FROM AWARENESS TO ACTION: INFLUENCE OF CLIMATE CHANGE PERCEPTION ON ADAPTATION CHOICES IN NIGER.

by

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(Under the Direction of Mateusz Filipski)

ABSTRACT

Recognition of the impacts of climate change is essential in developing effective adaptation strategies, including in the farm sector. However, research on the effects of the perception of climate change on adaptation to it is limited and relies mostly on cross-sectional correlations. This study analyzes the impact of perception on adaptation to climate change among rural households in Niger using panel data based on a nationally representative survey (LSMS 2011 and 2014). The study reveals that most rural households perceived climate change, and approximately 60% employed at least one adaptation strategy to address negative impacts, such as engaging more in non-agricultural activities, migration, reducing livestock, and changing seed varieties. The results from a fixed effects logit model showed that perception of decreasing rainfall, more frequent floods, changes in the rain seasonality, and access to extension services significantly influenced rural households' adaptation to climate change and their selection of adaptation measures.

INDEX WORDS: Perception, Adaptation, Fixed-effects, Niger, Rural Households

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DEDICATION

Dedicated to my beloved parents, my supportive brother, and my loving husband.

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# 1. INTRODUCTION

Climate change is a global issue that poses significant negative impacts on various sectors, including the economy, agriculture, and livelihood. The impacts of climate change in underdeveloped regions, especially in Sub-Saharan Africa are already evident in the reduction of major crop yields up to 10% since the beginning of the century (Sultan et al., 2019). The reasons behind this region's vulnerability to climate change are many, including limited adaptive capacities of rural communities towards the effects of climate change and frequent occurrences of extreme climatic events such as droughts, floods and outbreak of plant pests and diseases (Adger et al., 2009). Niger, a landlocked country in Sub-Saharan Africa where over 80% of the population relies in agriculture, is particularly susceptible to climate change effects' and is already experiencing significant impacts of climate change. This includes more frequent and severe droughts, reduction in the amount of rainfall and increased frequency of extreme weather events, such as floods and heat waves (Di Lorenzo & Fadika, 2022). These climate-induced impacts have serious implications on agricultural productivity, food security and overall economic development. In addition to these climate-induced effects, the high rate of population growth and poor sanitary facilities are responsible for exacerbating Niger's vulnerability to climate change (Ben Mohamed et al., 2002).

As climate change effects are prominent and have significant negative consequences on people's livelihood in Niger and these effects are expected to worsen in the coming decades, adaptation to climate change has become an urgent necessity. Adaptation includes modifying or adjustment of the natural or human systems to cope with the negative impacts of climate change, thus, reducing harm and taking advantage of favorable opportunities (McCarthy et al., 2001). In Niger, farmers have implemented several adaptation measures to cope with climatic variability. These measures include crop diversification, income diversification, altering planting and harvesting schedules, adopting soil fertility management techniques, and using drought tolerant/early maturing crop varieties (Zakari et al., 2022).

In spite of having higher degree of vulnerability to climate change, farmers, are also seen to have major role in the adaptation and mitigation efforts to climate change on account of their sensitivity and adaptive capacity to cope with the consequences of climatic variability (Berry et al., 2006). The way how individuals perceive climate change, its' causes, and its' potential impacts on their lives can influence their beliefs and attitudes and can shape their decision-making and behavior in response to the changing climatic conditions. So, understanding the local perceptions of climate change is essential in designing effective adaptation strategies that is responsive to local needs and context. The significance of climate change perception on adaptation to it is recognized by previous literature on climate change adaptation (Abid et al., 2019; Adger et al., 2009; Ado et al., 2019; Arbuckle et al., 2013; Bryant et al., 2000; Debela et al., 2015; Deressa et al., 2011; Esham & Garforth, 2013; Hassan & Nhemachena, 2008; Juana et al., 2013; Le Dang et al., 2014; Menapace et al., 2013, 2015).

Despite the growing attention on understanding the perceptions of farmers towards climate change, there are still gaps and limitations in the existing literature. First, earlier studies have either focused separately on climate change perceptions and their impacts (Debela et al., 2015; Kosmowski et al., 2016) or adaptation strategies and their determinants (Deressa et al., 2009; Hisali et al., 2011). While there are studies integrating the perception and adaptation of climate change that emphasize perception as a prerequisite for adaptation towards climate change, they have failed to assess the role of climate change perception on adaptation (Adimassu & Kessler, 2016; Akponikpè et al., 2010; Belay et al., 2017; Bryan et al., 2009; Deressa et al., 2011; Mertz et al., 2009). Second, most of the previous studies on climate change adaptation are based on limited perception variables or focused only on perceptions of average temperature and precipitation, neglecting other important climatic variables such as flood occurrence, rain seasonality, and period of great heat (Ado et al., 2019; Marie et al., 2020; Ndambiri et al., 2013; Nhemachena & Hassan, 2007). However, farmers do not entirely base their adaptation decisions on only alterations in average climatic conditions. Instead, they take account into a range of other climatic factors, including extreme weather events, changes in the frequency, timing, and intensity of rainfall, and early and late frosts, which they observe through personal experience (Marx et al., 2007; Thomas et al., 2007). This calls for more focus on other climatic factors and extreme weather events that previous climate change adaptation studies did not cover. Furthermore, previous studies have mostly relied on cross-sectional evidence, which limits the ability to draw stronger causal inferences about the relationship between climate change perception and adaptation.

Niger is one of the most vulnerable countries to climate change impacts. However, the literature concerning climate change adaptation in Niger is limited and fragmented, with few studies focusing on rural communities. This is significant because rural communities are particularly vulnerable to climate change impacts and play a key role in agriculture, which is the backbone of Niger's economy. Our study aims to address the existing knowledge gap on households' perception and adaptation strategies to climate change in Niger by using panel data to examine the impact of different climate change perception variables on adaptation outcomes in rural Niger. By exploiting the panel nature of our data, we can control for time-invariant unobserved heterogeneity and draw stronger causal inferences about the relationship between the perception of climate change and adaptation outcomes. Our study focuses deeper on the climate change perception by capturing perception of rainfall frequency, timing and seasonality of rains, frequency of floods, and period of great heat. rather than just focusing on perception of the average change in precipitation and temperature. We will examine how different climate-change perception variables impact rural household adaptation choices in Niger. The study is based on the following research questions:

1. Do rural households perceive changes in climate?
2. What are the major adaptation strategies employed by rural households to climate change?
3. What is the influence of perception of climate change in determining the choice of adaptation strategies?

By addressing these research questions, this study aims to contribute to a better understanding of the importance of climate change perception for effective adaptation in Niger. By identifying which perception variables are most important for effective adaptation, and how the adaptation choices vary with the perception variables, we can design more targeted interventions and policies that address the specific needs of rural communities in Niger. Furthermore, by using panel data and examining different climate change perception variables, this study contributes to a better understanding of the complex interaction between climate change perception and adaptation outcomes, which can inform more effective climate change policies and programs in Niger and other similar contexts.

Following the introduction, the rest of this thesis is organized as follows: Section two presents the empirical review of the literature on climate change, perception, and adaptation strategies in response to climate change. Section three describes the study location and methodology used in this study.  Section four presents the major results of the study and discusses it.  Finally, section five presents the conclusions of the study.

## 2. LITERATURE REVIEW

This literature review aims to provide an overview of the existing research on climate change perception and adaptation and identify gaps in the literature that could be addressed in future research.

**A number of studies have documented the perception of climate change and its impacts among farmers.**

A study by Maddison (2007) found that many African farmers believe temperature has risen and precipitation has declined due to climate change and suggests that experienced farmers are more likely to recognize these changes because they update their beliefs using Bayesian updating.

The study undertaken by Akponikpè et al. (2010) studied the perception of climate change and adaptation strategies using empirical evidence from 234 farmers across 78 villages in Benin, Burkina Faso, Ghana, Niger, and Togo. The results revealed that most respondents observed a decline in rainfall and a significant increase in temperature over time. They also reported changes in rainfall patterns, such as delayed onset and early cessation, and an increase in the number of hot days.

Another study by Debela et al. (2015) focused on understanding smallholder farmers' perception of climate change and its impact on local agriculture in South Ethiopia. Using a multinomial logit model, the study found that most participants perceived climate change and its impact on traditional rain-fed agriculture.

In Niger, Kosmowski et al. (2016) undertook a study to compare the perception of recent rainfall changes between climate-sensitive and non-climate-sensitive households. The study found that most respondents perceived a decrease in rainfall, inadequate distribution of rainfall throughout the year, more frequent droughts, and a delay in the rainy season, which ends earlier over the past five years.

**Another set of papers examined the major adaptation strategies used for climate change adaptation and the factors affecting the adaptation to climate change.**

A study done by Kurukulasuriya and Mendelsohn (2007) examined how farmers in Burkina Faso, Cameroon, Ghana, Niger, Senegal, Egypt, Ethiopia, Kenya, South Africa, Zambia, and Zimbawe choose their crops and livestock as a strategy to cope with climate change. The findings from multinomial logit model revealed that climate change affected crop choice, and farmers adjusted by switching crops. In addition, farmers in hotter climate tend to prefer goats and sheep over beef, cattle, and chicken because of their better adaptive capacity in harsh and dry conditions.

To examine the factors that influence farmers' choice of adaptation methods in the Nile basin of Ethiopia, Hassan and Nhemachena (2008) employed multinomial choice analysis. The findings indicate that rising temperature poses the most significant threat and increases the adoption of irrigation, multiple cropping, and livestock integration. Conversely, increased precipitation lowers the likelihood of using irrigation while providing advantages, especially for farms in dry regions. Factors such as level of education, age, gender, and household size had a significant influence on farmers’ willingness to adapt to climate change in the study area.

Similar study was conducted by Mertz et al. (2009) to examine how sedentary farmers in the savanna zone of central Senegal perceive climate change and cope with it through adaptation strategies. The research revealed that the communities studied were highly aware of climate change issues and argued that a range of other factors rather than just climate motivated their adaptation strategies, such as altering land use and livelihood strategies.

Another similar kind of study was done by Deressa et al. (2009) to determine the factors that influence farmers' selection of adaptation methods to cope with climate change in the Nile basin of Ethiopia using a multinomial logit model. They found level of education, gender, wealth of the head of household, access to extension and credit, climate information, social capital, agroecological settings, and temperature as significant factors influencing the choice of adaptation strategies.

In another study conducted by Apata (2011) in Southwest Nigeria, the two-step process of adaptation to climate change was analyzed using the Heckman probit model and cross-sectional data. The analysis revealed that educational level of the household head, household size, gender of the household head, livestock ownership, extension for crop and livestock production, availability of credit, farm size, temperature, and annual average precipitation significantly influenced farmers' adaptation to climate change.

In a similar study, Deressa et al. (2011) assessed climate change perception and adaptation based on empirical evidence from farmers in the Nile basin of Ethiopia. The study employed the Heckman sample selection model to investigate determinants of climate change adaptation among farmers. Factors such as education of household head, household size, gender, ownership of livestock, use of extension services, availability of credit, and environmental temperature significantly influenced adaptation to climate change.

Another study by Hisali et al. (2011) in Uganda analyzed climate change adaptation using micro-level data and a multinomial logistic model. The study identified the age of the household head, access to credit and extension services, and land tenure security as significant factors influencing adaptation to various shocks and strategies

In their research on how farmers in the Sekyedumase district of Ghana perceive and adapt to climate change, Fosu-Mensah et al. (2012) found that 92% of the respondents perceived an increase in temperature and 87% observed a decrease in rainfall over time. The study also revealed that factors such as land tenure, soil fertility levels, access to extension services, access to credit, and the community in which the farmers lived played a significant role in their choice of adaptation measures.

A study by Abid et al. (2015) also examined determinants of adaptation measures of farmers in the Punjab province of Pakistan. The study determined that 58% of the farm household implemented climate change adaptation strategies. Education level, farming experience, household size, land area, tenancy status, ownership of a tube well, access to market information, weather forecasting information, and agricultural extension services were significant factors influencing farmers' decision to adopt climate change adaptation measures.

In their research, Bello and Maman (2015) evaluated the impact of temperature and rainfall variability on agriculture in Niger Republic's Dosso and Maradi regions using Ricardian analysis. An important finding of this study was that farmers who practice climate change adaptation can offset potential losses from climatic variability from temperature and rainfall by up to 8.95% and 12.71% per ha, respectively.

In another study, Adimassu and Kessler (2016) focused on the factors influencing farmers' coping and adaptation strategies in response to the perceived decline in rainfall and crop productivity in the central Rift valley of Ethiopia. They found that adaptation strategies used by the farmers were influenced by livestock and landholdings, labor and knowledge availability, access to information, and social and cultural factors.

In their study, Belay et al. (2017) examined how smallholder farmers in the Central Rift valley of Ethiopia perceive the impacts of climate change, what adaptation strategies they use, and the factors that influence their choices. The common adaptation practices used were crop diversification, planting date adjustment, and soil and water conservation. The study found that education, family size, gender, age, livestock ownership, farming experience, contact with extension agents, farm size, access to market and climate information, and income were major determinants of farmers' choice of adaptation practices.

**And most closely related to this thesis, a few studies attempt to assess the relationship between climate change perception and adaptation but do so with cross-sectional data.**

A study was conducted by Gbetibouo (2009) on the climate change adaptation strategies of farmers in the Limpopo basin of South Africa. The research revealed that while many farmers observed long-term changes in temperature and precipitation, most were unable to take remedial measures. It found that access to extension services increases the likelihood that farmers will notice changes in climate conditions and argued on the importance of perceiving changes in climate conditions in shaping whether farmers act or not in response to climate change

The study undertaken by Bryan et al. (2009) focused on the adaptation to climate change in Ethiopia and South Africa. The research examined the factors that influenced adaptation and adaptation choices by using a probit model. The results from the probit model found access to extension, credit, and climate information to influence farmers' decision to adapt in Ethiopia, while food aid, extension services, and climate change information facilitated adaptation among the poorest farmers. Perception of extreme weather events such as flood occurrences in the last five years also influenced adaptation.

A study by, Onyeneke et al. (2012) investigated the factors influencing farmers' adaptation measures to climate change in the Niger Delta region of Nigeria, with a specific focus on Bayelsa State. The study used a multinomial logit model and identified awareness of climate change as one of the significant determinants of farm-level adaptation options.

Similarly in Iowa, USA, Arbuckle et al. (2013) used a cumulative logit model to examine the relationship between farmer beliefs about climate change, vulnerability concerns, and perspectives on adaptive and mitigative actions. Results indicated that farmers who believed that human activities caused climate change and were concerned about its impacts had a favorable attitude towards adaptive and mitigative strategies. This highlights the importance of farmers' perceptions of climate risk in shaping their adaptation attitudes.

In their research, Esham and Garforth (2013) explored agricultural adaptation to climate change in a farming community in Sri Lanka. The authors highlighted the crucial role of human cognition in determining climate change adaptation, particularly in terms of farmers' perception of climate change and their evaluation of the effectiveness of adaptation measures. The study emphasized the significance of considering the socioeconomic, cognitive, and normative factors of local communities when designing and implementing adaptation strategies.

In another study done by Ndambiri et al. (2013) in Kenya, farmers' perceptions and adaptation to climate change was analyzed. They found that most farmers perceived an increase in temperature, longer periods of high temperatures, decreased precipitation, changes in rainfall timing, and increased drought frequency and many had taken measures to mitigate climate change's negative effects. Changes in temperature and precipitation was one of the significant factors that affected farmers' adaptation along with other household and community characteristics.

In a similar study done by Shongwe et al. (2014), they used multinomial logistic regression model to investigate factors influencing households' climate change adaptation strategies in the Mpolonjeni ADP in Swaziland. The study found that climate change perceptions significantly influenced the choice of adaptation strategies along with age, occupation of the household head, social group membership, land category, access to credit and extension services, crop pest and disease incidence and input and food prices.

Another research undertaken by Ado et al. (2019) aimed to evaluate the influence of farmers' awareness and perception of climate change impacts on adaptation in the Anguie district of Niger. Probit analysis of the data indicated that farmers' awareness, perception, education, crop production, soil fertility, and annual revenue were predictors of their adaptation to climate change impacts.

In their research, Marie et al. (2020) examined the factors influencing the adoption of climate change adaptation strategies in northwestern Ethiopia. The study employed both multinomial logit and binary logistic models, and the results revealed that climate information, total annual farm income, and market access were significant determinants of adoption. However, the perception of climate change was statistically insignificant in influencing the adoption of climate change strategies.

In their study, Irham et al. (2022) compared the perception and adaptation to climate change of organic and conventional farmers and analyzed the factors affecting their decision-making. The study found that organic farmers had a better perception of climate change. Logistic regression analysis indicated that farmers' perception of climate change influenced the selection of adaptation strategies by farmers along with other factors such as age, education, distance to extension services, access to credit and information about climate.

There is a study by Apata et al. (2009) that used a logit model and panel data to study the determinants of perception and adaptation levels of climate change among arable food crop farmers in Southwestern Nigeria. Positive factors that influenced perception and adaptation levels included increased temperature, intercropping, mulching, zero tillage, making ridges, farm size, farming experience, education, and access to extension and credit facilities, Negative factors included falling temperature, changing the timing of rains, owning heavy machines, and household size.

*Table 1* provides a summary of the empirical findings on farmers' perceptions and adaptations to climate change in various regions and countries.

Table 1 Summary of empirical studies on farmers' perceptions and adaptations to climate change

| Author | Region/Country | Data/Sample size | Methodology | Key Findings |
|---|---|---|---|---|
| Studies related to climate change perception | | | | |
| (Maddison, 2007) | Africa | Cross-sectional data | Heckman sample selection model | African farmers perceived climate change. |
| (Akponikpè et al., 2010) | Benin, Burkina Faso, Ghana, Niger, and Togo | Cross-sectional Survey data (234 farmers) | Chi-square test | Farmers reported a decline in rainfall, an increase in temperature, delayed onset and early cessation of rain, and an increase in the number of hot days. |
| (Debela et al., 2015) | Borana of South Ethiopia | Cross-sectional data. | Multinomial logistic regression model | Most participants perceived climate change and its impact on rain-fed agriculture. |
| (Kosmowski et al., 2016) | Niger | Cross-sectional data | Mann-Whitney U test and Pearson's residual test | Opinions of climate-sensitive households closely aligned with observed local climate changes. |
| Studies related to climate change adaptation and their determinants | | | | |
| (Kurukulasuriya & Mendelsohn, 2007) | 12 African countries | Cross-sectional data of 11 countries | Multinomial logit model | Farmers adjust to climate change by switching to different crops. |
| (Hassan & Nhemachena, 2008) | 11 African countries | Cross-sectional data (8000 farms) | Multinomial choice analysis | Access to markets, extension and credit services, technology, and farm assets influenced farmers' adaptive strategies. |

| | | | | |
|---|---|---|---|---|
| (Mertz et al., 2009) | Savanna zone of Central Senegal | Cross-sectional data | Interviews, and household surveys | Farmers were highly aware of climate change issues and identified intensive wind and occasional excess rainfall as the most destructive climatic factors. |
| (Deressa et al., 2009) | Nile basin of Ethiopia | Cross-sectional household-level data | Multinomial logit model | The level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agroecological settings, and temperature all influenced farmers' choices. |
| (Apata, 2011) | Southwest Nigeria | Cross-sectional household survey (400 farmers) | Heckman probit model | Educational level and male gender of the household head, household size, livestock ownership, extension for crop and livestock production, availability of credit, farm size, temperature, and annual average precipitation influenced farmers' adaptation. |
| (Deressa et al., 2011) | Nile basin of Ethiopia | Cross-sectional household survey (1000 farmers) | Heckman sample selection model | Education of household head, household size, gender, ownership of livestock, use of extension services, availability of credit, and environmental temperature influenced adaptation. |
| (Hisali et al., 2011) | Uganda | Cross-sectional household-level data | Multinomial logit model | Age of the household head, access to credit and extension services, and land tenure security as significant factors influencing adaptation. |
| (Fosu-Mensah et al., 2012) | Sekyedumase district of Ghana | Cross-sectional data (180 farmers) | Binomial logit model | Extension services, credit, soil fertility, and land tenure influenced farmers' perception and adaptation. |
| (Abid et al., 2015) | Punjab province of Pakistan | Cross-sectional data | Binary logistic model. | Education level, farming experience, size of household, land area, tenancy status, ownership of a tube well, market information, weather information, and agricultural extension services influenced adaptation. |
| (Bello & Maman, 2015) | Dosso and Maradi regions of the Niger Republic | Cross-sectional data (household and district levels) | Ricardian analysis | Farmers who practice climate change were able to cover potential loss from climatic variability by more than 8% and 12% in Maradi and Dosso regions, respectively. |
| (Adimassu & Kessler, 2016) | Central rift valley of Ethiopia | Cross-sectional data (240 farmers) | Explanatory factor analysis and multivariate probit regression | Livestock and landholdings, labor and knowledge availability, access to information, and social and cultural factors affected farmers' choices of adaptation strategies. |
| (Belay et al., 2017) | Central Rift valley of Ethiopia | Cross-sectional data | Multinomial logit model | Education, family size, gender, age, livestock ownership, farming experience, contact with extension agents, farm size, access to market and climate information, and income affected farmers' adaptation decisions. |
| Studies linking climate change perception and adaptation | | | | |

| | | | | |
|---|---|---|---|---|
| (Gbetibouo, 2009) | Limpopo basin of South Africa | Cross-sectional data | Heckman probit model and multinomial logit model. | Perceiving changes in climate conditions important in shaping whether farmers act or not in response to climate change. |
| (Bryan et al., 2009) | Ethiopia, South Africa | Household-level pooled data | Probit model | Perceived extreme weather events such as flood occurrences in the last five years influenced adaptation. |
| (Onyeneke et al., 2012) | Bayelsa State of Niger Delta region of Nigeria | Cross-sectional data (200 farmers) | Multinomial logit model | Awareness of climate change influenced farm-level adaptation options. |
| (Arbuckle et al., 2013) | Iowa | Cross-sectional data (1600 farmers) | Descriptive statistics and multinomial logit | Highlighted the importance of farmers' perceptions of climate risk in shaping their adaptation attitudes. |
| (Esham & Garforth, 2013) | Sri Lanka | Cross-sectional data (126 farmers) | Descriptive statistics and multiple regression analysis | Found human cognition to be an important determinant of climate change adaptation. |
| (Ndambiri et al., 2013) | Kyuso district of Kenya | Cross-sectional data (246 farmers) | Heckman Sample selection model | Changes in temperature and precipitation influenced adaptation. |
| (Shongwe et al., 2014) | Mpolonjeni ADP in Swaziland | Cross-sectional data (257 crop-producing farmers) | Multinomial regression | Climate change perceptions significantly influenced the choice of adaptation strategies. |
| (Ado et al., 2019) | Aguie district of Niger | Cross-sectional data | Descriptive statistics and probit model | Found farmer awareness and perceptions of climate change impacts as the key factor in climate change adaptation. |
| (Marie et al., 2020) | Northwest Ethiopia | Cross-sectional data | Binary logistic models and multinomial logit models | Found perception of climate change to be statistically insignificant in influencing the adoption of climate change strategies |
| (Irham et al., 2022) | Indonesia | Cross-sectional data | Chi-square test and logistic regression | Found farmers' perception of climate change to influence the choice of adaptation strategies farmers. |
| (Apata et al., 2009) | Nigeria | Panel data | Logit model | Found increased temperature to positively influence adaptation. Found fall in temperature, change timing of rains to negatively influence adaptation. |
| This study | Niger | Panel data (LSMS 2011 and 2014) | Fixed effects logit model | |

In summary, most of the studies regarding climate change either focused on studying the perception of climate change by farmers or on the adaptation strategies commonly used by farmers to reduce the negative effects of climate change and the factors that affect adaptation. Some studies on the perception and adaptation of climate change emphasized the requirement of the perception of climate change by farmers to undertake efforts for adaptation towards climate change. However, those studies failed to address the impact of perception on climate change adaptation. Also, most of the studies are based on a particular area like the basin, or district of specific regions, and studies that are nationally representative, of Niger, are lacking. In addition, most of the studies are based on cross-sectional evidence which cannot control for time-invariant unobserved heterogeneity and draw stronger causal inferences about the relationship between the perception of climate change and adaptation outcomes. Furthermore, studies that used a multinomial logit model to identify factors affecting the choice of adaptation strategies to climate change required that farmers choose one adaptation strategy from given adaptation strategies. This assumption is not realistic, and farmers adopted more than one adaptation strategy for climate change adaptation which, therefore, makes the use of the MNL approach inappropriate. Our study uses fixed effects logit model to examine the influence of climate change perception on the selection of adaptation strategies by rural households in Niger by using panel data and employing fixed effects logit model.

# 3. RESEARCH METHODOLOGY

## 3.1 Description of the study area

Niger is a land-locked country in Sub-Saharan Africa with two-thirds of its area covered by desert and sub-desert (FAO, 1993). With mostly a semi-arid climate, Niger is exposed to hydrometeorological disasters such as recurrent flood and droughts. Major shocks due to drought occurred in 1996, 1999, 2003 and 2008, while floods occurred in 2008 and 2010, displacing 200,000 residents and contributed to sharp increase in the incidence of waterborne disease in addition to crop production loss (World Bank, 2013). Because of these frequent climatic shocks, Niger has suffered from poor harvests and regular food shortages. Between 1986 and 2020, 56 events were reported in Niger., where most of the events included droughts, floods, and epidemics, that caused 10,384 deaths and affected 28.2 million people. On the other hand, despite being less fatal than droughts and affecting a smaller share of the population, floods have emerged as a relevant threat to Niger in recent years with large floods reported in 2017, 2018, and 2020. On average, droughts have resulted in an estimated annual agricultural income loss of US$ 15 million, while floods on average cause loss of US$ 20 million to US$ 70 million (Di Lorenzo & Fadika, 2022). In overall, the study area is highly vulnerable to the impacts of climate change and this study aims to examine how the perception of climate change among rural household in this area affects their adaptation choices.


Figure 1 Map of Niger

3.2 Sampling and data collection at the household level

To investigate the impact of climate change perception on adaptation choices in Niger, we utilized the LSMS (Living Standards Measurement Study) data for 2011 and 2014. LSMS-ISA Niger is a multi-topic household survey that collects information on various socio-economic indicators such as income, education, health, assets, and climate change perception and adaptation choices. It is a nationally representative survey, including both urban and rural areas in all the regions of Niger, and provides a reliable source of data for research. The LSMS survey uses a multi-stage stratified random sampling method to select households for inclusion in the study. In the first stage, they select clusters of households from the sampling frame. In the second stage, they randomly select household from each cluster.

The questionnaire included questions on household demographics, income, assets, consumption, health, and education. In addition, the survey also collected information on households' perceptions of climate change and their adaptation choices. Households were specifically asked in the survey to respond to questions on patterns of long-term changes in rainfall measure, rainfall distribution, drought occurrence, flood occurrence, seasonality of rains, and period of great heat over the past 5 years and were inquired about the major adaptation strategies they employed to reduce the negative impact of climate change. Since this data are recall data over five years, this raises questions about the role of recency of climatic events in shaping farmer's beliefs and perceptions about climate change (Menapace et al., 2015). The total sample size for wave 1 (2011) and wave 2 (2014) surveys were 3967 and 3614 households.

We created panel data by merging the LSMS data for 2011 and 2014. This allowed us to track changes in households' perceptions of climate change and their adaptation choices over time. We restricted our sample to rural households that were present in both waves of the survey in the same location, resulting in a panel dataset of 2167 households.

### 3.3 Analytical method

#### 3.3.1 Analysis of the perception of long-term climate change and adaptation measures

We used descriptive statistics to analyze the perception of long-term climate changes and the major adaptation strategies used by rural households in Niger. Specifically, we computed summary statistics for variables related to the perception of climate change, such as the percentage of households that reported changes in rainfall amount, rainfall distribution, flood frequency, seasonality of rain, droughts frequency, and period of great heat over the last five years. We also examined the major adaptation strategies employed by households to reduce the negative effects of climate change.

3.3.2. Impact of climate change perceptions on the choice of adaptation strategies

Probit and logit models are among the most used models in agricultural technology adoption research (Hausman & Wise, 1978; Wu & Babcock, 1998). Binary probit or logit models are employed when the number of choices available is two (whether to adopt or not). To analyze the impact of the perception of long-term climate change on households' adaptation choices, we use a fixed effects logit model. This model has advantages in accounting for unobserved heterogeneity and exploiting the panel nature of our data. By focusing on changes within households over time, we can account for time-invariant characteristics that may affect both the perception of climate change and adaptation choices and are specific to each household. This helps to address concerns of omitted variable bias and improve the reliability of the estimates. Previous studies that have assessed farmers' adoption of climate change have mostly used the multinomial logit model (MNL). However, we do not employ the MNL model in this study because it assumes that households adopt only one adaptation strategy at a time, which is not a realistic assumption. The fixed effects logit model is more appropriate as it allows households to switch between adaptation strategies over time, which is a widespread practice in response to changing climate conditions.

According to (Wooldridge, 2010), the fixed effects logit model for a binary dependent variable is:

$$\Pr(y_{it} = 1) = \Pr(y_{it}^{*} > 0) = F(X_{it}'\beta),$$

Where F is the logistic cumulative distribution function and

$$y_{it}^{*} = X_{it}'\beta + \mu_i + \epsilon_{it},$$

Where $\mu_i$ is the individual-specific intercept and $\epsilon_{it}$ denotes the idiosyncratic error.

Here, Y is a dichotomous dependent variable taking the value of 1 when the household chooses an adaptation option and 0 otherwise.

We divided the dependent variable in this study, which is the households' adaptation choices, into four categories for better interpretation. This is because there were 13 different adaptation strategies that households could adopt, and analyzing each of them separately is challenging. The four categories used were: (1) Adaptation, (2) Crop-related adaptation, (3) Livestock-related adaptation, and (4) Alternative livelihood adaptation to analyze the influence of climate change perception variables in different categories of adaptation strategies, we employed binary logistic fixed effects model for each adaptation category separately. The main independent variable of interest was a measure of the household's perception of long-term climate change which included a perception of the decrease in rainfall measure, more frequent floods, rain seasonality, and longer period of great heat. We also controlled for a range of household and community-level characteristics, including the age of the household head, education of the household head, household size, female-headed household, access to radio, and exposure to extension services.

The estimated parameters from the fixed effects logit model only give the direction of the effect of independent variables on the binary dependent variable. In addition to estimating the fixed effects logit model, we also calculated the marginal effects to facilitate the interpretation of the results. Marginal effect is the change in the probability of the outcome variable resulting from a small change in one of the independent variables. In the context of our study, the marginal effects tell us how much the probability of a household adopting a particular adaptation category change in response to a change in their perception of long-term climate change, while controlling for other factors that may affect the household's adaptation choices.

To calculate the marginal effect in a fixed effects logistic regression model, we use the following formula:

Marginal effect = $b_k' \; \Pr(y_{it} = 1) \times (1 - \Pr(y_{it} = 1))$

3.4 Dependent and independent variables.

3.4.1 Dependent variables

The dependent variables of this study were the groups of adaptation strategies that the sample households employed in response to climate change. (See Table 2)

A. Adaptation: It is a dummy variable that takes the value of one if the household has used any of the 13 adaptation strategies which includes changing seed varieties, terracing the soil, or using other methods to protect soil against erosion, planting trees, irrigating more intensively, raising less livestock to increase agriculture, engaging in off-season agriculture, raising fewer small ruminants and switching to cattle, raising fewer cattle, and switching to camels, raising fewer sheep, switching to goats, adopting specific techniques to regenerate the grass cover favored by livestock, migration of certain members of the household, practicing other non-agricultural activities more often, and renting or mortgaging land. It serves to divide between households that have employed at least one adaptation strategy to act against climate change and those that have not.

B. Crop-related adaptation: A dummy variable indicating the use of a subset of the above-mentioned strategies. Six strategies are considered to be crop-related adaptation.

C. Livestock-related adaptation: It is also a dummy variable which indicates the use of four such strategies that comprises livestock-related adaptation.

D. Alternative livelihood adaptation: A dummy variable indicating the use of either of three strategies that falls under alternative livelihood adaptation.

### 3.4.2 Independent variables

The choice of explanatory (independent) variables used in this study is based on data availability and a review of the literature. The independent variables include perception variables like the perception of a lesser amount of rainfall, perception of more frequent floods, perception of altered timing of rains, and perception of a longer period of great heat. As control variables, we include household characteristics (e.g., age of household head, household head's education, size of household, female-headed household, radio ownership) and agricultural extension services. The age of the household head and the size of the household are continuous variables measured in years and numbers, respectively. All other factors are binary and take values of zero and one.

In our study, we initially included six climate change perception variables as independent variables in our regression analysis. However, we conducted tests for multicollinearity among the independent variables and found that two of them were correlated with other variables based on their correlation coefficient which were perception on worse distribution of rainfall and perception of more frequent drought. The results are included in

APPENDICES:

Appendix *1*. As a result, we decided to exclude these variables from the original regression analysis. This left us with only four climate change perception variables in our study. Although we excluded two climate change perception variables from our analysis of impact of climate change perception on adaptation to it, we still used them in the analysis of perception of climate change. We did this because these variables were important for the better understanding of the rural households' perception of climate change in Niger.

Table 2 shows the detailed description of the dependent variables and independent variables used in our study.

Table 2: Description of variables considered in the climate change adaptation models

| Variables | Description of variables |
|---|---|
| Dependent variables (Adaptation categories) | |
| Adaptation | Dummy variable=1 if household used at least one of the adaptation strategies |
| Crop-related adaptation | Dummy variable=1 if household used at least one of the following strategies:<br>1. Change seed varieties.<br>2. Terrace the soil or use other methods to protect against erosion.<br>3. Plant trees<br>4. Irrigate more intensively.<br>5. Raise less livestock to increase agriculture.<br>6. Engage in off-season agriculture |
| Livestock-related adaptation | Dummy variable=1 if household used at least one of the following strategies:<br>1. Raise fewer small ruminants and switch to cattle.<br>2. Raise fewer cattle and switch to camels.<br>3. Raise fewer sheep and switch to goats.<br>4. Adopt specific techniques to regenerate the grass cover favored by livestock |
| Alternative livelihood adaptation | Dummy variable=1 if household used at least one of the following strategies:<br>1. Migration of certain members of the household<br>2. Practice (diversify) more often other non-agricultural activities (diversify sources of revenue)<br>3. Rent or mortgage land |
| Independent Variables | |
| Perception variables (Perception of long-term climate change) | |
| less_rain | Dummy variable= 1 if household perceived lesser rainfall amount in last five years, and 0 otherwise |
| freq_flood | Dummy variable= 1 if household perceived more frequent flood in last five years, and 0 otherwise |
| altered_rain | Dummy variable= 1 if household perceived change in seasonality of rainy season (delay in the start of the rainy season and early finishing of the rainy season) in last five years, and 0 otherwise |
| longer_heat | Dummy variable= 1 if household perceived longer period of great heat in last five years, and 0 otherwise |
| Control variables (Household Characteristics) | |
| hage | Age of the household head in years |
| heduc | Dummy variable=1 if household head had at least primary level of education, and 0 otherwise. |
| hhsize | Household size (Number) |
| female | Dummy variable=1 if household head is female and 0 if male |
| radio | Dummy variable=1 if household have a radio, and 0 otherwise |
| extension | Dummy variable=1 if any of the household members ever received training from the extension service, and 0 otherwise |

[1]

[1] The variable altered_rain was created by merging the perception of delay in the start of the rainy season and perception of early finishing of rainy season. The household must perceive both of them to perceive the change in rain seasonality.

# 4. RESULTS AND DISCUSSION

This section presents the major findings of our study. The first segment delves into the characteristics of the rural households of the sample. The second segment examines the perceptions of farmers regarding long-term climate changes. The third segment analyzes the adaptation strategies utilized by farmers at the farm level to address climate change. Lastly, we thoroughly examine and discuss the impact of farmers' perception of long-term changes in climate on their choice of adaptation strategies.

## 4.1. Summary statistics of the sample

As indicated in Table 3, approximately 13.7% of households in the full sample are headed by female. The mean age of household heads was 46.3 years and only about 10.7% of them had at least a primary level of education. The majority of household heads were engaged in farming (66%). The average household size was 6.54 members and just over one-third had access to a radio (34.6%). Only a minority of households received extension services (17.6%).

Table 3 Descriptive statistics of the sampled households

| Variables | Wave1 (2011) | | Wave 2 (2014) | | Panel | |
|---|---|---|---|---|---|---|
| | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| Dependent Variables: | | | | | | |
| Adaptation categories: | | | | | | |
| Adaptation | 0.574 | 0.495 | 0.628 | 0.484 | 0.599 | 0.490 |
| Crop-related | 0.359 | 0.480 | 0.413 | 0.493 | 0.384 | 0.486 |
| Livestock related | 0.223 | 0.416 | 0.268 | 0.443 | 0.243 | 0.429 |
| Alternative | 0.359 | 0.480 | 0.416 | 0.493 | 0.385 | 0.487 |
| Independent Variables | | | | | | |
| Perceptions: | | | | | | |
| Decrease in rainfall | 0.804 | 0.397 | 0.534 | 0.499 | 0.680 | 0.467 |
| More frequent flood | 0.267 | 0.443 | 0.251 | 0.434 | 0.260 | 0.439 |
| Change in rain seasonality | 0.620 | 0.486 | 0.555 | 0.497 | 0.587 | 0.492 |
| Longer heat period | 0.655 | 0.475 | 0.478 | 0.500 | 0.573 | 0.495 |
| Household characteristics: | | | | | | |
| Age of household head | 45.019 | 14.878 | 47.577 | 14.593 | 46.298 | 14.790 |
| Education of household head | 0.118 | 0.322 | 0.096 | 0.294 | 0.107 | 0.309 |
| Household size | 6.595 | 3.335 | 6.495 | 3.247 | 6.545 | 3.291 |
| Female-headed household | 0.110 | 0.313 | 0.164 | 0.370 | 0.137 | 0.344 |
| Farming | 0.713 | 0.452 | 0.607 | 0.488 | 0.660 | 0.474 |
| Access to radio | 0.386 | 0.487 | 0.306 | 0.461 | 0.346 | 0.476 |
| Exposure to extension services | 0.119 | 0.324 | 0.245 | 0.430 | 0.176 | 0.381 |
| N | 2167 | | 2167 | | 4334 | |

4.2. Household-level perceptions of climate change

For the household-level perceptions of climate change, respondents are questioned about how they viewed long-term variations in climate indicators within their region in the past five years, and the results are summarized in the following sub-sections. A more detailed table presenting the descriptive statistics for the climate change perception variables is provided in Appendix 2.

4.2.1 Perception of rainfall changes:

Figure 2 shows that 68.45% of the participants reported a decrease in the amount of rainfall, while 19.27% observed an increase in rainfall. The remaining 12.28% of respondents reported no change in the rainfall measure. This means that the majority of the respondents (68.45%) reported a decrease in the amount of rainfall. Akponikpè et al. (2010) also reported similar results where farmers in Benin, Burkina Faso, and Niger reported a total rainfall decrease of 60-95%

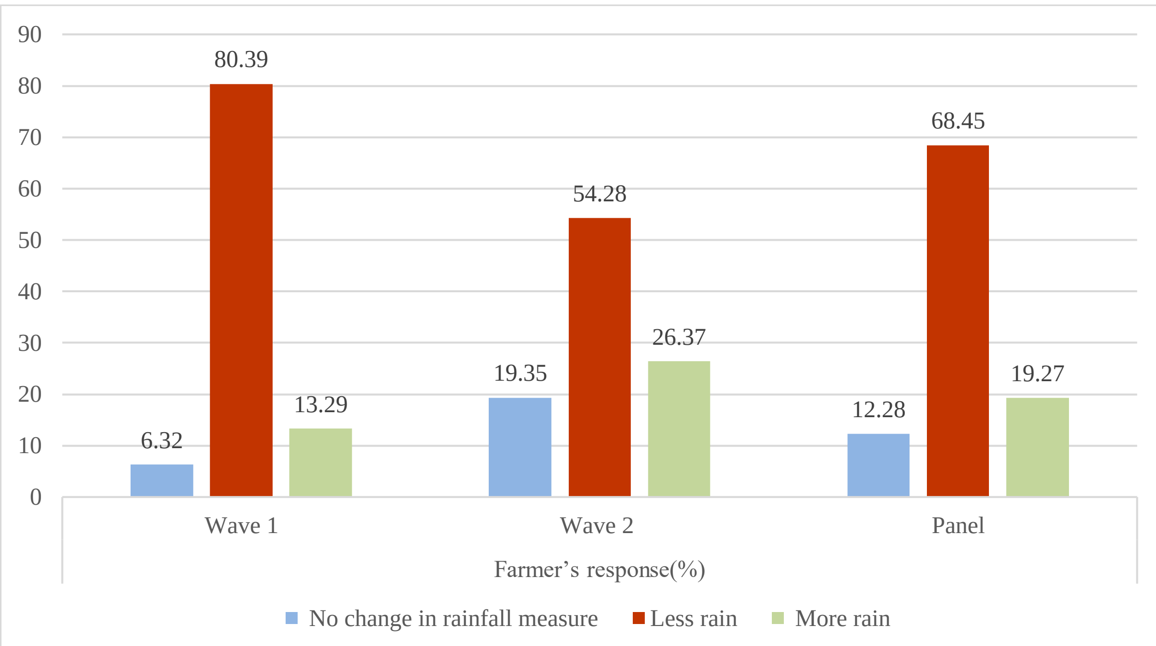


Figure 2 Household-level perception of changes in rainfall measure (%) in the last five years

4.2.2 Perception of changes in the distribution of rainfall

Regarding the perception of the distribution of rainfall, Figure 3 shows that 70.26% of the respondents reported the worse distribution of rainfall. About 16.89% of respondents reported better distribution of rainfall while 12.85% reported no change in the rainfall distribution. These findings confirm that the majority of respondents, amounting to 70.26%, perceived worsened distribution of rainfall.

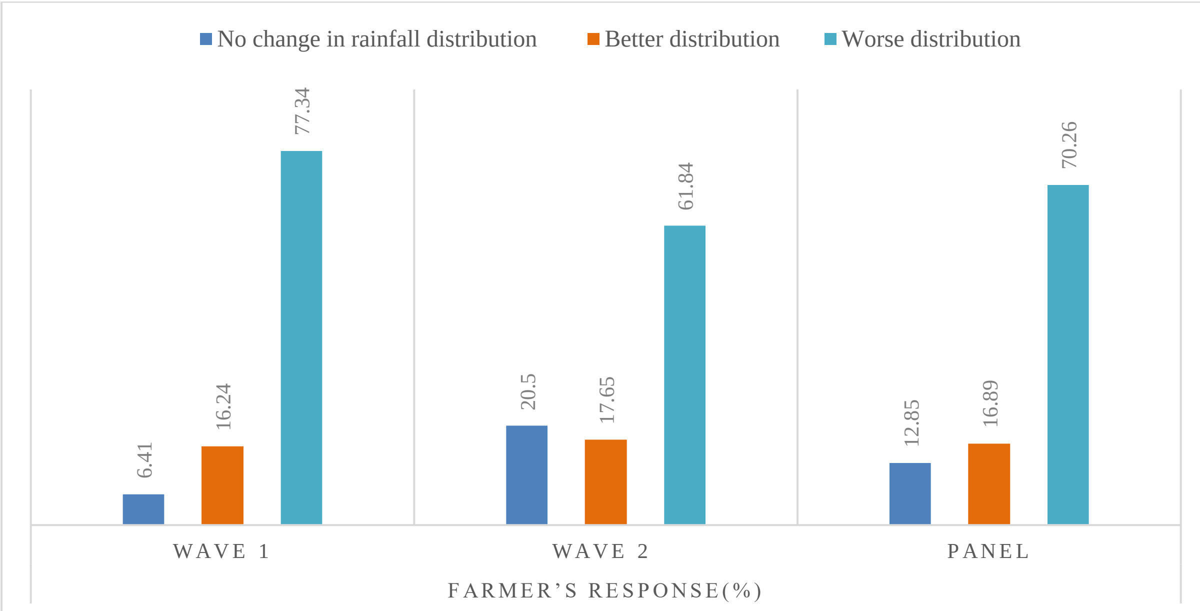


Figure 3 Household-level perception of changes in rainfall distribution (%) in the last five years

4.2.3 Perception of changes in drought occurrence

Figure 4 reveals that 77.67% of the respondents reported a more frequent occurrence of drought, while 22.33% reported a less frequent occurrence. Similar results were reported by a study conducted by Akponikpè et al. (2010), which reported that a higher proportion of farmers in Benin, Burkina Faso, and Niger mentioned an increase in the number of dry spells, ranging from 70% to 95%.

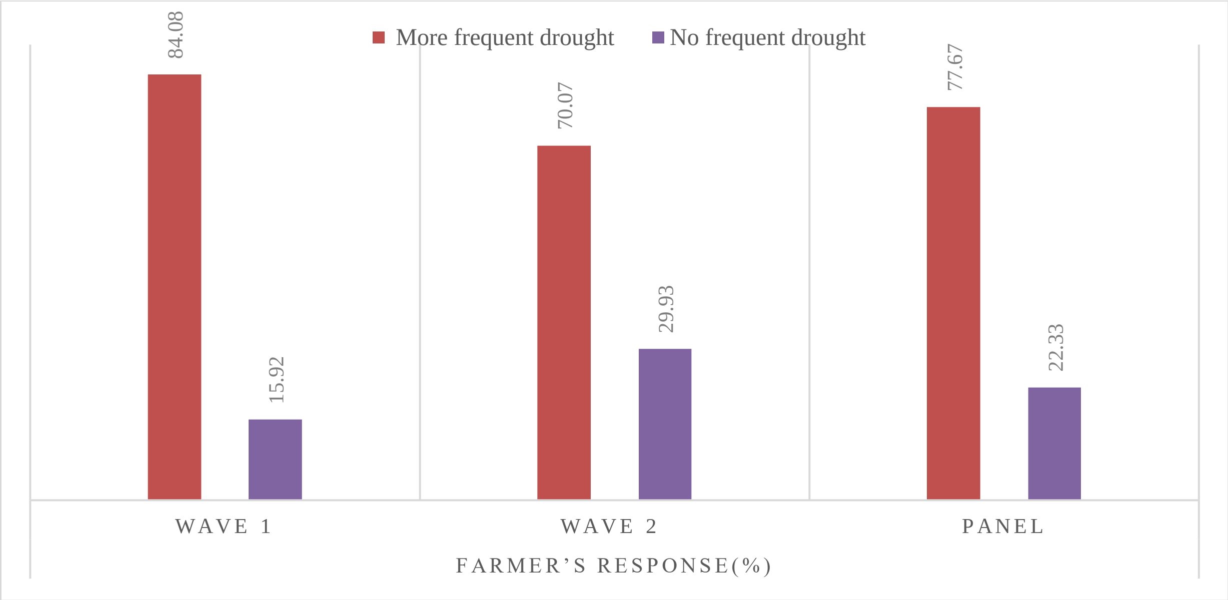


Figure 4 Household-level perception of changes in drought occurrence (%) in the last five years

### 4.2.4 Perception of changes in flood occurrence

According to Figure 5, 26.16% of the respondents observed an increase in the frequency of flood occurrences in the last five years, while 73.84% reported a decrease in frequency.

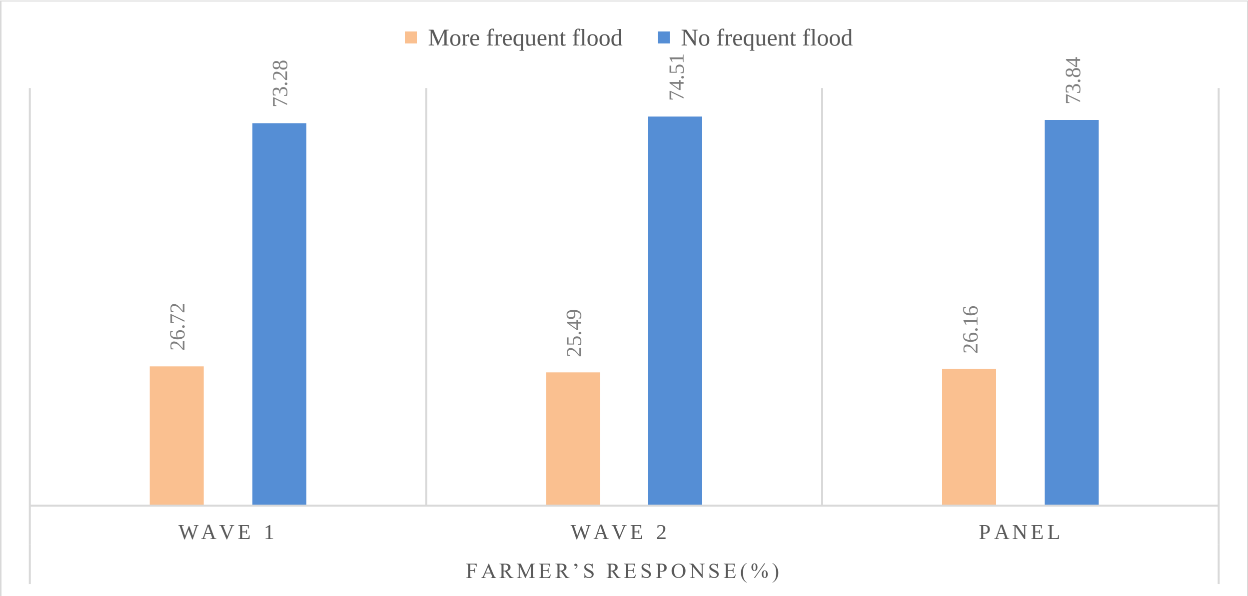


Figure 5 Household-level perception of changes in flood occurrence (%) over the last five years

4.2.5 Perception of changes in seasonality in the rainy season

A considerable proportion of respondents reported changes in the seasonality of the rainy season, with 72.14% reporting a delay in the start of the rainy season and 81.41% reporting an early finish as shown in Figure 6 and Figure 7. On the other hand, 27.86% and 18.59% of respondents reported no delay in the start of the rainy season and no early finish, respectively. These findings are consistent with a study by Akponikpè et al. (2010), with 70-90% of Sahelian farmers reporting a later onset and early cessation of the rainy season.

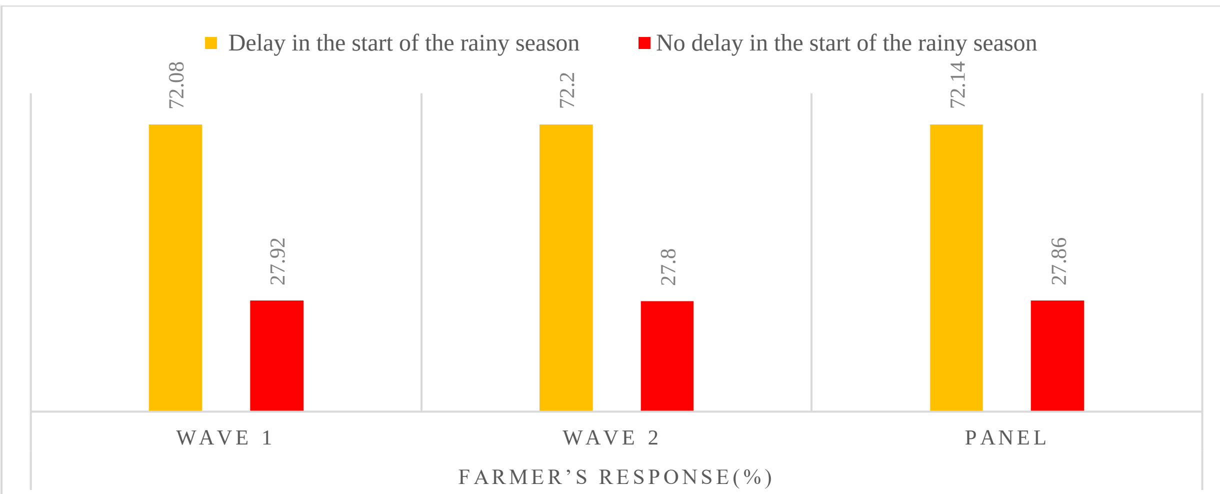


Figure 6 Perception of delay in the start of the rainy season in the last five years

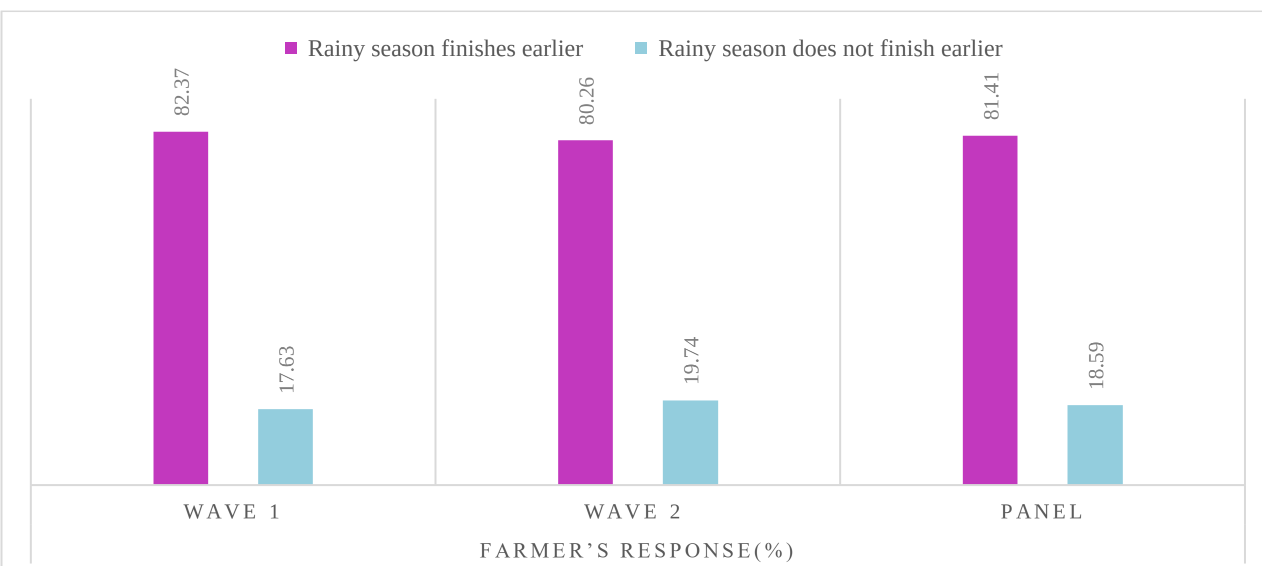

Figure 7 Household-level perception on early finishing of the rainy season (%) in the last five years

4.2.6 Perception of changes in the period of great heat.

In terms of the perception of changes in the period of great heat, Figure 8 shows that 57.75% of households reported a longer period in the last five years, while 16.39% reported a shorter period. This matches a study by Akponikpè et al. (2010), where farmers in Sub-Saharan West Africa reported an increase in temperature and the number of hot days by more than 60% and 50%, respectively.

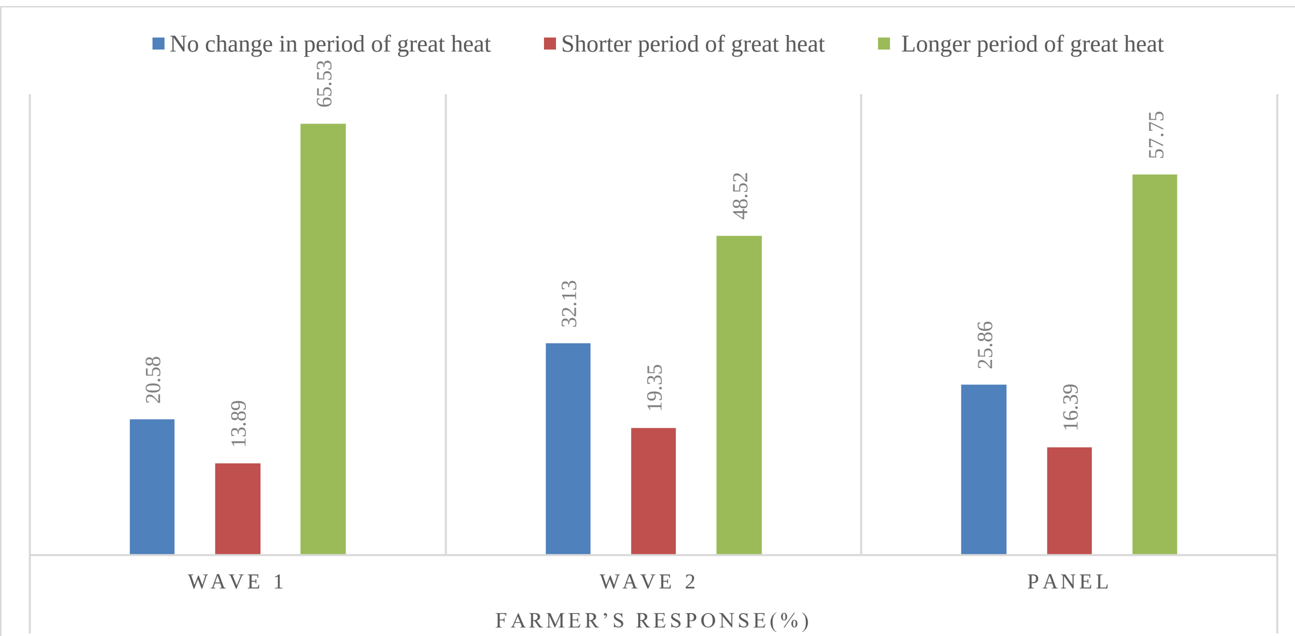


Figure 8 Household-level perception of changes in the period of great heat (%) in the last five years

4.3 Household-level climate change adaptation strategies

We also analyzed the major adaptation strategies employed by the rural household of Niger to reduce the impacts of climate change and a summary of the adaptation strategies is presented in

9. A more detailed description of the adoption of adaptation strategies are included in Appendix 3.

In response to the climatic variability, about 60% of rural households in Niger employed various adaptation strategies. Among these, the most common strategies were practicing non-agricultural activities more often (27.36%), migration of certain household members (20.57%), raising less livestock to increase agriculture (18.11%), and changing seed varieties (17.71%). The significant use of non-agricultural activities could be attributed to the lesser risk associated with such activities in comparison to agriculture, given the impacts of climatic variability. This finding is consistent with previous studies by Epule et al. (2017), Fentahun et al. (2018), and Wan et al. (2016), which emphasized the importance of income diversification as an adaptation strategy in managing disaster risk and improving welfare in Sahel, Ethiopia, and Northern China, respectively.

The migration of certain household members could be attributed to better opportunities and income generation, especially given the negative impacts of floods. In developing countries, societies use migration as a means of coping with climate variability, and it continues to be an essential mechanism for livelihood resilience, as argued by Adger et al. (2003). Changing seed varieties, the second most adapted strategy could be associated with its low cost and ease of access. In a study by Dhakal et al. (2022), adoption of adaptation measures such as improved crop varieties, irrigation, and use of organic fertilizers was found to have a positive and significant impact on farm income in Nepal and they argued that farmers who adopt adaptation measures are better able to cope with the negative effects of climate change. The least popular adaptation methods used by the households were raising fewer cattle and switching to camels (5.39%) and renting or mortgaging land (4.72%).

The results from Appendix 3 show that from wave 1 to wave 2, the percentage of households that utilized adaptation strategies to climate variability increased from 57.41% to 62.77%

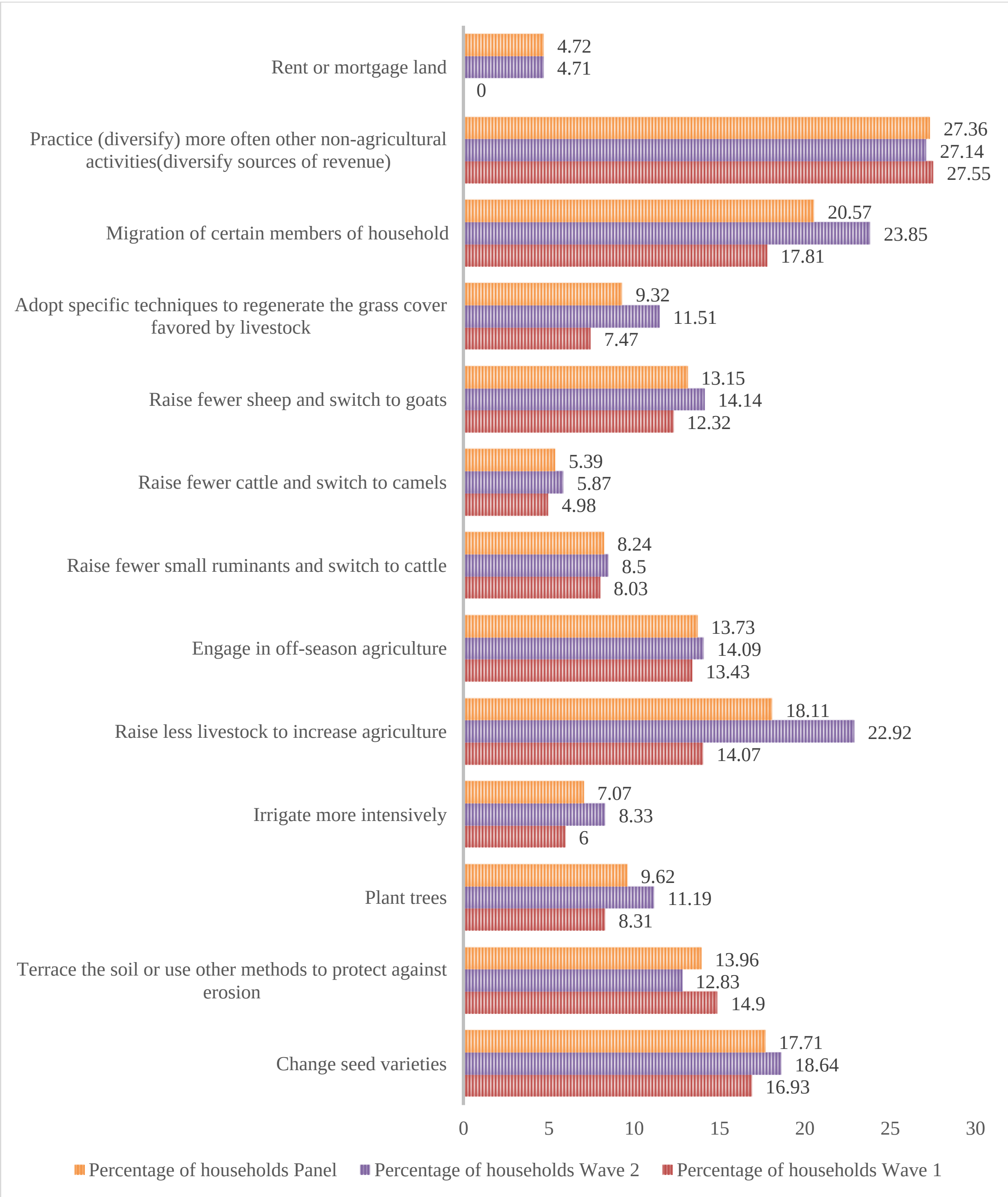


Figure 9 Summary of adaptation strategies used by sampled households in wave 1, wave 2, and panel.

Source: Own computation from survey data, 2023

Note: Percentages do not add to 100 since households employ more than one adaptation strategy at a time.

4.4. Impact of climate change perception on the choice of adaptation strategies used by the household

The study seeks to quantify the impact of households' perception of climate change on their adaptive capacity. The model's results were presented in Table 4, which showed the marginal effects of the perception variables and other explanatory variables on the various categories of adaptation choices. In the following subsections, we describe the impact of only the significant perception variables and other explanatory variables on the probabilities of adopting different adaptation categories in response to climatic variability.

**Perception of decrease in rainfall measure**: The analysis showed that the change in perception of a decrease in rainfall measure had a positive impact on households' probability of using crop-related adaptation strategies. However, this perception variables did not have significant effect on other categories of adaptation strategies. The results indicated that a change in perception of a decrease in rainfall measure increased the probability of using crop-related adaptation strategies by 5.96%. These strategies included changing seed varieties, terracing the soil, or using other methods to protect soil against erosion, planting trees, irrigating more intensively, raising less livestock to increase agriculture, and engaging in off-season agriculture. The results are in line with previous studies that have reported the positive impact of perception and awareness of climate change on adaptation choices. These adaptation strategies can help households to use available water resources efficiently, reduce the negative impact of climate change on agricultural production, and increase the likelihood of sustainable and conservational practices. Studies by Irham et al. (2022), Ado et al. (2019), and Akponikpè et al. (2010) also found that farmers in Indonesia, Niger, and Burkina Faso respectively use adaptation strategies such as using superior varieties, organic manure, and soil water conservation techniques to cope with decreasing rainfall.

**Perception of a more frequent flood**: The results show that a change in a household's perception of frequent floods has a significant positive impact on the probability of adopting any adaptation strategies, as well as on the probability of adopting all three specific categories of adaptation. Perception of a more frequent flood is another crucial factor in climate change perception. The study reveals that the households that changed their perception of more frequent flood occurrences also increased the probability of using all groups of adaptation strategies. This means that the households' perception of a more frequent flood occurrence increases the probability of using crop-related strategies, livestock-related strategies, and alternative livelihood strategies. The change in perception of more frequent flood occurrence by rural households increases the probability of using at least one of the adaptation strategies by 11.1% to reduce the impacts of climate change. Similarly, it increases the probability of using crop-related strategies by 8.59%, livestock-related strategies by 10.6%, and alternative livelihood strategies by 10.8%. Perception of increased flood occurrence had the most significant positive effect on alternative-livelihood adaptation strategies such as migration, diversifying revenue sources, and renting or mortgaging land. This is because migration provides new opportunities for flood-affected individuals while diversifying sources of revenue reduce risks associated with agricultural production losses due to frequent floods. Bryan et al. (2009) supported the positive effect of perceived extreme weather events on farmers' decision to adapt in Ethiopia and South Africa. They suggested that farmers are more adaptive to reduce the risk of future extreme weather shocks, rather than reacting to measured differences in the average amount of rainfall variability.

**Perception of changes in the seasonality of the rainy season**: The study found that changes in perception of changes in the seasonality of the rainy season negatively affected the probability of using crop-related adaptation strategies, as evidenced by a 5.63% decrease. This finding is consistent with a previous study by Apata et al. (2009), which reported that changes in rainfall timing significantly reduced the likelihood of arable food crop farmers adapting to climate change in Southwestern Nigeria.

**Extension services**: Results from Table 4 shows that changes in access to extension services significantly affect the probability of households adapting to climate change. Specifically, households that have changes in access to extension services are more likely to employ all categories of adaptation strategies, with an increase in the likelihood of employing at least one adaptation strategy by 25.9%. Additionally, the probability of employing crop-related adaptation strategies, livestock-related adaptation strategies, and alternative livelihood options increases by 28.2%, 18.3%, and 19.7%, respectively. Access to extension services provides crucial information on contemporary climate-related issues and offers training on agricultural production and adaptation practices, including crop management strategies, soil conservation, off-season agriculture production, and livestock management. The utilization of extension services enhances households' understanding of different management practices and technologies, which improves their adoption rates. Supporting results include Belay et al. (2017) which found that access to extension services positively and significantly affects the adoption of adaptation practices toward climate change in Ethiopia's Central Rift Valley. Maddison (2007), Debela et al. (2015), and Deressa et al. (2009) also reported equivalent results in other regions of Ethiopia and Africa.

The result also revealed that having farming as the primary occupation of the household head decreases the probability of adaptation to climate change by using livestock-related adaptation strategies and alternative livelihood options by 7.81% and 7% respectively. Besides these variables, the other variables in the regression are insignificant like the perception of longer heat period, age of the household head, female-headed household head, and household that has radio. However, some variables like household size and education of household head had a significant and negative effect on the probability of climate change adaptation which is not clear and difficult to explain since household size and education are supposed to have a positive effect on the adaptation process. These contrasting results call upon further research to explain these results.

Table 4 Marginal effects from the fixed effects logit models of household-level adaptation categories.

| | Adaptation | Crop-based | Livestock-based | Alternative |
|---|---|---|---|---|
| less_rain | -0.000693 | 0.0596* | -0.0110 | 0.00131 |
| | (-0.03) | (2.35) | (-0.48) | (0.05) |
| freq_flood | 0.111*** | 0.0859** | 0.106** | 0.108*** |
| | (3.90) | (3.00) | (2.66) | (3.79) |
| altered_rain | -0.0241 | -0.0563* | 0.0363 | -0.0190 |
| | (-0.95) | (-2.09) | (1.37) | (-0.73) |
| longer_heat | -0.0259 | 0.0221 | -0.0123 | -0.0242 |
| | (-1.08) | (0.87) | (-0.52) | (-0.95) |
| hage | 0.000284 | 0.00229 | -0.000998 | 0.00185 |
| | (0.13) | (0.95) | (-0.47) | (0.75) |
| educ_head | -0.131* | -0.116 | -0.102 | -0.0648 |
| | (-2.11) | (-1.85) | (-1.75) | (-1.02) |
| hhsize | -0.00980 | -0.0149 | -0.0233** | -0.0133 |
| | (-1.19) | (-1.74) | (-2.93) | (-1.52) |
| female | 0.00116 | 0.0195 | 0.0150 | 0.0812 |
| | (0.02) | (0.33) | (0.23) | (1.31) |
| farmer | -0.0510 | -0.0403 | -0.0781* | -0.0700* |
| | (-1.62) | (-1.23) | (-2.34) | (-2.14) |
| radio | 0.0339 | -0.00355 | 0.0118 | -0.00758 |
| | (-1.23) | (-0.12) | (0.42) | (-0.26) |
| extension | 0.250*** | 0.282*** | 0.183*** | 0.197*** |
| | (7.47) | (8.03) | (3.42) | (6.49) |
| N | 1856 | 1664 | 1304 | 1658 |

[2]

Note: ***, **, and * signify level of significance at 1%, 5%, and 10%, respectively. The value included in the parentheses is t statistics.

Source: Own computation from survey data, 2023

The detailed description of these variables' names is given in Table 2.

[2] The results from the fixed effects logit model including the estimated parameters in included in Appendix *4*

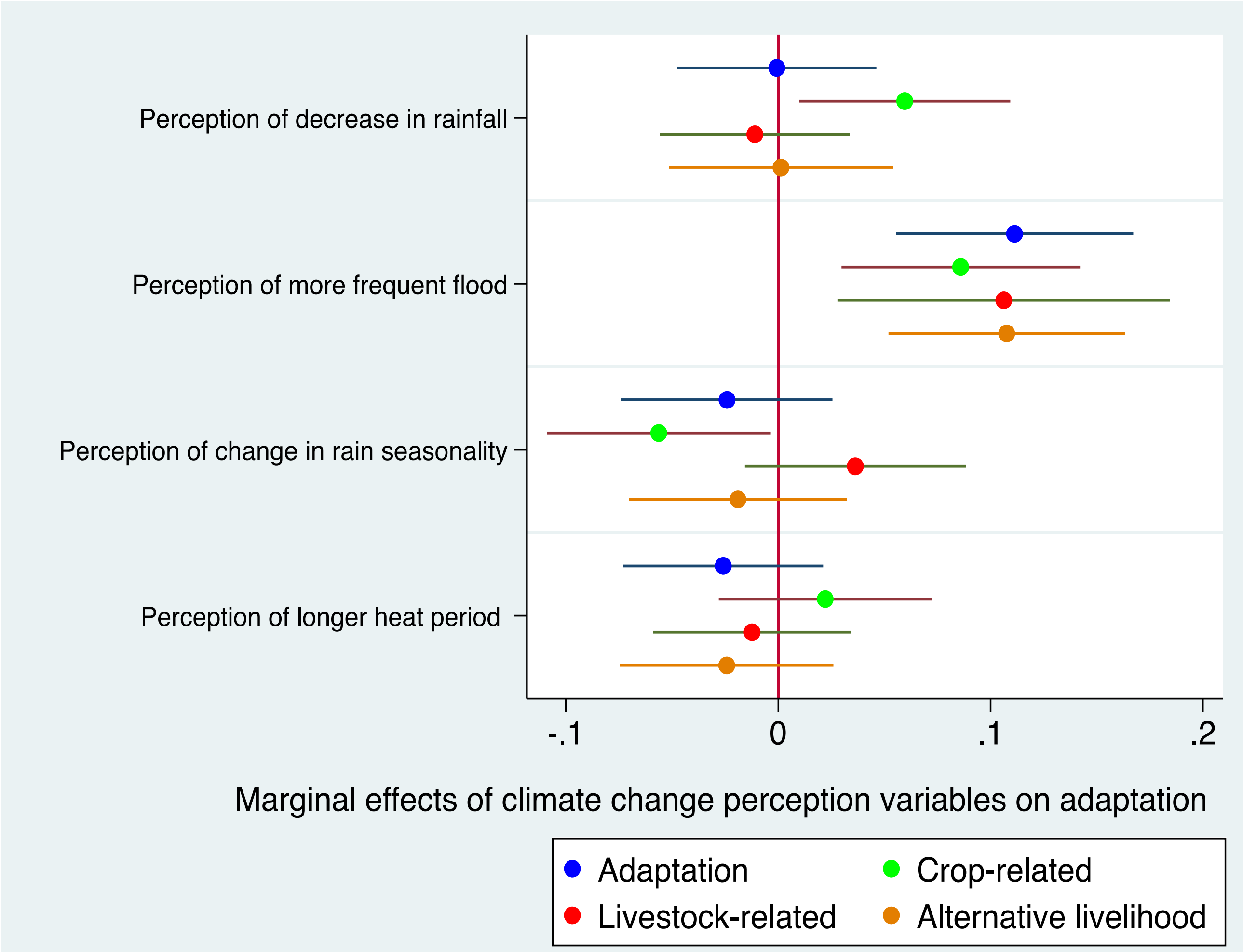


Figure 10 Marginal effects of perception variables from the fixed effects logit models of household-level adaptation categories.

Source: Own computation from survey data, 2023

[3]

[3] For better interpretation, we only showed the marginal effects of climate change perception variables.

# 5. CONCLUSION

In conclusion, the present study analyzed the perception of rural households in Niger towards long-term climate change, discussed commonly used adaptation strategies towards climate change, and examined the influence of climate change perception on adaptation towards climate change. We used panel data with a fixed effects logit model to estimate the marginal effects of various perception and household factors on four categories of adaptation which is an improvement compared to the approach of previous studies and allows better understanding of the complex relationship between climate change perception and adaptation. The results showed that most rural households in Niger perceived long-term changes in climate and employed at least one of the adaptation strategies to minimize the negative impacts of climate change. Notably, households are employing strategies like engaging often in non-agricultural activities, migration of certain members of the household, and changing seed varieties.

We found that households who changed their perception of climate change were also more likely to increase adaptation by using different adaptation categories. More frequent floods had a significant positive effect on all categories of adaptation, indicating that households are more likely to adopt adaptation measures when they change their perception of more frequent floods. On the other hand, less rainfall had a positive effect on crop-based adaptations and rain seasonality had a negative effect on crop-based adaptations. Longer heat periods did not show significant effects on any of the adaptation categories. Furthermore, education level and household size had negative effects on some categories of adaptation, while participation in extension programs had a positive effect across all categories.

Overall, the study adds that even though rural households in Niger are highly vulnerable to climate change, they are making efforts for adaptation to climate change effects by employing diverse adaptation strategies. The most common strategy employed by households was engaging more often in non-agricultural activities to diversify the source of revenue and migration of certain members of household. This implies that rural households are slowly transitioning from agricultural to non-agricultural activities in response to the impacts of climate change and this could be associated with the lesser risk in non-agricultural activities given the greater climatic variability impacts in agriculture. This supports the findings of Epule et al. (2017); Fentahun et al. (2018), and Wan et al. (2016) that argued income diversification is the main adaptation strategy to act against the negative consequences of climate change in Sahel, Ethiopia, and Northern China respectively.

The results of fixed effects logit model indicated that perception-based variables were significant in influencing the level of adaptation. Notably, this provides new findings compared to a previous study conducted by Marie et al. (2020), where the perception of climate change was found to be insignificant in climate change adaptation. In addition to this, it confirms the findings in the literature that emphasized human cognition as significant factor influencing climate change adaptation (Grothmann & Patt, 2005; Kuruppu & Liverman, 2011). Similarly, the perception of the more frequent flood being the most significant among all perception variables also reveals the importance of considering extreme weather events and other climatic variables while studying the influence of perception of climate change on its' adaptation for better understanding, rather than just focusing on average rainfall and temperature. This study contributes in filling a knowledge gap emphasized by Epule et al. (2017) which argued about the importance of exploring and verifying the effects of climate shocks such as winds, droughts and floods in driving adaptation efforts. And this finding supports the study conducted by Bryan et al. (2009) where they advocated for positive effect of perceived extreme events on farmers' decision to adapt in Ethiopia and South Africa.

Overall, the findings from this study provides further evidence that perception of long-term climate change have influence in shaping adaptive behavior and also in the choice of adaptation strategies. It also provides important insights on how rural household of Niger perceive long term changes in climate and what measures they employ to reduce the negative effect of climate change. By digging deeper into perception of climate change and exploiting the panel nature of data, this study contributes to the growing body of literature on climate change adaptation. However, it is important to note that the impact of perception on adaptive behavior can be different for different context and this requires further research in the perception and adaptation of climate change.

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APPENDICES:

Appendix 1 Correlation matrix for climate change perception variables

| | less_rain | worse_dist | freq_drought | freq_flood | delay_rainy | finish_rainy | longer_heat |
|---|---|---|---|---|---|---|---|
| less_rain | 1.0000 | | | | | | |
| worse_dist | 0.4415 | 1.0000 | | | | | |
| freq_drought | 0.2858 | 0.2755 | 1.0000 | | | | |
| freq_flood | -0.1064 | 0.0072 | -0.0136 | 1.0000 | | | |
| delay_rainy | 0.1932 | 0.1884 | 0.3426 | 0.0444 | 1.0000 | | |
| finish_rainy | 0.2789 | 0.2803 | 0.3994 | -0.0674 | 0.3057 | 1.0000 | |
| longer_heat | 0.2043 | 0.3386 | 0.2341 | 0.0957 | 0.1631 | 0.1623 | 1.0000 |

Appendix 2 Household-level perception of changes in climate

| Climatic variables | Farmer's response (%) | | |
|---|---|---|---|
| | Wave 1 | Wave 2 | Panel |
| Rainfall Measure | | | |
| 1. No change in rainfall measure | 6.32 | 19.35 | 12.28 |
| 2. Less rain | 80.39 | 54.28 | 68.45 |
| 3. More rain | 13.29 | 26.37 | 19.27 |
| Distribution of rainfall this year | | | |
| 4.No change in rainfall distribution | 6.41 | 20.50 | 12.85 |
| 5. Better distribution | 16.24 | 17.65 | 16.89 |
| 6. Worse distribution | 77.34 | 61.84 | 70.26 |
| Drought occurrence | | | |
| 7. More frequent drought | 84.08 | 70.07 | 77.67 |
| 8. No frequent drought | 15.92 | 29.93 | 22.33 |
| Flood occurrence | | | |
| 9. More frequent flood | 26.72 | 25.49 | 26.16 |
| 10. No frequent flood | 73.28 | 74.51 | 73.84 |
| Start of the rainy season | | | |
| 11. Delay in the start of the rainy season | 72.08 | 72.20 | 72.14 |
| 12. No delay in the start of the rainy season | 27.92 | 27.80 | 27.86 |
| Finishing of the rainy season | | | |
| 13. The rainy season finishes earlier | 82.37 | 80.26 | 81.41 |
| 14. Rainy season does not finish earlier | 17.63 | 19.74 | 18.59 |
| Period of great heat | | | |
| 15. No change in the period of great heat | 20.58 | 32.13 | 25.86 |
| 16. A shorter period of great heat | 13.89 | 19.35 | 16.39 |
| 17. A longer period of great heat | 65.53 | 48.52 | 57.75 |

Appendix 3 Summary of adoption of adaptation strategies employed by sample rural households for wave1, wave2, and panel.

| Adaptation Strategies | Percentage of households | | |
|---|---|---|---|
| | Wave1 | Wave2 | Panel |
| 1. Adaptation | 57.41 | 62.77 | 59.86 |
| 2. Crop-related adaptation | 35.90 | 41.34 | 38.39 |
| a. Change seed varieties | 16.93 | 18.64 | 17.71 |
| b. Terrace the soil or use other methods to protect against erosion | 14.90 | 12.83 | 13.96 |
| c. Plant trees | 8.31 | 11.19 | 9.62 |
| d. Irrigate more intensively | 6.00 | 8.33 | 7.07 |
| e. Raise less livestock to increase agriculture | 14.07 | 22.92 | 18.11 |
| f. Engage in off-season agriculture | 13.43 | 14.09 | 13.73 |
| 3. Livestock-related adaptation | 22.29 | 26.75 | 24.33 |
| a. Raise fewer small ruminants and switch to cattle | 8.03 | 8.50 | 8.24 |
| b. Raise fewer cattle and switch to camels | 4.98 | 5.87 | 5.39 |
| c. Raise fewer sheep and switch to goats | 12.32 | 14.14 | 13.15 |
| d. Adopt specific techniques to regenerate the grass cover favored by livestock | 7.47 | 11.51 | 9.32 |
| 4. Alternative livelihood adaptation | 35.95 | 41.56 | 38.51 |
| a. Migration of certain members of the household | 17.81 | 23.85 | 20.57 |
| b. Practice (diversify) more often other non-agricultural activities (diversify sources of revenue) | 27.55 | 27.14 | 27.36 |
| c. Rent or mortgage land | 0 | 4.71 | 4.72 |
| 5. No adaptation | 42.59 | 37.23 | 40.29 |

Appendix 4 Regression results from the fixed effects logit model

| | Adaptation | Crop-based | Livestock-based | Alternative |
|---|---|---|---|---|
| less_rain | -0.00302 | 0.264* | -0.0590 | 0.00559 |
| | (-0.03) | (2.31) | (-0.48) | (0.05) |
| freq_flood | 0.485*** | 0.380** | 0.568*** | 0.458*** |
| | (4.11) | (3.00) | (3.80) | (3.76) |
| altered_rain | -0.105 | -0.249* | 0.194 | -0.0808 |
| | (-0.95) | (-2.08) | (1.47) | (-0.73) |
| longer_heat | -0.113 | 0.0980 | -0.0658 | -0.103 |
| | (-1.07) | (0.86) | (-0.52) | (-0.94) |
| hage | 0.00123 | 0.0101 | -0.00534 | 0.00785 |
| | (0.13) | (0.90) | (-0.42) | (0.75) |
| educ_head | -0.571* | -0.513 | -0.543 | -0.276 |
| | (-2.07) | (-1.86) | (-1.76) | (-1.02) |
| hhsize | -0.0427 | -0.0660 | -0.125** | -0.0568 |
| | (-1.14) | (-1.79) | (-2.84) | (-1.48) |
| female | 0.00506 | 0.0864 | 0.0800 | 0.346 |
| | (0.02) | (0.33) | (0.24) | (1.31) |
| farmer | -0.222 | -0.178 | -0.418* | -0.298* |
| | (-1.58) | (-1.25) | (-2.43) | (-2.10) |
| radio | -0.148 | -0.0157 | 0.0631 | -0.0322 |
| | (-1.23) | (-0.12) | (0.43) | (-0.26) |
| extension | 1.089*** | 1.247*** | 0.979*** | 0.838*** |
| | (7.91) | (8.75) | (6.08) | (6.26) |
| N | 1856 | 1664 | 1304 | 1658 |

Note: ***, **, and * signify level of significance at 1%, 5%, and 10%, respectively. The value included in the parentheses is t statistics.