lack the technical skills to implement a particular innovation). The third component is the 'perceived adaptation cost', which refers to the cost of taking the adaptive action (such as monetary, time, effort). Based on the outcome of these two processes the household responds to the threat. Two responses are possible: adaptation and maladaptation, while the former reduces the damage from the threat, the latter increases the damage. Some examples of maladaptive responses are denial of the threat and wishful thinking (Grothmann & Patt, 2005). One major limitation of this theory is that it does not take into account all of the cognitive and contextual factors, including the influence of social norms.

3. METHODOLOGY

3.1 Description of the study area and sampling

The study area is Niger Delta region. It is located at latitudes 4˚25'N to 6˚00'N and longitudes 5˚00'E to 7˚5'E (PEDI, 2020). It is situated on the Atlantic Coast of southern Nigeria where the River Niger divides into many branches (Uyigue and Agho 2007). It is the second biggest delta in the world having a coastline covering around 450 kilometers which ends at the mouth of Imo River (Awosika 1995). The region is divided into four ecological zones namely coastal inland zone, mangrove swamp zone, freshwater zone, and lowland rain forest zone.

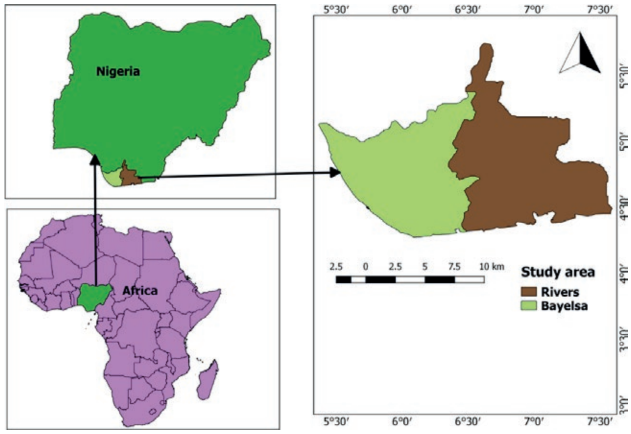

Figure 1. Map of Nigeria showing the study area.

The Niger Delta region officially comprises nine states namely, Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and River States. It has about 185 local government areas (LGAs) and over 40 ethnic groups in an estimated 3000 communities (PEDI, 2020). The region has an estimated population of about 36 million (World meter 2020), and the large majority depend on fishing and farming as a means of livelihood. Figure 1 below shows the map of Nigeria showing the two states in the Niger Delta region where data for the study was collected.

A multi-stage sampling technique was used in selecting the households used in the study. In the first stage, 2 states were purposively selected out of the nine states due to their dependence on farming and fishing, and the coastal nature of the states which predisposes them to frequent flooding and coastal erosion. In the second stage 13 local government areas (LGAs) out of 23 LGAs were selected from Rivers State purposively due to the predominance of agricultural activities and 4 LGAs out of 8 LGAs were selected from Bayelsa state. In the third stage proportional random sampling was used to select 18 and 8 communities from the selected LGAs in Rivers and Bayelsa states respectively. In the fourth stage, proportional random sampling was used in selecting the 251 farming households and 252 fishing households. A total of 503 household heads were interviewed and where the household head was not available the next available adult was interviewed. We are aware that the choice to interview the next available adult where the household head was not available could have impacted the results in some ways, but we cannot comment on the magnitude of any potential selection bias.

The United Nations (2005 p. 44-45) sample size formula (see equation 3.1) was used to determine the number of households selected for the study. Using a confidence interval (Z) of 95%, 50% default value of prevalence of indicators (r), a sample size of 430 households was required. However, to account for possible missing values and outliers, the sample size was increased to 510. In the end, only 503 of the questionnaires were valid and were used for the analysis.

$$N = \frac{[(Z^2)(r)(1-r)(f)(k)]}{[(p)(n)(e^2)]} \quad 3.1$$

Where: N= sample size,
Z = confidence interval (95% level is 1.96),
r = estimate of key indicators being measured (default value is 0.5),
f = sample design effect (has a default value of 2),
k = multiplier accounting for non-response (1.1),
p= proportion of the total population accounted for by the target population (0.4),
n = mean of household size (5),
e = precision level (10% precision level equals 0.01r)

3.2 Data collection

Both secondary and primary data were collected for the study. The secondary data on temperature and rainfall were collected from the Nigerian Meteorological Agency (NIMET). The primary data on quantitative information was obtained from households of farmers and fishermen. Structured questionnaires were employed. To ensure the reliability and validity of the survey instrument, the survey instrument was given to 3 experts for validation. Questionnaires were pre-tested on 10 respondents and modifications were done where necessary before actual data collection (e.g., we modified the framing of some questions that appeared ambiguous to better target the goal of the study). The questionnaires were administered between March and April 2018. The questionnaires had sections on household socio-demographic and institutional characteristics, perceptions of climate shocks and impact, and adaptation strategies (for a detailed description of the type of questions asked see supplementary materials). The secondary data comprises annual temperature and rainfall data for the region for the period between 1982 and 2018. Rainfall was measured in millimeters (mm) and temperature in degrees Celsius (°C). For ethical considerations, we included an informed consent form to the introductory note on the purpose of the survey and the survey team used it to obtain verbal consent of each respondent's willingness to participate in the survey.

3.3 Econometric estimation

To identify adaptation strategies employed by the two livelihood groups descriptive statistics such as percentages were employed. First, the respondents were asked if they've experienced any changes in the temperature and rainfall pattern in the last 30 years. Where the answer is yes, a follow question is asked on the strategies used to adapt to these changes. Some of the respondents reported having been using some of the management practices before the changes but had to intensify their use with the recent changes in climate, while some reported that they only started using the management practices in response to the climate change. In this study the adaptation strategies employed by farmers have been grouped into three namely: soil and water management, crop management and livelihood diversification while adaptation strategies employed by fishermen have been grouped into two: intensification and livelihood diversification.

To determine factors influencing choice of adaptation strategies by the two livelihood groups the multinomial logit model was used. The multinomial logit and multinomial probit models are usually used to analyse adoption decisions involving multiple choices such as adaptation decisions that are made jointly (Wooldridge, 2002 Madalla, 1983). Given the myriads of possible drivers of climate change adaptation, Zucaro et al., (2021) propose the need for applying multi-criteria analysis to select the most effective climate change adaptation measures. However, the choice of the multinomial logit model over the multinomial probit is because it is computationally easier to calculate the choice probabilities which are expressible in analytical form (Tse, 1987). It provides a suitable closed form for underlying choice probabilities, ruling out the need for multivariate integration and this makes it easy to compute choice situations with several alternatives. The computation is also made easier as a result of its likelihood function which is globally concave (Hausman & McFadden, 1984). The limitation of the model is the independence of irrelevant alternatives (IIA) property. This assumption states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Hausman & McFadden, 1984; Tse, 1987). Specifically, this assumption means that the probability of using a particular adaptation strategy by a household should be independent of the probability of choosing another adaptation strategy. Hausman test was used to judge the validity of the assumption. The test is based on the fact that if an alternative is irrelevant, removing an alternative or several alternatives from the model should not change the coefficients systematically. The result of the Hausman tests of IIA assumption (Appendix 1 and 2) showed that null hypothesis: Odds (Outcome-J vs Outcome-K) are independent of other alternatives (P>chi2 =.), hence does not violate the assumption that the probability of using a particular adaptation strategy by a household should be independent of the probability of choosing another adaptation strategy.

To describe the multinomial logit model let A_i denote a random variable representing the adaptation strategy adopted by any household (already identified). We assume that each household faces a set of discrete, mutually exclusive options for adaptation strategies. These strategies are assumed to depend on a number of households, institutional, environmental and other attributes X. The multinomial logit model specifies the relationship between the probability of choosing alternative A_i and the set of explanatory variables X as seen in equation 3.2 (Greene, 2003):

$$Prob(A_i = \text{j}) = \frac{e^{\beta_j x_i}}{1+\sum_{k=1}^{j} e^{\beta_k x_i}}, j = 1,2 \ldots . J \qquad 3.2$$

In this study the adaptation strategies employed by farmers have been grouped into three namely: soil and water management, crop management and livelihood diversification while adaptation strategies employed by fishermen have been grouped into two: intensification and livelihood diversification. The independent variables used in the model are listed in Table 3.1.

Estimating equation 3.2 gives the J log-odds ratio in equation 3.3.

$$\ln\left(\frac{\partial P_j}{\partial x_i}\right) = x_i'(\beta_j - \beta_k) = x_i'\beta_j, \ if \ k = 0 \qquad 3.3$$

The coefficient β_j of the multinomial logit model only shows the direction of the effect of the explanatory variable on the dependent variables (adaptation option) and does not provide the actual magnitude of the change or probability. Therefore, differentiating equation (3.2) above with respect to the independent variables gives the marginal effects of the independent variables and is stated in equation 3.4:

$$\frac{\partial P_j}{\partial x_i} = P_j\left(\beta_j - \sum_{k=0}^{J} P_k \beta_k\right) \qquad 3.4$$

Marginal effects measure the expected change in the likelihood of a particular adaptation strategy being chosen with respect to a unit change in an explanatory variable from the mean (Greene, 2000). The signs of the marginal effects and respective parameter estimates may vary, this is because marginal effects depend on the sign and magnitude of all other parameter estimates. Some studies (e.g., Amare & Simane, 2017; Atinkut & Mebrat, 2016; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Gunathilaka, Smart, & Fleming, 2018) have adopted the multinomial logit model to assess the determinants of adaptation strategies employed.

3.4 Model specification

Household socio-economic, institutional, farm level, environmental and location characteristics were hypothesized to influence the choice of adaptation strategies employed. The following explanatory variables were considered in the multinomial model: educational level, household size, age of household head, years of experience in farming/fishing, sex of household head, household income, access to extension services, membership of association, access to information on climate change, access to credit, farm size, perception of shift in temperature, perception of shift in rainfall and location. The empirical model is stated in equation 3.5.

$$\boldsymbol{ADS_i = B_0 + B_n S_n + B_m I_m + B_z I_z} \qquad \mathbf{3.5}$$

Where ADS_i denotes the adaptation strategies employed by farming or fishing households, S, B and I represent the sociodemographic, institutional, and climatic factors, respectively. B_0 denotes the intercept; B_n, B_m and B_z denote the parameters estimates for each sociodemographic (n), institutional (m) and climatic (z) factor.

A description of the explanatory variables used in the model, the measurement and the apriori expectation has been presented in Table 1.

4. RESULTS AND DISCUSSION

4.1 Household characteristics and climatic patterns

Descriptive results are presented in Table 2 and Figures 2-5. Based on the results, about 62% of the sampled households were male-headed households, the majority (77.3%) of them were married and only a few (3%) of them had no formal education. This profile on marital status is higher than the national average, where about 58% of the population are married, but lower in terms of education where literacy rate reached 77.62% in 2021 (Statistica, 2022). Most (94%) of the households had no access to extension services, no access to credit (about

Table 1. Description of explanatory variable and hypothesized signs.

Variable	Description	Measure	Apriori expectation
Sociodemographic factors			
Educ	Years of education	Continuous (years)	+
HHsize	Size of household	Continuous (number)	+/-
Age	Age of household head	Continuous (years)	+/-
Exp	Farming/fishing experience	Continuous (years)	+/-
Sex	Sex of household head	Dummy (1=male, 0=female)	+/-
HHincome	Household income	Continuous (naira)	+
Fsize	Farm size	Continuous (hectares)	+/-
Institutional factors			
Ext	Access to extension services	Dummy (1=yes, 0=no)	+
Asso	Membership of association	Dummy (1=yes, 0=no)	+
Info	Information on climate change	Dummy (1=yes, 0=no)	+
Cred	Access to credit	Dummy (1=yes, 0=no)	+
Climate factors			
Temp	Perception of shift in temperature	Dummy (1=yes, 0=no)	+
Rain	Perception of shift in rainfall	Dummy (1=yes, 0=no)	+
State	Location	Dummy (1=Bayelsa, 0=Rivers)	+/-

Source: Author.

88%) and do not belong to any farmer/fisher-based association (89%). This finding corresponded to the national average as reported in Emeana (2017) who reported a farmer to extension service ration of 1:10. About 79% of the households had access to health care which is lower than the national average where over 90 percent of Nigerian households reported being able to access necessary healthcare (Statistica, 2022). About 51% of the households were engaged in off-farm work, this is close to the national average as reported in Ume, Nuppenau and Domptail (2022). On average, the sampled household heads were aged 48 years, had 9 years of schooling, a household size of 7, a farming/fishing experience of 25 years, and farm size (for farming households) of 0.3 hectares. There were no significant differences in the age, experience, household size, access to credit, and access to climate information by farming and fishing households which is evident from the two samples mean comparison test. However, there were significant differences in the gender, years of schooling, membership in social networks, access to extension services, household income, and perception regarding changes in temperature and rainfall by farming and fishing households.

Responses on farmers' perception about long-term temperature and rainfall changes (Figure 2) show that majority (84.46%) of the surveyed households perceived that the temperature has increased over the last 20 years, 12.75% perceived that it has decreased while the remaining 2.79% did not perceive any change. On the other hand, majority (63.49%) of the respondents perceived that precipitation has decreased, 31.75% perceived that there has been an increase in rainfall while the remaining 4.76% have not observed any change. The perception of households regarding climate shocks has serious implications as to whether to adapt or not and the type of adaptation strategies to adopt. Households cannot adapt to what they do not perceive or experience. Some studies show that farmers who perceive or experience climate related risks are more likely to plan for adaptation (Al-Amin et al., 2019; Habtemariam et al., 2020; Mahmood et al., 2021)

Furthermore, descriptive analysis presented the annual temperature and rainfall data for the region for the period between 1982 and 2018 as shown in Figures 3, 4, and 5. This also validated the local perception of the long-term change in temperature and rainfall. This aligns with the findings of Mahmood et al., (2021) who found that the farmers' perception of the local climate was consistent with historical meteorological trends of temperature and rainfall from 1980 to 2017.

The rainfall data showed a large negative deviation compared to their long-term means (dotted lines) for most years particularly between 1982-1983 and 1992-1998 indicating high rainfall variability (Figure 3). The rainfall data revealed that the annual rainfall increased by 2.29 mm every decade. This result does not corroborate the local perception of observed decrease in rainfall. However, the findings are consistent with Koomson et

Table 2. Summary statistics of household characteristics.

Variables	Description	Full sample Mean	Farmers Mean	Fishers Mean	t-test *t*-value
Age	Age of HH head (years)	47.75 (12.60)	47.48 (13.48)	48.02 (11.68)	-0.48
Gender	Gender of HH head (1= male; 0 = female)	0.62 (0.49)	0.39 (0.49)	0.86 (0.35)	-12.31***
Experience	Farming/fishing experience of HH head (years)	24.97 (13.81)	25.19 (14.74)	24.75 (12.86)	0.36
Household size	Number of HH members	7.42 (2.55)	7.41 (2.74)	7.43 (2.36)	-0.10
Education	Formal education of HH head (years)	9.07 (4.50)	9.61 (4.63)	8.54 (4.30)	2.69***
Access to credit	HH had access to credit services (1 = yes, 0 = no)	0.12 (0.33)	0.15 (0.36)	0.10 (0.30)	1.65
Social network	HH had membership in local organization (1= yes, 0 = no)	0.11 (0.31)	0.15 (0.36)	0.07 (0.25)	2.92***
Extension	HH had access to extension services (1= yes, 0 = no)	0.06 (0.24)	0.08 (0.28)	0.04 (0.19)	2.28**
Access to climate information	HH had access to information on climate (1=yes, 0=no)	0.49 (0.50)	0.49 (0.50)	0.50 (0.50)	-0.13
Farm size	Size of land cultivated (hectare)	-	0.63 (0.54)	-	-
Household income	Total HH annual income (₦)	821805.2 (718922)	610908.5 (529628)	1031865 (815801)	-6.86***
Perception of shift in temperature	HH perceived that temperature has changed over the last 30 years (1 = yes, 0 = no)	0.78 (0.42)	0.88 (0.33)	0.68 (0.47)	5.25***
Perception of shift in rainfall	Perception of change in rainfall has changed over the last 30 years period (1 = yes, 0 = no)	0.64 (0.48)	0.74 (0.44)	0.53 (0.50)	4.99***
Location	HH located in Bayelsa (1= Bayelsa, 0 = otherwise)	2.99 (1.00)	3.00 (1.00)	3.00 (1.00)	0.04
	HH located in Rivers (1= Rivers, 0 = otherwise)	2.99 (1.00)	3.00 (1.00)	3.00 (1.00)	- 0.04

Note: ***, ** and * indicate 1%, 5% and 10% level of significance respectively; 1 USD = ₦380; Values in parenthesis are standard deviations. Source: Field survey, 2018.

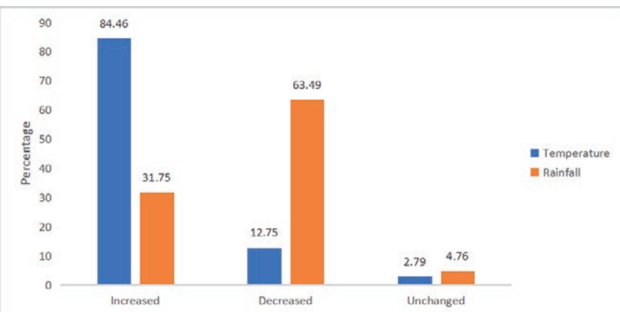

Figure 2. Local perception of long-term temperature and rainfall changes. Source: Field survey (2018).

al. (2020), who showed an overall increase in rainfall in the last decade in Effutu Municipality, Ghana from 1989 to 2018.

As expected, the minimum temperature data showed less dramatic variability over time with overall warming being noticeable, particularly in the middle of the temporal span (Figure 4). The period between 1989 and 2012 had lower temperatures than the annual mean minimum temperature of 22.4°C. The analysis of the descriptive results further showed that the mean annual minimum temperature increased by 0.01°C every decade. The annual mean maximum temperature (Figure 5) shows a more dramatic variability over time than the annual minimum temperature and is increasing at a faster rate of 0.02°C per decade. The annual mean temperature shows a less dramatic variability over time than the annual maximum temperature and is increasing at a rate of 0.01°C per decade. This evidently shows that the days are warming over time. From the analysis of the temporal data, it can be inferred that the local percep-

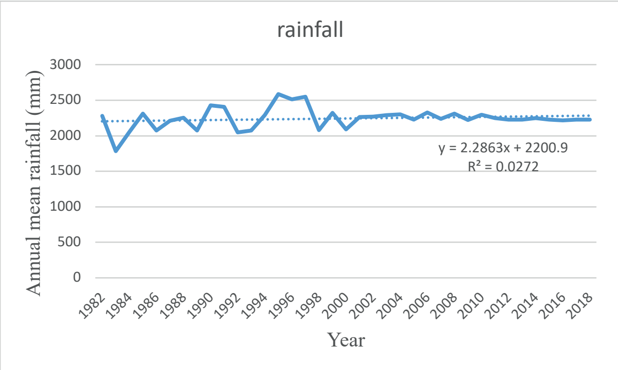

Figure 3. Interannual variability in rainfall in the study area between 1982-2018. Source: Author's creation from CRU climate data.

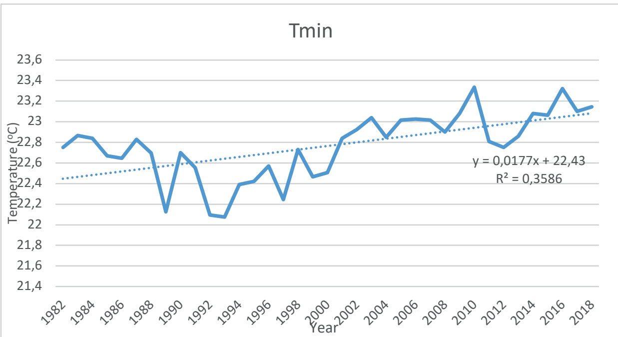

Figure 4. Interannual variability in minimum temperature in the study area between 1982 and 2018. Source: Author's own creation from CRU climate data.

tion of climate variability agreed with the historical data on temperature.

4.2 Adaptation strategies to climate shocks

The adaptation strategies the farming households employed were grouped into three (3) categories for computational ease. They include soil and water management, crop management, livelihood diversification, and the 'no adaptation' option, which was used as the base category in the MNL. In this study, the following adaptation strategies (cover crops, deep tillage, hedging, mulching, ridge cultivation, and run-off harvesting) were grouped into the soil and water management component (SWM). Crop rotation, crop diversification, agroforestry, changing of planting and harvesting dates, use of improved and drought resistant varieties were grouped under crop management component (CM). Engagement in off-farm and non-farm activity was grouped under livelihood diversification component (LD). Majority (78.5%) of the

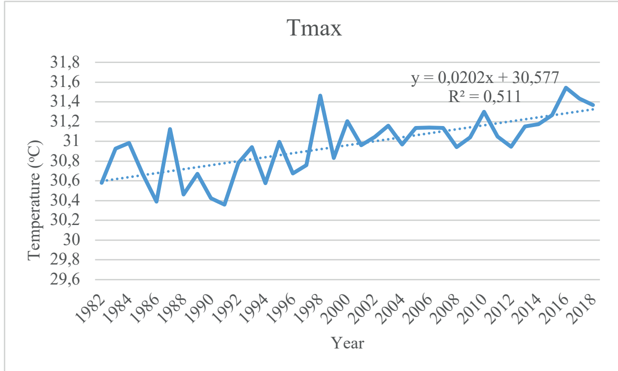

Figure 5. Inter-annual variability in maximum temperature in the study area between 1982 and 2018. Source: Author's own creation from CRU climate data.

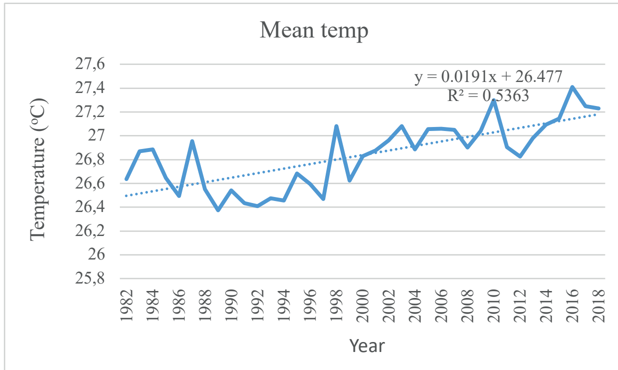

Figure 6. Inter annual variability in mean temperature in the study area between 1982 and 2018. Source: Author's creation from CRU climate data.

surveyed farming households used livelihood diversification as an adaptation option (Table 3). This is followed by crop management (77.7%) and soil and water management options (64.5%). However, 10% of the farming households mentioned that they do not use any adaptation strategies. Similar studies which have found that farmers adopted some of the above-mentioned strategies are (Khanal et al., 2018; Mahmood et al., 2021; Owusu et al., 2021; Shikuku et al., 2017).

Furthermore, the adaptation strategies the fishing households employed were categorized into two: intensification and livelihood diversification for the purpose of computational ease (Table 3). Use of improved gears, extension of working hours, varying fishing locations and fishing over large expanses were grouped as intensification. Engagement in off-fishing and non-fishing activities were grouped as livelihood diversification. The 'no adaptation' option was included in the

Table 3. Adaptation strategies employed by farming and fishing households in the study area.

Adaptation options	Frequency	Percentage (%)
Farmers		
Soil and water management (SWM)	162	64.54
Cover crops	106	42.23
Deep tillage	130	51.79
Hedging	58	23.11
Mulching	33	13.15
Ridge cultivation	69	27.49
Run-off harvesting	12	4.78
Crop management (CM)	195	77.69
Crop rotation	118	47.01
Crop diversification	143	56.97
Agroforestry	12	4.78
Changing of planting and harvesting date	168	66.93
Improved and drought resistant varieties	157	62.55
Livelihood diversification (LD)	197	78.49
Fishing households		
Intensifying fishing efforts	49	80.33
Using improved fishing gear	36	59.02
Extending working hours	41	67.21
Varying fishing location	25	40.98
Fishing over large expanse		
Livelihood diversification	51	83.61

Note: multiple responses indicated.
Source: Field Survey (2018).

computation of factors influencing choice of adaptation strategies. Majority (83.61%) of the surveyed fishing households used livelihood diversification as an adaptation option. This is followed by use of improved gears (80.33%) and varying fishing locations (67.21%) while the least used strategy was fishing over large expanse (40.98%). Similar studies which reported fishers using the afore mentioned adaptation strategies are (Deb & Haque, 2017; Galappaththi et al., 2019, 2021; Kabisa & Chibamba, 2017; Mabe & Asase, 2020; Yanda et al., 2018).

4.3 Determinants of choice of adaptation strategies

4.3.1 Determinants of choice of adaptation strategies by farming households

The decision to choose a certain adaptation strategy is based on several socio-demographic, economic, institutional, and biophysical factors, which are estimated using the multinomial logit model. The results of the multinomial logit model are presented in Table 4. The marginal effects of all the explanatory variables have been reported.

The results indicate that age of household head positively and significantly affected the probability of adopting soil and water management practices as an adaptation strategy at probability level of 0.05. The magnitude of this effect is 0.003. This suggests that the likelihood of adopting soil and water management practices increases by 0.3% for every year of household head age. A plausible explanation for this result is that older farmers are more experienced and more likely to experience changes in climate and therefore, adopt adaptation strategies to cope with the change. For instance, the study by Al-Amin et al. (2019) showed that older women were more likely to perceive climate change than younger women. Previous studies that reported that age positively affected the adoption of adaptation strategies to climate change include Adimassu & Kessler (2016); Opiyo et al., (2016); Alemayehu & Bewket (2017) and Belay & Fekadu (2021), while others like Kassim, Alhassan, & Appiah-Adjei (2021) and Ali & Erenstein (2017) contradicted the results by reporting negative and significant relationship of age with early planting adaptation strategies in Ghana and crop management (*i.e.*, adjustment in sowing time, drought-tolerant varieties and shift to new crops) in Pakistan.

The result shows that gender of household head exerts a positive and significant ($p<0.1$) influence on the adoption of soil and water management practices. This means that male-headed households are 13% more likely to use soil and water management practices as an adaptation strategy than female headed households. This is probably because male-headed households have better access to resources and information as well as higher decision power to make decisions regarding adaptation. Previous studies that corroborate these findings include Asfaw & Admassie (2004), Deressa et al., (2014), Deressa et al., (2009) Mahmood et al., (2021). On the other hand, gender was found to influence the adoption of livelihood diversification as an adaptation strategy negatively and significantly ($p<0.1$). The marginal effect of the variable is -0.1841. This means that female-headed households had an 18% higher chance of adopting livelihood diversification as an adaptation strategy. This result is in agreement with the findings of Amare & Simane (2017) and (Kassim et al., 2021) who found that female headed households diversified more and are more likely to engage in off-farm activities. However, it contradicts the findings of Asfaw et al., (2017) and Rahman & Akter (2014) who found that males adopted non-farm livelihood diversification more than females because of their involvement in household chores which leaves them with little or no time to engage in off-farm activities.

Household size was found to influence the adoption of crop management practices positively and sig-

Table 4. Multinomial regression results for determinants of adaptation strategies by farming households.

Explanatory variables	Soil and water management Marginal effects	Crop management Marginal effects	Livelihood diversification Marginal effects
Age	0.003** (0.061)	-0.002 (0.015)	0.000 (0.019)
Gender	0.127* (1.164)	0.023 (-0.326)	-0.184* (-0.889)
Household size	-0.0135 (-0.048)	0.089*** (0.353)	-0.061 (0.002)
Education	0.006* (0.188)	0.023** (0.142)	-0.021 (0.036)
Access to credit	-0.067*** (-0.226)	0.113 (1.672)	0.036 (1.532)
Social network	-0.559** (-0.583)	-0.028 (0.619)	0.131 (0.985)
Extension	0.113 (0.148)	0.037 (-0.849)	-0.218*** (-1.983)
Access to climate information	0.036 (0.689)	-0.136* (-0.168)	0.112 (0.422)
Farm size	0.091** (-0.433)	-0.042 (0.867)	0.218*** (1.517)
Perception of shift in temperature	-0.018 (-0.507)	0.036 (-0.177)	-0.039 (-0.355)
Perception of shift in rainfall	0.015 (0.074)	0.181** (0.271)	-0.211 -0.661
Constant	-4.695**	-3.684	-0.013
Diagnostics			
Number of observations	251		
LR(33)	128.64		
Prob > chi2	0.0000		
Log likelihood	-240.00978		
Pseudo R^2	0.2113		

Note: Base category: no adaptation; ***, ** and * indicate significance at 1%, 5% and 10% respectively. Values in parentheses are the standard errors.
Source: Field survey (2018).

nificantly ($p<0.01$). As household size increases by one the probability that the household will adopt crop management practices increases by 8.9%. This is probably because activities involved in crop management are capital intensive and so only large households size who have household members engaged in other income generating activities that generate extra income to invest in this adaptation option. In addition, it is understandable that large households would like to engage their workforce in different income generating activities and hence are more likely to diversify. Another reason could be that most agricultural activities in Nigeria are labour intensive due to low mechanization; large household size therefore constitutes a source of labour to enable households engage in adaptation practices and other agricultural practices such as tree planting, soil conservation and other crop management practices. This result is in agreement with the findings of Shikuku et al., (2017), Ali & Erenstein (2017), Habtemariam et al., (2020) and Diallo, Donkor, & Owusu (2021) who found that large households are more likely to adopt adaptation strategies such as changing planting date, improved varieties and planting of trees.

The variable education exerts a positive and significant effect on farming households' decision to adopt soil and water management and crop management practices as an adaptation strategy to climate shocks albeit at the 10% and 5% levels. The marginal effects result thus indicates that an increase in the year of schooling by 1 year increases the probability that households will adopt soil and water management and crop management practices by 0.6% and 2.3% respectively. This is expected as education provides more understanding as to the impacts of climate change as well as adaptation methods to be adopted to be able to cope with these impacts. This result is in agreement with previous studies such as Alauddin & Sarker (2014), Alam et al., (2016), Khanal et al., (2018), Belay & Fekadu, (2021) Mahmood et al., (2021) and Kassim et al., (2021) which reported the positive influence of education on adaptation.

Interestingly, access to extension services was found to exert no significant influence on the adoption of soil and water conservation and crop management but was found to exert a significant ($p<0.05$) and negative effect on the adoption of livelihood diversification as an adaptation strategy. This means that households with no access to extension services are 21.8% more likely to adopt livelihood diversification as an adaptation strategy. This is contrary to apriori expectations as extension agents are expected to be at the forefront of communicating climate information and innovations in agriculture. A plausible explanation for the negative effect could be that households with no access to extension services are equipped with information on other adaptation strategies such as off-farm activities that they could choose. Another plausible explanation could be the weakness of the extension delivery system typically in most African countries as pointed out by Oladele & Sakagami (2004) and Antwi-Agyei & Stringer (2021) which include poor financial decentralization, inadequate use of alternative extension methods, lack of knowledge on climate change by extension agents, high bureaucratic setting and inadequate cooperation and coordination with other agencies. Most previous studies such as (Al-Amin et al., 2019; Alemayehu & Bewket, 2017; Ali & Erenstein, 2017; Habtemariam et al., 2020; Kassim et al., 2021) have often reported positive effects of extension service on adoption of adaptation strategies such as use of improved varieties, soil and water conservation practices. However, our finding is consistent with the findings of Owusu et al., (2021) and Shikuku et al., (2017) who reported a negative effect of extension services on adoption of adaptation strategies.

Farm size was found to exert a positive and significant influence on farming household decisions to adopt soil and water management practices and livelihood diversification as an adaptation strategy to climate shocks at 5% and 1% levels respectively. A unit increase in farm size increases the chances of adoption of livelihood diversification and soil and water management practice as an adaptation strategy by 22% and 9.1% respectively. This means that households with larger farm sizes were more likely to diversify more probably to generate additional income for adaptation and expand production. They are more likely to have capacity to invest in climate shock adaptation options. It could also be that farming households with large farm sizes are more worried about the impact of climate shocks since they are more likely to lose a larger proportion of their output compared to those with smaller farm sizes and so are not willing to take the risk. Hence, their eagerness to adopt livelihood diversification and soil and water management practices to off-set any adverse effects. This result contradicts the findings of Deressa et al., (2011); Bazezew et al., (2013) and Gebreyesus (2016) that reported that farm size negatively affects the probability of using livelihood diversification as an adaptation measure. However, it agrees with the findings of (Al-Amin et al., 2019; Ali & Erenstein, 2017; Kassim et al., 2021) who reported positive effect of farm size on adaptation strategies such as upland planting, planting of horticultural crops and improved varieties.

Another interesting finding is access to credit which was found to exert negative and significant effect on the probability to adopt soil and water conservation as an adaptation strategy at 1%. This means that credit constrained households are 6.7% more likely to take up soil and water conservation as an adaptation strategy. This finding is consistent with the findings ofTeklewold et al., (2019) who found that households with lack of access to credit are more likely to take up soil conservation practices. However, it contradicts studies such as Al-Amin et al., (2019), Diallo et al., (2021), Shikuku et al., (2017), Belay & Fekadu, (2021) which all argued that households with access to credit are more likely to take up adaptation strategies such as soil and water conservation and crop management practices since access to capital is a major deciding factor in the choice to adopt an innovation and hence required to facilitate adoption of adaptation strategies.

Again, the variable social network also showed some interesting results. It was found to exert a negative and significant influence on the adoption of soil and water management practices as an adaptation strategy against climate shocks at a 5% level. This means that those who do not belong to any farmer-based organizations or groups are 55.9% more likely to adopt soil and water conservation as an adaptation strategy. This is contrary to apriori expectation since studies such as Teklewold et al., (2019), and Owusu et al., (2021) have shown that social capital networks positively influence adoption of adaptation strategies and innovation. The reason for the negative influence could be that the farmers belonged to several organizations and received conflicting climate change information from several sources. However, our finding is consistent with the findings of Belay & Fekadu (2021), Diallo et al., (2021) and Al-Amin et al., (2019) who found that social capital negatively influences farmers' adoption of climate change adaptation strategies such as fertilizer, short duration and drought tolerant varieties.

Perhaps again somewhat surprisingly, access to information was found to exert negative and significant effect on the adoption of crop management as an adaptation strategy albeit at a 10% level. This means that those who do not have access to climate information are 13.6% more likely to employ crop management as an adaptation strategy. There are mixed findings about the effect of climate information on adaptation strategies. Access to climate information has been found by some studies such as Kassim et al., (2021), Khanal et al., (2018), Alam et al., (2016) to promote adoption of adaptation strategies. However, Owusu et al., (2021) found no significant impact of the use of climate information on the adoption of adaptation strategies in response to climate change. Our finding corroborates the findings of Teklewold et al., (2019) who found that climate information negatively influences the adoption of soil conservation as an adaptation strategy.

Finally, the variable perception of a shift in rainfall showed a positive and significant influence on the adoption of crop management as an adaptation strategy. This means that households who perceived that there has been a change in rainfall are 18.1% more likely to adopt crop management as an adaptation strategy. Our finding aligns with other studies like Khanal et al., (2018), Kassim et al., (2021) Al-Amin et al., (2019) Owusu et al., (2021) who all argue that households who perceive and experience climate change are more likely to adopt adaptation strategies to respond to the adverse effect of climate change.

4.3.2 Determinants of choice of adaptation strategies by fishing households

Studies have shown that farmers' attitudes perceived behavioral control and past behavior are very important in predicting intentions to adopt the private sustainability schemes (Menozzi et al., 2015). This means that the decision to choose a certain adaptation strategy is based on several socio-demographic, economic, institutional and biophysical factors. The results of the multinomial logit model are presented in Table 5. The results indicate that education of household heads positively and significantly affected the probability of adopting intensification of fishing efforts and livelihood diversification as an adaption strategy at 1% and 5% levels respectively. This means as years of schooling of household head is increased by one year the probability of adopting intensification increases by 1.5% and livelihood diversification by 0.9%. Higher education is associated with greater access to information and skills to adopt adaptation strategies and innovation (Belay & Fekadu, 2021). This result agrees with previous studies such as Sereenonchai & Arunrat, (2019) and Alam et al., (2016) which reported that education positively influences adaptation choices.

Access to climate information was found to have a significant negative influence on the choice of intensification as an adaptation strategy by fishing households at a 5% level. This means that fishing households who do not have access to climate information are 7% more likely to adopt intensification as an adaptation strategy. This result is contrary to some studies like Mabe & Asase, (2020) and Sereenonchai & Arunrat (2019) which asserts that fishing households with access to climate information are more likely to adopt adaptation strategies to avert the adverse effect of climate change.

As expected, the results of the study showed that household income positively and significantly influences the probability of adopting livelihood diversification as an adaptation strategy at a 5% significance level. This means that as income increases, the probability of households diversifying their sources of livelihood increases. This may be because of the availability of capital to invest in other non-fishing activities to reduce the risk that climate shock poses to their fishing livelihood. This result is supported by the findings of Sereenonchai & Arunrat, (2019) who showed that an increasing non-fishing income increases the probability of adopting adaptation strategies. Findings from Meressa & Navrud, (2020) also showed that farmers' adoption of new varieties could be greatly increased by incorporating traits that are in high demand, suggesting the need for increased income in increasing farmers' adoption of new technology.

The variable perception of shift in rainfall exerts a positive and significant effect on farming households' decision to adopt both intensification and livelihood diversification as an adaptation strategy at 5% level. This means as fishing households who perceive that there have been changes in rainfall are 9.7% and 9.2% more likely to adopt intensification and livelihood diversification respectively as an adaptation strategy.

Finally, location was found to exert a negative and significant effect on the adoption of intensification as an adaptation strategy at 1%. This means that fishing households who were located in Rivers State were 13.8% more likely to adopt intensification as an adaptation strategy. It is important to note that when compared to Bayelsa State, Rivers State is more developed and has a weather station. It is possible to fishers located there has more access to climate information than their counterparts thereby making them adopt adaptation strategies.

Table 5. Multinomial regression results for determinants of adaptation strategies by fishing households.

Explanatory variables	Intensification Coefficient	Livelihood diversification Coefficient
Age	0.001 (0.030)	-0.001 (0.019)
Gender	0.018 (0.529)	0.006 (0.139)
Fishing experience	-0.002 (-0.039)	0.001 (0.018)
Household size	-0.004 (-0.104)	-0.001 (-0.032)
Education	0.015*** (0.367)	0.009** (0.196)
Access to credit	0.030 (0.622)	0.023 (0.416)
Social network	-0.017 (-0.518)	-0.028 (-0.700)
Extension	0.034 (1.077)	0.309 2.4239
Access to climate information	-0.070** (-1.664)	-0.042 (-0.886)
Household income	2.61e-08 (6.83e-07)	3.71e-08** (7.38e-07)
Perception of shift in temperature	-0.037 (-0.859)	-0.058 (-0.980)
Perception of shift in rainfall	0.097** (2.346)	0.092** (1.867)
Location	-0.138*** (-2.738)	0.003 (-0.099)
Constant	-5.5811***	-4.5704**
Diagnostics		
Number of observations	252	
LR(26)	144.03	
Prob > chi2	0.0000	
Log likelihood	-106.04623	
Pseudo R^2	0.4044	

Note: Base category: no adaptation; ***, ** and * indicate significance at 1%, 5% and 10% respectively; Location base category: Rivers; Values in parentheses are the standard errors.
Source: Field survey (2018).

Location has been found by others studies such as Mabe & Asase (2020), Ali & Erenstein (2017) to be an important factor influencing adoption of adaptation strategies.

5. CONCLUSION AND POLICY RECOMMENDATION

The study examined the farmers' and fishers' perceptions of the changing climate. They perceived a decrease in rainfall and an increase in temperature which is consistent with the historical meteorological trend from 1982-2018. Furthermore, the study investigated the various adaptation strategies employed by farmers and fishers to adapt to climate shocks and factors that affect the adoption of these adaptation strategies. The main adaptation strategies employed by farming households were soil and water conservation practices, crop management practices, and livelihood diversification while fishing households adopted intensification and livelihood diversification as adaptation strategies. Livelihood diversification was a common adaptation strategy for both livelihood groups. We used the MNL model to examine the factors influencing the adoption of the various adaptation strategies by both livelihood groups and the findings confirm that age, education, farm size, and being a male-headed household are among the important factors that increase the likelihood of farmers to adapt to climate shock using soil and water conservation practices whereas access to credit and social network discourages farmers from using this as an adaptation strategy. Our results further show that household size, education, and perception of changes in rainfall exert positive effects on the use of crop management as an adaptation strategy while access to climate information exerts a negative influence. We also find that farm size positively influences farmers to diversify their sources of livelihood whereas female headed households and households who do not have access to extension are more likely to adopt livelihood diversification as an adaptation strategy. On the other hand, factors such as education, household income, and perception of rainfall change positively influence the adoption of livelihood diversification as an adaptation strategy by fishing households. Furthermore, the results show that education and perception of changes in rainfall exert positive effects on the use of intensification as an adaptation strategy while fishers who do not have access to climate information and in Rivers State are more likely to use intensification.

The findings of this study have strong implications for agricultural policy formulation. The heterogeneity in adaptation strategies and determinant suggest that "one size fits all" policies will not work to adapt to climate change. Institutional factors such as extension visits, access to credit, social networks, and access to climate information for the farmers should be further investigated as such factors negatively influence the choice of climate change adaptation strategies contrary to the findings of some studies. The empirical findings of this study reinforce the need for policymakers to intensify their efforts in improving the extension service in Nigeria. As can be seen from the results only 8% and 4% of the farmers and fishers respectively had access to extension.

This would facilitate the free flow of information on climate and agricultural innovations to farmers and fishers, especially to those who cannot afford information technology devices. Again, membership in associations is another important channel for climate information acquisition that facilitates the adoption of adaptation measures. As can be seen from the study only 15% and 7% of farmers and fishers had membership in any social group. Local opinion leaders and other stakeholders should encourage the establishment of farmer and fisher-based organizations in the communities. This could facilitate efficient relay of climate information, and education on the use of climate information in the adoption of adaptation measures. Also, the limited access of the farmers (15%) and fishers (10%) to credit could be the reason why they are not adopting the crop management and livelihood diversification as an adaptation strategy. These adaptation strategies could be capital intensive, so policy makers and relevant stakeholders could help ease their liquidity constraints by providing them with affordable credit schemes. In addition, the meteorological services in the region should be improved so that they can educate and provide real-time weather information to enhance the households' understanding of climatic changes to make strategic adaptation decisions. Investing in education is critical for overall development and may thus provide a policy instrument for enhancing their perception of climate change and promoting the use of climate shock adaptation strategies and thereby reducing the vulnerability of both farmers and fishers. Finally, since household size and farm size were found to positively influence adoption, the policy implication could be the provide access to farm machinery, which will minimize labour requirements and thereby enable farming households to implement adaptation measures.

Given the increasing threat from climate change and increase in the demand for food resulting from increasing population, improving adaptation by addressing the aforementioned issues is a fundamental intervention in pursuit of reducing the vulnerability of farming and fishing households thereby improving their livelihoods. More so, since women are mainly responsible for food production in the area, as well as supply majority of the labour used in agriculture, further research could be conducted to examine how climate change might have a differential impact based on gender as well as the determinants of adaptation through gender lenses. As gender has been found to play an important role in decision-making in households. Finally, this study was based on cross-sectional data and hence might not provide a robust mechanism for establishing causality, as would have been the case with a time series or panel data. In addition, the data used in this study is not representative of the national demography. We, therefore, recommend future studies using nationally representative panel data to better test addressed the research questions posed in this study.

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Appendix 1. Hausman tests of IIA assumption for farmers.

	Chi square	df	P>Chi square
0	-4.039	24	.
1	-1.943	23	.
2	4.638	24	1.000
3	-14.650	24	.

Appendix 2. Hausman tests of IIA assumption for fishermen.

	Chi square	df	P>Chi square
No adapt	-6.131	13	.
intensif	-0.533	13	.
diversif	-7.049	13	.