



***CLIMATE CHANGE ADAPTATION AND SUSTAINABLE RURAL LIVELIHOODS IN  
NIGER***

**By**

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DEA/Master's in agricultural economics and policy (UO2, now University Thomas Sankara, Ouagadougou)

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MAY, 2023

## AUTHORISATION TO COPY

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## **CERTIFICATION**

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## ACRONYMS

AIL : Adaptation Institution and Livelihood  
BMBF: German Federal Ministry of Education and Research  
CBNRM: Community-based Natural Resource Management  
CNDD: National Council of Environment for Sustainable Development  
ECVMA: Survey on the Households' living Conditions and Agriculture  
EHCVM: Harmonised Survey on the Households' living Conditions and Agriculture  
FAO: Food and Agricultural Organisation of the United Nations  
FCFA: Franc of the African Financial Community  
GEF: Global Environmental Fund  
GDP: Gross Domestic Product  
IFRC: International Federation of Red Cross and Red Crescent Societies  
INS: National Institute of Statistics  
IOM: International Organisation for Migration  
IPCC: Inter-governmental Panel on Climate Change  
LDCs: Least Developed Countries  
MCA: Millennium Challenge Account  
MPPACC: Model of Private Proactive Adaptation to Climate Change  
NAPA: National Adaptation Programme of Action  
NAPs: National Adaptation Plans  
NGOs: Non-Governmental Organisations  
NNN (3N): Nigeriens Nourish Nigeriens  
PDES: Social and Economic Development Plan  
PIPs: Policy Institutions and Processes  
SDR: Rural Development Strategy  
SPR: Poverty Reduction Strategy  
SRL: Sustainable Rural Livelihoods

SUR: Seemingly Unrelated Regression

UNFCCC: United Nations Framework Convention on Climate Change

UNDP: United Nations Development Program

WASCAL: West African Science Service Center on Climate Change and Adapted Land Use

## **DEDICATION**

I dedicate this thesis to my family:

- My parents, Soueba Sabiou and Elh Mahaman Yaou,
- To all my brothers and sisters
- To my Beloved wife, Zaratou Issa Elh Amada,
- My two children, Anass and Zakariyaou.

## ABSTRACT

Rural population in developing countries have been exposed and severely affected by climate vagaries, while adaptation has been challenging due to their lack of knowledge, capitals and capabilities to face risks. This research provides new empirical evidence on rural household's sustainability and climate change adaptation in Niger. This was necessitated by the fact that although the direct physical and biophysical impacts of climate change are mostly assessed, very little knowledge exists on the indirect economic, social, and human impacts of climate change, and the vulnerability of rural communities involved in livelihood-improving adaptation. The thesis consisted of assessing the level and determinants of the awareness of climate change, identifying the main drivers and welfare impacts of food storage, pastoralism, and labour diversification constituting three of the five specified adaptation classes, and evaluating rural maladaptive actions that drive changes in the adaptive capacity of different community groups engaged in conflicts over access to natural resources. The research uses a multistage sampling to collect primary data on 835 households on climate change, education, and conflicts in Tahoua, the central pastoral region of Niger, and Maradi, one of the central agricultural regions of the country. Two panel datasets from the three survey cohorts on households' living conditions and agriculture (ECVMA), secondary data collected by the National Institute of Statistics of Niger and the World Bank with 20,323 observations on households and 23,750 observations on land plots was also sourced. A logit regression, Seemingly Unrelated Regression (SUR) and instrumental variable regression were respectively estimated on the awareness of climate change, the drivers of adaptation, and maladaptation and conflicts. The results show that only higher education significantly determines awareness, while information broadcasting highly determines awareness of climate change. Adaptation was revealed to be highly incentivised by weather anomalies and market shocks. Responding to climate variability through food storage, labour diversification, and pastoralism have significant welfare effects on the households. Disadvantaged groups settle with low-risk but low-return adaptation techniques due to their social status. The study found important dynamics of maladaptation, magnified by governance failure, undermining the adaptive capacity of communities and resulting in to conflicts. Development efforts through the national adaptation plan (NAPs) should focus on integrating food storage, labour diversification, and pastoralism as household level adaptation technics, and integrate awareness raising in the rural areas. It should consider adopting more consultation and inclusiveness to account not only the physical impacts but also the economic, social, and human impacts of climate change. Finally, governance at different levels and institutions should be reformed to integrate accountability, leadership, and flexibility to facilitate peaceful climate change adaptation.

**Key Words:** Conflicts; Climate shocks; Market shocks; Maladaptation; Welfare;

# CHAPTER ONE

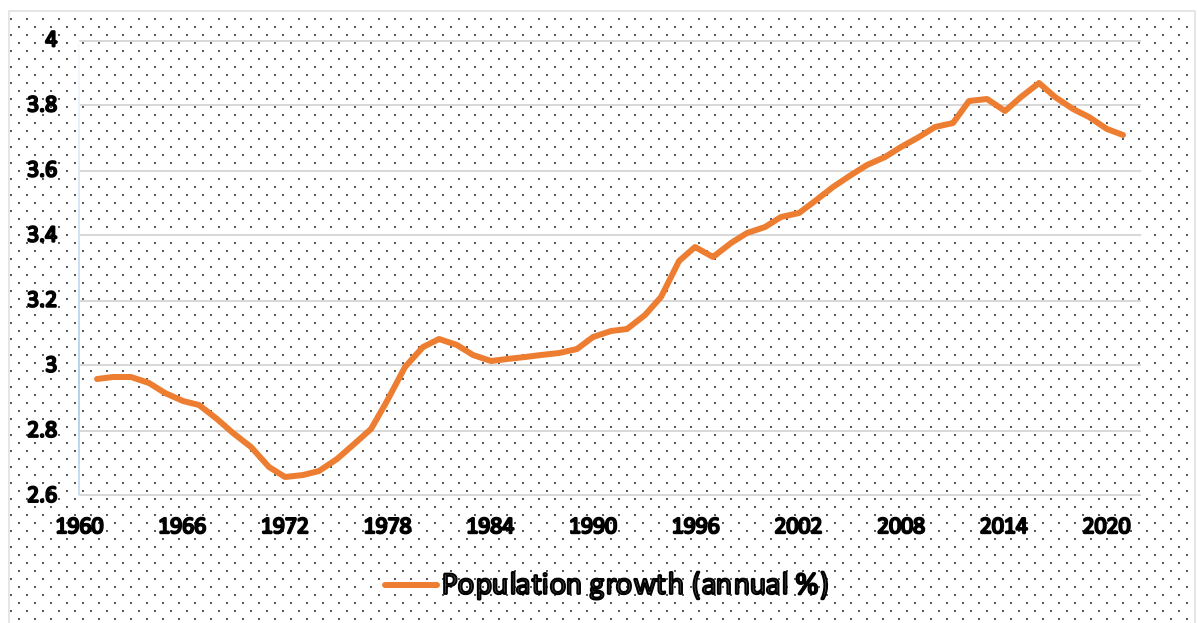
## INTRODUCTION

### 1.1. Background of the Study

Climate change is a major challenge of this century, ubiquitously affecting all continents and undermining human governance towards sustainable cities, livelihoods, and resource management regimes. The recent changes in the climate alter its variability, and properties, of which rainfall patterns, temperature, and humidity are essential for the livelihoods of rural households in developing countries (IPCC, 2014; Asfaw et al., 2018). These shifts in the climate properties precipitate climate disasters, the most frequent of which are droughts, floods, and locust outbreaks in tropical countries (UNFCCC, 2011). These affect the livelihoods of poor households in these regions through reduced agricultural yield, contracted life opportunities, and increased tensions around the control and use of already scarce resources (Leonardsson et al., 2021). Climate change also rhymes with other social contexts of vulnerability such as gender, ethnicity, social status, and economic upsets such as agricultural inputs and food market price shocks to conflict with various governments' and international agencies' actions of addressing present development issues (Owen, 2020).

Nevertheless, the past two decades have seen a significant rise in the development actions and implementation of climate change adaptation worldwide (Agrawal, McSweeney, et Perrin, 2008; Owen, 2020). That has benefited from increased funding opportunities –Green climate fund, adaptation fund, special climate change fund, least developed countries fund– and increased awareness and improved scientific

understanding of climate change and associated challenges and opportunities. In parallel, a range of spontaneous adaptations has also been developed out of planning, financing, or scientific discussions and has significantly improved rural households' social and ecological conditions (Reij et al., 2010; FAO, 2015). Adaptation emerges as instrumental and one of the most important international frameworks in addressing the climate adversities for the most vulnerable and marginalised societies (Asfaw et al., 2018; Schipper et al., 2021; Leonardsson et al., 2021).



**Figure 1.1: Population Growth (annual %)**

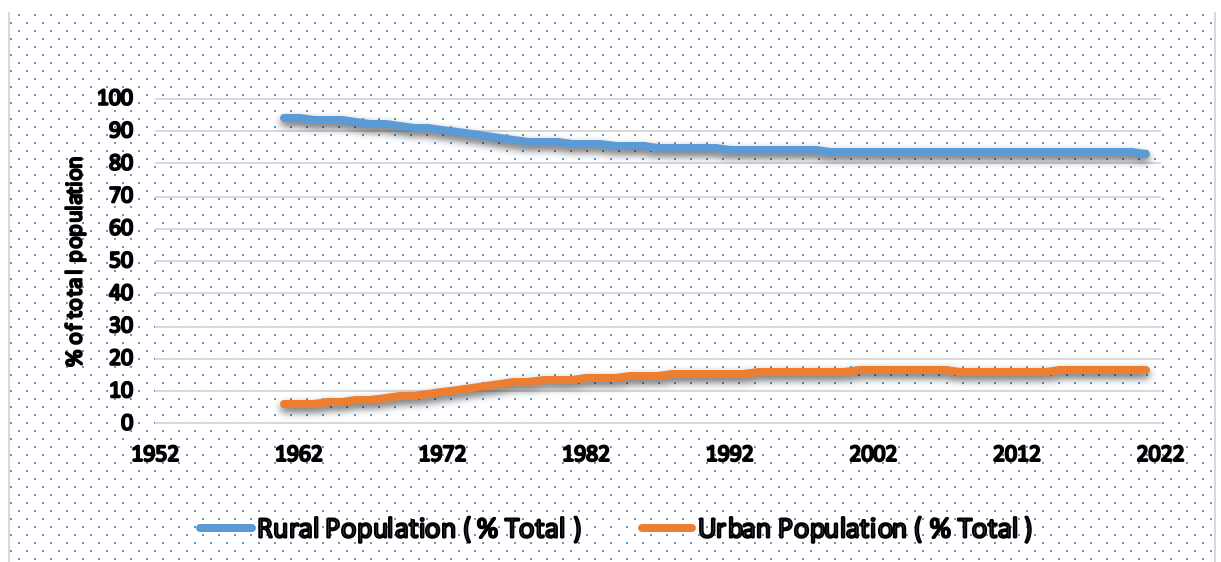
*Source:* Author, from the World Bank datasets 2023

However, adaptation to climate change and market shocks are difficult for households with a lack of crucial capital assets (Aldrich et al., 2016; Martin et Lorenzen, 2016) including social learning, interactions and knowledge creation (Grothmann et Patt, 2005; Pahl-Wostl, 2009; Nguyen et al., 2016). The lack of capital assets endowment drives adaptation lock-ins and plunges populations into a spiral of poverty and low livelihood opportunities and capabilities (Asfaw et al., 2018). Sub-Saharan Africa is particularly

concerned about future climate impact and natural resource governance due to rapidly expanding population dynamics (Figure 1.1 above), increasing short, and long-term weather changes (Asfaw et al., 2018), and high market volatility (Aker, 2010).

### 1.1.1. The Social and Environmental Context of Climate Change in Niger

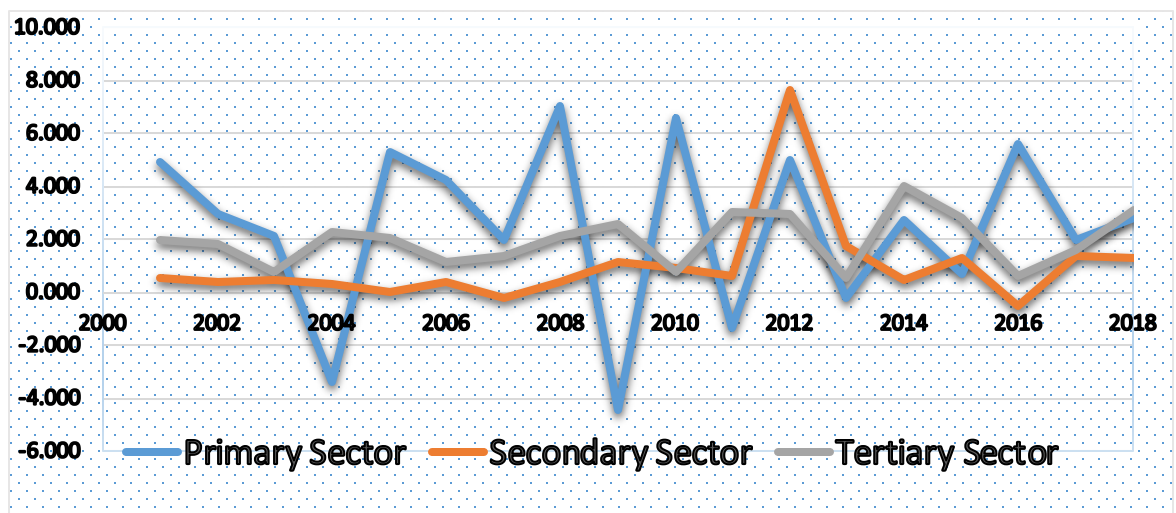
Niger is an inland Sahelian country located in the Sub-Saharan region, plagued by rapid population growth, high poverty rates –ranked 189th over 189 countries according to UNDP (2020)– and growing natural resources access-related conflicts (Thébaud et al., 2001; PNUE, 2011; Snorek et al., 2014) threatening development efforts consented by national and multilateral organisations. Nigerien communities are said to be particularly reluctant to adapt to climate change due to the persistent reliance on extensive rain-fed agriculture, shallow education level, lack of technical knowledge, and the lack of policy support to sustain subsistence-poor households –characterising adaptation deficit (Asfaw et al., 2018).



**Figure 1.2:** Population distributions by area

*Source:* Author, from the World Bank datasets 2023

Niger’s economy is essentially rural, with 83% of the population living in rural areas engaging in agriculture (INS, 2016) as presented in Figure 1.2. According to the National Institute of Statistics of Niger (INS), agriculture contributes more than 41% to the national revenue and more than 31% to export income. Niger's ecosystem is frail and characterised by rainfall deficits, floods due to erratic rains, and droughts caused by increased temperature trends. The social context of Niger is also characterised by acute and persistent food insecurity. According to an appeal of the International Federation of Red Cross and Red Crescent Societies of May 2022, which ends in April 2024, 4.4 million people need immediate humanitarian assistance in Niger due to the worse food insecurity crisis of this decade caused by drought (IFRC, 2022).



**Figure 1.3: contribution (%) of the three sectors in Niger’s economy**

*Source:* Author, from BCEAO datasets, 2023

The socio-environmental context of Niger is characterised by a long history of peaceful and complementary cohabitation between sedentary farmers and nomadic herders before the disrupting natural and anthropogenic effects of climate change. The territory is divided by law N° 61-5 of 26 May 1961, establishing a northern limit to agriculture and dedicating the vast north only to pastoralism. Any damage by herds in crop fields in the

northern part of this limit is not subject to compensation by herders. However, the agricultural south is dotted with hundreds of pastoral territories, strategic for the pastoralists and opened up by pastoral corridors along which are arranged pasture areas, watering points, animal rest areas and that links the northern pastoral zones to the southern agricultural lands. These pastoral territories are organised into “*territoires d’attache*”, meaning the home territory for pastoralists—Decree N° 97-007/PRN/MAG/E of 10 January 1997—a geographical area in which the pastoralist live during a significant period of the year and to which they are attached when they move to transhumance, nomadism or migration. Within their territory, pastoralist have priority, but not exclusivity, of the use of all the natural resources, including the land, pasture, and water, by article 28 of the 1993 ordinance, N° 93-015, which laid down the guiding principles of the Rural Code, completed by Ordinance N° 2010-29 of May 20, 2010, relating to pastoralism. Alliances are formed between pastoralists, especially at the time and throughout the transhumance roads, with the owners of the “*territoires d’attache*” accessing pasture and water in the areas. In the absence of social alliances, a symbolic payment is required by the owners of the “*territoires d’attache*” before watering animals, especially to maintain the walls in the area.

The only rainy agricultural season in Niger lasts from June to November. The agricultural lands in the south are liberated around December of each year for pastoralists to descend with their herds southward for crop residues, pasture, and water while the north has become dry and needs to regenerate – article 34 of the ordinance N° 2010-29 of May 20, 2010, relating to pastoralism. Pastoralists form also alliances with farmers on their transhumance ways to stay for a determined period –two or three weeks—to fertilise their lands. In return, they will find grass, crop residues, and sometimes farmers’ payment.

However, due to an exacerbation of climatic conditions, particularly the rise in temperature, and the deterioration of social situations, farmers start diversifying their assets by adopting many herds. At the same time, the herders consider adopting agricultural lands in the “*territoires d’attache*”. The herders from the north are no more welcome in the south for land fertilisation, while the farmers cut and store the crop residues to feed domestic animals and fertilise the lands with their manure. That is also exacerbated by a general misunderstanding of the texts of the rural code by the community groups, especially pastoralists in the “*territoires d’attache*” that think they have exclusive rights to use the natural resources in the “*territoires d’attache*”. That has given rise to a surge of conflicts between different communities, especially farmers and pastoralists, but also between pastoralists themselves for securing rights to pasture and water. To stem this phenomenon of disputes and conflicts in rural areas, the government has put in place specific provisions, in particular, the prohibition of the cutting and storing of crop residues and pastures by farmers by article 60 of the Ordinance N° 2010-29 of May 20, 2010, relating to pastoralism. A system of closing and liberation of the rain-fed agricultural lands for pastoralism in the agricultural south, by article 34 of the Ordinance N° 2010-29 of May 20, 2010, relating to pastoralism.

The closing and field liberation dates are determined by a decrees of the governor's representative in the concerned region. Transhumance, pastoralism, or any herds roaming are prohibited after the closing of the agricultural land, while no compensation is foreseeable in the case of crop damage by animals after the date of field liberation. Several provisions are also made for the management of conflicts between actors. However, despite all this legal arsenal, the rural local governance turns out to be very ineffective in resolving the problem of conflicts in Niger. Many authors, instead, think

this governance contributes to the resurgence of the phenomenon (Salih et al., 2002; Snorek et al., 2014; Thébaud et Batterbury, 2001).

### **1.1.2. Adaptation Planning in Niger**

Conscious of the challenge that the rural sector represents in Niger for peace, cohesion, and development, the country's successive governments have developed various strategies to eradicate rural poverty and improve livelihoods. The poverty reduction (SRP) strategy in Niger was declined in the Strategy of Rural Development (SDR), elaborated in 2003 under the agricultural sector policy and the United Nations Sustainable Development Goals. The objective of the SDR was directly linked to that of the SRP and was to diminish rural poverty incidence by 13% from 2003 to 2015. In 2012, the economic and social development plan (PDES) was elaborated and declined into many other programs, of which the 3N (Nigériens Nourish Nigériens) for which the ambition was to protect Nigériens from hunger in the horizon of 2035. The government and international agencies also developed many other development strategies, including Millennium Challenge Accounts (MCA) and the agenda 2063 of the African Union.

Niger developed its first and unique National Adaptation Program of Action (NAPA) in July 2006 through the National Council of environment for sustainable development (CNDD) with the assistance of the United Nations development program (UNDP) to identify the vulnerable sectors and for urgent decisions to be taken in the field of climate change. Its elaboration enters into the implementation of the United Nations Framework convention on climate change (UNFCCC), signed and ratified by the country respectively on the 11<sup>th</sup> of June 1992 and the 25<sup>th</sup> of July 1995. The main objective is to contribute to alleviating the adverse effects of climate variability and changes on the

most vulnerable populations with the prospect of sustainable development. It focused on the following approach (CNEDD, 2006):

- A consultative and participatory approach involving all the parties, particularly the regions, local authorities, local communities, representatives of the private sector, NGOs, and Civil Society Organisations;
- A multi-disciplinary and transparent approach based on the participation of all the specialists
- A complementary approach in synergy with the existing National Plans and Programs and Multilateral Environmental Agreements.

However, the analysis of the NAPA of Niger reveals many shortcomings and room for improvement due to a limited understanding of the indirect economic, social and human aspects of climate change and its impacts. In this research, the study ambition to propose mechanisms for filling this gap by mobilising appropriate literature and analysis and contributing to improving the understanding of climate change adaptation. These shortcomings of the NAPA of Niger include, among others:

- **The lack of inclusivity in the process of the elaboration of the PANA.**

Although consultation and participation are claimed in elaborating the PANA of Niger, it is evident from the list and the profiles of experts and contributors to the elaboration process that the indirect impacts on households' livelihoods –small scale farming, pastoralism, social safety– has not been accorded much attention. Niger has a ministry of livestock and herding, and pastoralism is represented in all social classes, including NGOs, the research community, the private sector, and civil organisations. However, of all these social strata, no profile related to pastoralism is included in the elaboration of the NAPA. As a consequence, it is observed:

- **The centrism of the PANA of Niger on the direct physical impact of climate change**

As climate change's indirect social and economic impacts are not well known or explored, the NAPA of Niger failed to explore the burden that the poor Nigerien population will bear from climate change. That is due to their lack of resistance means, access to credit, quality of shelters, the psychological burden and the disproportionate burden on women, children, and other disadvantaged groups due to their social status.

- **The NAPA failed to propose policy and support for pastoral livelihoods and other strategic adaptation techniques in the country.**

Pastoralism has been among the first historical and fundamental adaptation strategies for pastoralists and herders in the context of the Sahel. However, due to the delicacy of the pastoral question, pastoral livelihoods encounter the lack of the on-field policy involvement of all climate change stakeholders, including government institutions, NGOs, Civil societies, and international agencies (Thébaud and Batterbury, 2001). Pastoralism is unfortunately not explored in the NAPA of Niger, nor among the fourteen (14) project sheets identified by the country, while it was recognised as an adaptation option by article 2 of the Ordinance No. 2010-29 of May 20, 2010, relating to pastoralism. That can be improved in the subsequent NAPs that the country will draft.

- **The consequent absence of policy on the upsurge of conflicts between communities, the latter being extended in all the sub-region.**

The conflict between pastoralists and sedentary groups and among pastoralists has become very common, and the strategies and policies to resolve these conflicts and establish a peaceful coexistence are yet to deliver significant results. A clear policy and









projects on conflicts must be set to stop this plague that is causing hundreds of deaths in the country and the sub-region.

## **1.2. Problem Statement**

Niger has a high prevalence of disaster risks, with an increasing trend of disasters (European Union, 2020), more than most West African countries (table 1.1 below). That place the poor population in precarious day-to-day living, drawing from climate-sensitive activities, being highly exposed to –economic, climatic, health, and security– shocks and leading to a “wait and see” situation. The lack of access to resources, infrastructure, and education in rural Niger has severe implications for households’ ability to adapt to the changing environment. Without access to resources and services, households are unable to diversify their income, leading to extreme poverty and food insecurity. In addition, limited education and health care services mean that households are unable to access the information and technology needed to adapt to climate change.

As stated above, under the United Nation framework convention on climate change (UNFCCC), Niger developed its National Adaptation Plan of Action (NAPA) in 2006, with the financial assistance of the Global Environmental Fund through the United Nations Development Program (UNDP). That would highlight critical sectors and vulnerable populations and the adaptation strategies to alleviate the climate and economic impacts on the people (CNEDD, 2006). Nevertheless, the process of developing the adaptation program was marred by significant constraints, highlighted by the third national communication of Niger (CNEDD, 2016), including:

**Table 1.1: Disaster Risk ranking and three years Trend**

Country	Risk	Three years trend	Type of trend
Benin	4.4		Normal trend
Burkina	5.3		Normal trend
Cote d'Ivoire	6		Normal trend
Ghana	3.8		Normal trend
Mali	6.4		Normal trend
Niger	6.7		Increasing trend
Nigeria	6.9		Increasing trend
Senegal	5		Normal trend

Source: adapted from European Union, 2020

- The weak development of education, training, and research on climate change, particularly concerning vulnerability and adaptation;
- The lack of national expertise in terms of a holistic evaluation of vulnerability and adaptation to climate change;
- The weak capacity of national experts in modelling climatic phenomena;
- The poor mastery of the problem of climate change by the National actors;

That shows the critical need to fill the knowledge gaps at all scales –including the scientific expertise on climate change, the institutional understanding of climate change and adaptation, and the households’ awareness, understanding, and adaptation knowledge creation –through multi-scale transformative learning and interactions.

### 1.3. Research questions

The main question this research wants to respond to is how climate change adaptation determines a sustainable livelihood in rural Niger?

The research wants to know the following:

1. What determine the awareness of rural households on climate change in Niger?
2. What are the links between climate change adaptation and the livelihoods of rural households in Niger?
3. What are the effects of maladaptation on conflicts between different groups in the rural Niger

#### **1.4. Objective of the Study**

The main objective of this thesis is to determine the contribution of climate change adaptation to the sustainable rural livelihoods in Niger.

Specifically, it is:

1. To assess the determinants of farmers' awareness of climate change in the study area.
2. To determine the links between climate change adaptation and the livelihoods of rural households in Niger.
3. To evaluate the effects of maladaptation on social conflicts in rural Niger.

#### **1.5. Research Hypothesis**

With regards to the objectives of the study, the following hypothesis are formulated:

1. Socioeconomic and biophysical variables determine awareness of climate change in rural Niger
2. Adaptation to climate change improve the livelihoods of rural households in Niger
3. Adaptation processes are strewn by maladaptive outcomes that trigger conflicts in rural Niger

## **1.6. Scope of the Study**

This study investigate the role of climate change adaptation in sustaining the livelihoods of rural population in the face of climate change in Niger. It covers three different components of households' sustainability, starting with the level of awareness of climate change of the rural households, the determinants of the decision to adapt to climate change and how does it affect the rural livelihoods, and the role of maladaptation in the upheaval of the conflicting behaviour between households. Both primary and secondary datasets were used to achieve the objectives of this thesis. The data collection through fieldwork covered two regions of Niger in the north and the south. Both the household and the agricultural datasets from the Survey on Households' Living conditions and Agriculture secondary data which covered all the regions of the country were also used. In addition to the households' socioeconomic characteristics, biophysical variables like the perceived distribution of rainfall, the perceived change in the amount of the rainfall, the perceived increase in the frequency of droughts and floods were integrated to see how perception can shape awareness of climate change. The study also introduced experienced climate shocks like droughts and floods, and prices shocks of which input and food price shocks to see how they can trigger households' adaptation. Finally this study evaluated the role of local governance in resolving conflicts in the rural areas.

## **1.7. Significance of the Study**

This study is important because it seeks to conciliate the subjective adaptation option based on collective learning and transformative governance to the objective adaptation –transforming assets endowments of the households into adaptive capacity. The high incidence of poverty in developing countries in general, and Niger in particular, the long-lasting and lagging struggles of the government and international organisations to

combat poverty, undernourishment, food insecurity, and humanitarian surges, and the additional burden imposed by climate shocks, understanding how does households fit and adapt to multiple stressors is important to develop policy geared at improving their livelihoods.

Finally, the study has empirically brought into light how certain rural spontaneous adaptation practices, documented in previous research (Snorek et al., 2014; Thébaud et al., 2001), and intended for the households to survive the global changes reduces the adaptive capacity of other user groups and end up triggering conflicts that have gained prominence in the country's and even the whole region's rural areas today.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Conceptual Review**

##### **2.1.1. Climate Science, the State of the Changes and Variability Calling for Adaptation**

Climate change today monopolises all the debates and discussions. Even the refractors of climate change are now asking questions about the phenomena governments and populations face and combat in different corners of the world. Despite the increasing efforts of the scientific community to understand and estimate climate change, some aspects remain unsettled (Palmer and Stevens, 2019; Benjaminsen, 2012; Oettle et al., 2014). Nevertheless, our understanding of global warming and its anthropogenic origin and the reciprocal relationship between global warming and the hydrological cycle – changes to rainfall and other weather patterns – is enough to comfort our dissatisfaction with the business-as-usual scenario for climate action. The more the climate action is delayed, the costlier it will be and pose more technological, institutional, social, and economic challenges (IPCC, 2014a).

Until the recent past, only the direct impacts of climate change on biophysical characteristics –atmosphere, oceans, land use, deforestation–were assessed, while the indirect social and economic impact was unknown to the scientific community. Poor people, especially in developing countries, are expected to bear more burden of the impact of climate change. These countries lack crucial adaptation means like financial

capacity and quality of shelters (Noble et al., 2014) and rely on rain-fed agriculture and low capacity to recover from climate stressors (Castells-Quintana et al., 2018). Thus, climate change threatens many livelihood options vital for human well-being. The nexus between climate change and human livelihoods is very poorly documented and understood today and is worth to be drowned in this section.

Climate change can be referred to as the observed long-term variation in the biophysical characteristics of the climate, namely the increasing temperature trend and unprecedented changes in rainfall patterns. That manifests in various hazardous events depending on the geography and the weather of the regions on earth (sea level rise, floods, droughts, storm surges, hurricanes). Livelihood options are formed from the combination of assets, capabilities, and activities at the disposal of households and from which living is derived. These depend on the access and use of human, physical, social, financial, and natural capitals (Wang et al., 2013). Climate hazards like droughts undermine food security by reducing food availability and quality. Drought also affects the number and quality of livestock (physical capital), undermining the population's nutritional status (human capital). Floods can also drive impacts on livelihood. This hazard destroys human shelters (physical capital) and imposes mental traumas on the casualties (human capital). These are a few examples of the impacts of climate-related events on human livelihoods. By eroding the livelihood adaptation means, climate change systematically increases human vulnerability to future climatic and non-climatic shocks and reduces the adaptive capacity of the population. Adaptation is identified to be the only means to alleviate climate change impacts on human development (Smit et al., 2001). However, adaptation must be mainstreamed at different scales to alleviate climate risk.

### **2.1.2. Awareness and Perception of Climate Change, Cognitive Process to Build a Path toward Effective Adaptation**

While climate change is projected to be one of the greatest challenges to sustainable development, it is further noted that climate change awareness varies according to region. Latent technological lag, institutional inefficiency, lack of productive assets, and above all, the weakening of collective actions built on social networks and ties—channels for learning and information—undermine climate change awareness in developing countries, including Africa, the Middle East, and Asia where it is almost negligible (Phuong et al., 2019; Mustafa et al., 2019; Khan-Abbasi and Nawaz, 2020; Idoma et al., 2020).

How individuals and communities perceive climate change affect the attitude and action they take toward the phenomenon (Khan-Abbasi and Nawaz, 2020). Climate change awareness “is the extent to which primary producers and communities understand, relate to, and prioritise climate change as a driver of change within bio-agronomic systems” (Marshall et al., 2013: p.1). Climate change awareness “entails knowledge creation, values development, a transformation of attitudes and building skills and abilities amongst individuals and social groups regarding the issues of climate change to attaining a better quality environment” (Khan-Abbasi and Nawaz, 2020).

Awareness—conditioned by learning—is important in preconditioning adaptive capacity and adaptation to climate change (Marshall et al., 2013; Khan-Abbasi and Nawaz, 2020). Mustafa et al. (2019) note that households’ awareness level increases the formulation of alternate adaptation strategies that can reduce vulnerability and improve rural livelihoods.

### **2.1.3. Vulnerability to Climate Risks, Poverty, and Assets**

Conceptualising key climate notions is as crucial as designing adaptive policy responses since the effectiveness and adequacy of the adaptive response depends on the clarity with which it was conceptualised (Heltberg, 2008). Since the publication of the world development report in 1990 (World Bank, 1990), vulnerability assessment has been given more attention in the policy and scientific arena. Vulnerability is a very complex concept and can be defined by the magnitude of the hazard (IPCC, 2007), the asset endowment, and the poverty status of the household (Moser, 1998) or socially differentiated by the state of well-being (Adger, 1999). “Asset vulnerability framework” focuses on the assets as the means of resistance that a system—households or communities— can mobilise during hardship (Moser, 1998). And so, this conceptualisation tightly links vulnerability to the asset. The more asset you have, the less vulnerable you are.

The social vulnerability framework conceptualises a more holistic view of vulnerability and, besides asset endowments, considers people’s environmental state, social norms, political institutions, technology, and inequalities (Adger, 1999). Individual vulnerability in this conceptual framework is determined by income diversity and access to resources, social status —like gender, ethnicity and social capital— in the community. Collective vulnerability, in turn, views communities, regions, or nations embedded in its environmental context —exposure to droughts, floods— institutional and market structure dynamics, formal and informal social security, infrastructure, and GDP. In analysing social vulnerability, an external human side of risk and shock appears, out of any control by individuals or groups (van Wesenbeeck et al., 2016), and a social dimension exists whether or not climate risks and stress prevails (Eakin, 2005).

Although the two terms are distinct, vulnerability is closely related to poverty and is often used to replace poverty. Even though all the poor are vulnerable to shocks and risks, not all vulnerable people are poor (Moser, 1998). Poverty is a static concept, determined at a certain time by a certain threshold of the household income (income/consumption poverty), while vulnerability is dynamic and is measured by the movements of households in and out of poverty. Thus, vulnerability is the ex-ante magnitude of the threat of poverty in households or communities (Hoddinott and Agnes, 2010).

Following Adger (1999), vulnerability is conceptualized as social vulnerability in this study, considering not only the external environmental threat from stress but also the social dynamics of norms, political institutions, technology, and market conditions. Therefore, vulnerability is understood as the extent to which a community or a system can endure a given social or environmental contingency and stress, given its geographic and socio-economic characteristics, without severe harm to its functioning and its sustainability. Following the IPCC (2007), the study considers vulnerability compounded by three elements, exposure, sensitivity, and adaptive capacity.

Sensitivity is the susceptibility to harm after a sudden social or environmental change and is a system–individual, household, or community–centred concept. It is the amount of a given social or environmental adversity that a system can endure before getting affected. If I consider two systems, a cement brick, well-designed housing, and an adobe brick housing, to evaluate sensitivity to flooding, irrespective of where the two systems are located (exposure), the former can bear much more flooding before it gets damaged compared to the latter. It is thus less sensitive to flood than the latter.

Exposure can be defined as the susceptibility to hazardous social or environmental events and is hazards centred. I refer to it as the depth of a given social or environmental adversity that can be reached before a system gets affected, irrespective of the damage it can cause (sensitivity). If the last example is always considered, with the cement brick housing located on the river banks and the adobe brick housing on the highland, one can easily acknowledge that the cement brick housing is more exposed to flooding than the adobe brick housing.

Adaptive capacity is the possibility that have individuals, households, and communities to alter and structurally reorganise their activities to lower present threats to their survival while enhancing their ability to address new risks (Eakin, 2005).

#### **2.1.4. Coping Mechanisms and Adaptation to Changes, a Choice Combination Portfolio for Ex-Ante Preparedness and Ex-Post Recovery of Risks**

Households do not just undergo risk but try to manage it through diverse and sophisticated manners. The adoption of a specific coping and adaptation strategy by households and communities depends on economic, social, natural, financial, and human capitals endowments, networks, and access to power and resources. However, the boundary between coping mechanisms and adaptation practices is difficult to draw (Agrawal and Perrin, 2008). While the United Nations framework convention on climate change (UNFCCC) refers to the aforementioned classes of adaptation strategies as coping mechanisms, most of the literature on adaptation refers to them as adaptation options (Wang et al., 2013; Wang et al., 2016; Agrawal, McSweeney, and Perrin, 2008). Adaptation is considered by many to be prospective, in response to the prevailing risk of hazards, in contrast to the coping mechanism as being retrospective (Agrawal and Perrin, 2008). In the framework of this essay, the study consider these strategies to be

useful for both livelihood coping strategies and adaptation options for households. I will now discuss how these strategies serve as backrest options to stabilise household livelihood benefits in the face of climate risks.

Until now, the study has only considered the objective dimension of adaptation to climate change, based on transforming resources and entitlements to greater adaptive capacity. From that perspective, it is challenging to increase households' adaptive capacity, knowing the ongoing long-lasting struggle by governments and development agencies to combat poverty, especially in developing countries (Seara et al., 2016). Associating the subjective dimension of climate change adaptation, based on learning participation and depolarisation of adaptation, governance, and power gives an easy way to increase adaptive capacity and build a long-term adaptive response (Armitage et al., 2011; Teodoro et al., 2021). Strong social ties based on mutual understanding, influence, and respect have been demonstrated to positively influence individual and collective perceptions of climate change. That leads to individuals' change of perception and beliefs as a consequence of participation and exposure to the perception and beliefs of the members of the community of actions (Teodoro et al., 2021).

Besides, social learning is increasingly counted as a key and valid adaptation option (Pelling et al., 2008; Armitage et al., 2011; Baird et al., 2014; Teodoro et al., 2021), at the same stake as the aforementioned coping and adaptive mechanisms. Adaptive capacity can be defined as the ability of exposed people to cope with, prepare for and adapt to changes. That implicitly hides the role of learning through change and experimentation to the state of being adaptive (Armitage et al., 2011). In the adaptation process, change is inevitable to fit the new state and context of the social-ecological systems (Pelling et al., 2008; Leonardsson et al., 2021). Adaptation, in that perspective,

is an alteration in a system's state and or functionality in response to environmental changes in which key variables are conserved or enhanced (Pelling et al., 2008). Learning as an adaptation option to climate change and resource governance regime is characterised by features like:

- Multi-scale stakeholder participation as an anchor to build trust, understanding, and consensus for a shared learning experience and knowledge production.
- Transparency and consultation have been central to the learning process from the early stage. Change towards sustainability is not enacted but negotiated—in a bottom-up setting—in the shared practices across scales.
- Context-based implementation, clearly articulated goals, and monitoring and evaluation mechanisms towards the achievement of the goals of the negotiated governance regime within transparent norms and principles;
- Flexibility and cooperation between formal and informal institutions from different sectors—horizontal linkages—and scales—vertical linkages—are instrumental in stimulating multi-scale partnerships, cooperation, and leadership.
- Addressing power polarisation and coloniality and keen attention to including minorities and marginalised groups in knowledge production.

Indeed, a bulk of auteurs from environmental co-management (Armitage et al., 2011; Teodoro et al., 2021), ecological economics (Leonardsson et al., 2021), and sustainability science (Phuong et al., 2019; Norström et al., 2020) are of the view that peaceful climate change adaptation can't be transformative and sustainable until it is implemented through learning methodology.

### **2.1.5. Climate Adaptation Needs and Constraints, Characteristics of a Successful Adaptation across Scales**

Adaptation to climate change requires a set of economic, social, and political resources on which households rely for preparedness or a build-back better in case of disasters (Wang et al., 2013; Martin and Lorenzen, 2016; Wang et al., 2016; Asfaw et al., 2018; Bebbington, 2021). It also needs behavioural, cognitive, and historical congruity for a satisfactory initiative result (O'Brien, 2009; Adger et al., 2009; Simonet and Leseur, 2019). Stakeholder participation from design to implementation is important for the legitimacy and quality of adaptive decisions (Lange et al., 2021). In this section, I will detail the material and immaterial characteristics from the viewpoint of who adapts to facilitate the understanding of adaptation to climate change.

#### ***2.1.5.1. Adaptation Forms and Processes***

The climate is part of the global seasonal environment around what human livelihood is designed, and that seasonality has been motivating human adaptation (Adger et al., 2003). In the context of global climate change, the increasing interest in adaptation research is sustained by two drivers. First, decisions are being made in all the stands and scales on adaptation without even considering whether these changes are consistent with anthropogenic climate change (Adger et al., 2005a). Second, science-based evidence foresees that even with a drastic reduction in Green House gas (GHG) emissions—mitigation actions—the global surface temperature will continue rising. Sea level is expected to continue rising, along with other climate properties. Hence, planning development requires addressing these risks through adaptation as a necessary complement to mitigation actions (Smit et al., 2001) and even as a substitute for mitigation in providing “breathing space” for global emission trajectories (Adger et al.,

2005a). Adaptation involves managing financial, human, social, physical, natural, and institutional means to anticipate or adjust to climate variation and its impacts to minimise harm or exploit the resulting opportunities. Adaptation can also occur in response to non-climatic, social, and economic events – for instance, market price increase or expectation of better income elsewhere (Smit et al., 2000; Adger et al., 2005b). It is classified into autonomous and planned adaptation according to the origin of the decision to adapt. The distinction is also made between incremental and transformative adaptation, considering the nature of the expected adaptation outcome.

Agricultural households, fisheries, and coastal dwellers spontaneously adjust their livelihoods to the natural circumstances they find themselves and count on their capital asset endowments (Adger et al., 2003). This adaptation mostly characterises developing countries and is not easily subject to identification and monitoring among many social, economic, and environmental-driven decisions (O'Brien and Leichenko, 2000). Planning adaptation is key in involving multiple-scale stakeholders in a participatory process toward common goals and benefits. That has the multi-fold virtue of improving knowledge about climate change adaptation, improving the quality of decisions, the legitimacy of these decisions, and the effectiveness of the adaptation process (Lange et al., 2021). However, inadequate planning and implementation of climate change adaptation can result in greater vulnerability in the targeted systems over time or other systems (Smit et al., 2000; Adger et al., 2005b; Schipper et al., 2021).

Adaptation to climate change is associated with actions to maintain and enhance the capacity to deal with changes – incremental adaptation – and the decision-making process to undertake and manage changes in existing systems – transformative adaptation – (Park et al., 2012) to avoid lock-in effects and maladaptation (Castells-

Quintana et al., 2018). Incremental adaptation focuses on improving the existing system's – locations, livelihoods, and forms of production– capacity to continue functioning sustainably within its organisational, economic, and ecological context (Park et al., 2012; Blakeney and Siddique, 2020: p. 80). That is a more or less spontaneous adaptation setting and does not require significant information and decisions to adopt (Wheeler et al., 2013). That includes, for example, adopting irrigation as an alternative to rainfall scarcity and investing in more resistant crop varieties, preventing long dry spells, locusts, and pest invasions. In contrast, transformative/transformational adaptation occurs when the global or local climatic, economic, or social conditions challenge the tenability of the existing location, livelihoods, and production system (Wheeler et al., 2013). It consists of a fundamental change in the structure, function, or location of a social, economic, or biophysical system, enhancing its capacity to face present or future environmental and socio-economic irregularities. Examples includes diversifying income sources –towards non-weather-dependent activities– or migration from marginalised and flood-prone areas (Park et al., 2012; Castells-Quintana et al., 2018).

#### ***2.1.5.2. Objectives of Climate Adaptation, Complex Linkages, and Processes to Confer Sustainability to Social and Ecological Systems***

Adaptation is a continuous stream of actions, activities, decisions, and attitudes to fit the dynamic nature of human ecosystems. It refers to the process of adapting and the state of being adapted (Smit et al., 2000; IPCC, 2001: p. 892). Diverse objectives can be associated with climate change adaptation. A growing cluster of authors (Adger et al., 2005b; Park et al., 2012) defines adaptation as aiming at three objectives. These objectives are, however, complementary and sometimes concomitant in addressing

climate change and its effects. One goal of adaptation is to reduce a system's sensitivity to risk by adopting more resistant crop variety, for example, or increasing the capacity of the water storage reservoirs to deal with water shortage. Adaptation could also involve altering the system's exposure to various risks through investments in information technologies, education, and more accurate climate forecasts. The third objective of adaptation is to increase the resilience of social and ecological systems. Other purposes of adaptation interventions are to increase adaptive capacity and or reduce vulnerability to shocks (Owen, 2020).

Much research has emphasised the role of technology, institutions, poverty, and marginalisation in limiting effective climate change adaptation to occur (Wang et al., 2013; Snorek et al., 2014; Asfaw et al., 2018). Yet, there is growing evidence that adaptation to climate change can be undermined by individuals' and groups' beliefs and values (O'Brien, 2009; Adger et al., 2009; Simonet and Leseur, 2019). In this section, I refer to the cognitive limitations as top-down, non-participatory enforcement of adaptive majors, for example that deter the effective climate change adaptation. This conception of adaptive barriers considers the limits to be endogenous and emerging from the inside of society (Adger et al., 2009). Adaptation to climate change being local needs the participation and interest of local people and authorities. Any failure to meet this interest and involvement—mainly due to conflicting views between what people consider valuable to them, regarding their culture, religion, or history—to the adaptive action will make it ineffective. The role of particular meta-domains will be investigated in the social construction of climate change adaptation limits. The *ethical* consideration of what is valuable—how and what the recipient society value—, the *knowledge* perspective—how and what the recipient society know—, the *risk* perception of individuals and groups—how and what the recipient society perceive—, and the local *cultural values*—how and

why that recipient society lives (Adger et al., 2009) are part of the social constructs to be considered when designing adaptation interventions. Planned adaptation to climate change in the developing world is mainly funded—through the green climate fund, for instance—and carries along the goals and values of the funders (democracy, human rights). These goals and values may not match those of the recipient community members and lead to crushing. Most importantly, the adaptation process should interrogate how the process comes about, for whom, and by whom (Owen, 2020; Schipper et al., 2021).

### ***2.1.5.3. Climate change adaptation and mitigation***

As mentioned earlier, climate change dynamic is engaged and will continue influencing—in one way or another—the human livelihoods, opportunities, and benefit streams. To adjust life to that dynamic at the present stake and for the future, two possible and non-exclusive options are open. Adaptation to climate change seeks to manage the direct and indirect effects originating from the changes in the climate, while mitigation guarantees the sustainability of future generations in the face of changing conditions. To Laukkonen et al., (2009), an adaptation aims at managing the unavoidable and mitigation seeks to avoid the unmanageable. Adaptation is necessary for developing countries to take into account international equity in terms of climate change. These countries have limited responsibility for the historic greenhouse gas emissions responsible for anthropogenic disturbances and continue to be the least emitting today. Conversely, they bear a disproportionate burden in terms of disruption, following their dependence on natural resources and climate-sensitive livelihoods (IPCC, 2014b).

#### ***2.1.5.4. The Roles of Institutions in Adaptation to Climate Change***

The importance of institutions in climate change adaptation is uncovered by considering the “double exposure” of how global political and economic challenges in simultaneous interaction with climate risks shape the livelihood opportunities and benefit streams of poor households (O’Brien and Leichenko, 2000; Eakin, 2005). Institutions shape individual behaviours in this social context and provide coordination and cooperation for actors—households and communities—that cannot achieve their goals independently of one another to act collectively and effectively (Roggero et al., 2018). In their review, Roggero et al. (2018) consider three elements that make a case for institutional analysis in climate change adaptation, perception—how well households are aware and perceive climate risks; experience—learning from past hazards that affect the households, and interaction—at various levels of decision-making to lower impacts. They then link these three elements to the constitutive elements of adaptation, which they define as *vulnerability, learning, adaptive capacity, and barriers to adaptation*, with institutions interfering in each of these steps. The institutional arrangement determining individuals’, households’, and communities’ entitlements will directly influence vulnerability. The latter is thus seen as “embedded in complex relations of power, resource distribution, knowledge and technological development (Eakin, 2005; Roggero et al., 2018). Institutions also shape how actors perceive climate change and link it to potential solutions—through the broadcasting campaign. Adaptive capacity is closely related to vulnerability and learning, as introduced above. Its institutional interplay overlaps with how institutions shape the learning and vulnerability outcomes for adaptation. Finally, under barriers to adaptation lies essentially interaction problems like poor interplay, inadequate rules and procedures, limited cooperation, and conflicting views (Roggero et al., 2018). Although this conception fails to provide a clear definition

of vulnerability, one can see perspectives of how institutions can determine the outcomes of climate adaptive actions.

In a more holistic view, the adaptation, institution, and livelihood (AIL) framework, developed by Agrawal and Perrin (2008) draws the lines for institutional interventions in climate change adaptation. Households discriminate between adaptation options depending on the institutional context in which they are embedded, the magnitude of the climate risk they face, their market accessibility and quality, and their endowments (Wang et al., 2016). Institutions here are man-made formal—laws and policies—and informal—social norms—mechanisms that structure human interactions, expectations, and behaviour (Agrawal and Perrin, 2008; Wang et al., 2013; Wang et al., 2016). That includes public/government institutions—like local governments—private/market institutions—like insurance companies—and civil/communal institutions—like NGOs and agricultural cooperatives. They influence and determine rural livelihoods and adaptation in three distinct ways (Agrawal and Perrin, 2008):

- Institutions shape how climate impact affects different individuals and communities and the vulnerability of different groups. Access to institutions reduces the vulnerability of individuals and groups through risk information, institutional capacities and learning, and the flow of external adaptive resources—like technology and finance, which raises the questions of resource allocation marginalisation and inequalities. An interesting example is the agricultural input subsidies that enhance farmers' adaptive capacity through increased yield but benefit only farmers with information and accessibility to the relevant local institution.
- At the local level, institutions shape the outcome of the community's responses to climate risks. By linking individuals to collective actions and providing incentive

conditions for a particular adaptive framework, institutions create the conditions for an individual or collective response to risks. Communities deprived of capital and infrastructure will be unable to use storage or exchange to adapt. They are rather more likely to migrate—the case of massive and perilous migration through the Mediterranean Sea to Europe. The absence of clear rights—the case of water walls between herders who water their animals and sedentary communities in rural Niger—undermines the adaptive capacity of the groups and creates socio-professional conflicts in rural areas.

- Institutions mediate external support to adaptation for local communities. External intervention can assume various forms—finance, training and skills development, knowledge and information, technology—in the case of climate change adaptation, and facilitate or undermine—maladaptive outcome—rural adaptation process. Local institutions serve as intermediaries between the flow of assistance and local communities. Thus it is understandable that adaptation never occurs in the context of the institutional vacuum (Agrawal, 2016; Wang et al., 2013).

Among other characteristics, operational flexibility and cooperation between institutions are critical conditions for institutions to facilitate climate change adaptation. This institutional quality makes it possible for institutions to cover their mutual weaknesses and strengthen their ability to understand risk and vulnerability (Agrawal, 2016; Agrawal, McSweeney, and Perrin, 2008). That depends on the common institutional perception of risks to be addressed, coordination of strategies towards goals, fairness in resource allocation, and accountability of decision-makers and other officials, among other things (see Agrawal, 2016 for a more detailed explanation). Two types of institutional relations are identified for this purpose; *linkages to institutions/institutional access* that characterise how households are connected to various institutions in their

locality, and the effects that linkages are having on households' adaptive capacity – access to institutional resources, greater flexibility in the within and between adaptation options. *Linkages between institutions/institutional articulation* are explained by the connections and networking of a particular local institution with other local and external institutions. That is vital for the effectiveness of local institutions in coordinating and responding to climate risk – a determinant for the availability of adaptive resources at the local institution level (Agrawal, McSweeney, and Perrin, 2008; Agrawal, 2016).

### **2.1.6. Limits to Climate Change Adaptation and Maladaptive Outcome**

Adaptation and mitigation are critical elements for meeting sustainable development and equity in the context of global change. Diverse efforts across scales – by individuals, governments, and NGOs – are being made, and resources are being injected in that sense for a safe and sustainable present and future livelihoods and well-being. Yet the feedback from that process is not conclusive on which adaptation to finance and which process is efficient (Magnan et al., 2016). Even worse, certain adaptation initiative outcomes negate the well-being of public and private bodies they are supposed to protect or other social-economic systems (Snorek et al., 2014; Adger et al., 2009; Owen, 2020; Schipper et al., 2021). The latter characterises maladaptation to climate change that may amplify the impacts of climate change by diverse mechanisms. That exposes the more vulnerable, marginalised, with the least socio-political power to cascading, greater and irreversible impacts (Schipper et al., 2021).

### ***2.1.6.1. Evaluating and Monitoring Climate Change Adaptation, Feedback for a Successful Adaptation Process***

Climate change adaptation interventions are very complex to evaluate both for funders and recipient communities. Adaptation can be triggered by climate change, while other adaptations can arise due to social—abrupt death or injury of active household members— and economic —simultaneous increase in market food and input prices— changes. It becomes thus challenging to isolate and monitor climate change adaptation benefits from other actions aimed at improving households' livelihoods (Adger et al., 2005b; Adger et al., 2009; Olsson et al., 2015; Schipper et al., 2021).

The success of adaptation is not only met by the achievement of the objectives of the adapting parties. Successful adaptation should consider assessing how the action of the adapting actors affects the adaptive capacity of other social and environmental systems in space and time (Adger et al., 2005b; Snorek et al., 2014). Motivated by ineffective and unsustainable anticipatory decision, adaptation action usually increase and pause disproportionate burdens to the most exposed layers of the population (Schipper et al., 2021). A longer time scale can uncover greater and clearer changes as a result of the made adjustments by socio-economic systems in response to climate and market shocks. The absence of immediate results usually creates fatigue and the abandonment of promising projects. Downstream impacts may also reveal on a larger space scale— construction of a dam on a water stream to stimulate irrigation that exposes downstream communities to disproportionate low river streams—as adaptation outcome is assessed across space. In addition, adaptation to non-climatic drivers can increase vulnerability to climate-related stress (Adger et al., 2005b). For instance, using households' resources to adapt to flails like poverty, health care, and economic

fluctuations encumber resources available for climate change adaptation (Olsson et al., 2015).

Scholarly contribution to climate change adaptation has also largely discussed the role of the distribution of power and politics in the effectiveness of climate change adaptation (Eriksen et al., 2015). Climate change adaptation governance should consider equity, legitimacy, efficiency, harmony, participation, and sustainability (Adger et al., 2005b; Victoria and Renewal, 2010; Juhola et al., 2016; Schipper et al., 2021). Vulnerable groups, poor and marginalised individuals, and society need not be cast as victims or villains in the global environmental response. There is a need to go beyond the participation of disadvantaged groups in programs designed by powerful groups to a co-production of the responses by vulnerable groups (Eriksen et al., 2015). Politics and power play a crucial role in the success of climate change adaptation and issues. They determine how resources are governed and accessed from a larger scale down to the groups adapting to climate change at the local level. That draws us to the question of the role played by institutions in shaping adaptive response, as discussed in the previous section.

#### ***2.1.6.2. Limits And Failure of Climate Change Adaptation, Characterizing Maladaptation in The Context of Climate Change***

The previous discussions show that not all adaptation initiatives will be successful. That failure sometimes does not limit to only financial loss but rather negates the adaptive capacity or increases the vulnerability of the beneficial group or other groups across space and time (Barnett and O'Neill, 2010; Juhola et al., 2016; Magnan et al., 2016). This failure of adaptation to successfully address the direct and indirect impact of hazards is known as maladaptation in the context of climate change. Maladaptation is

thus an unattended and undesirable outcome of adaptation across time and space, resulting from poor planning or low participation of stakeholders in climate change adaptation. The term maladaptation is tightly linked to adaptation. The use of this term insinuates recognition of the ideal of adaptation but also acknowledges the possibility of negative outcomes of this process. It is brought in by neglecting the future impacts of climate change and the main drivers of vulnerability (Magnan et al., 2016). Classes of maladaptive outcomes can be categorised depending on who is affected and in what way. Hence it is driven by three types of maladaptive feedback (Magnan et al., 2016; Juhola et al., 2016; Schipper et al., 2021):

- *Rebounding vulnerability* occurs when adaptation intervention increases current or future climate change vulnerability for the targeted group (or the implementing group, in the case of autonomous adaptation). That can potentially undermine adaptation in three ways, increasing exposure and sensitivity to climate risk and decreasing adaptive capacity. Most frequently, this outcome is observed when adaptation intervention is designed in a top-down approach, by a privileged group, rather than associating the intended beneficiaries, ending up eroding the benefits of adaptation in favour of local elites (Schipper et al., 2021). Elite capture can also occur inadvertently if the real drivers of vulnerability are not assessed before intervention. Land-oriented adaptation design may exclude the most vulnerable and marginalised groups, as they frequently lack physical capital (Magnan et al., 2016; Asfaw et al., 2018; Schipper et al., 2021). Finally, this outcome can also occur due to geographical constraints and the marginalisation of vulnerable groups across space. Adaptation intervention may indeed fail to reach geographically marginalised households, compounded by lack of information and low institutional access (Schipper et al., 2021).

- *Sifting vulnerability* characterises a situation where adaptation intervention increases the current or future vulnerability conditions for one or more external actors or over special areas (Juhola et al., 2016; Schipper et al., 2021). One group’s adaptation can potentially be another group’s hazard. This maladaptive outcome often occurs in land, water, and coastal areas intervention, where improving water quality generates the high cost of access to water, excluding low-income vulnerable groups (Barnett and O’Neill, 2010; Juhola et al., 2016).
- *Introducing new vulnerabilities/eroding sustainable development* is a third possible outcome of climate change maladaptation that encounters low consideration of the drivers of vulnerability and sustainable development. Sustainable adaptation and maladaptive outcomes are just two faces of the same coin (Magnan et al., 2016). In essence, maladaptation of this kind concentrates on negative feedback on a global scale that undermines sustainable development pathways. It is an outcome deemed to erode the basis on which adaptation relies (Juhola et al., 2016) –by increasing greenhouse gas emissions in the atmosphere, for example. Decision-making usually confronts a trade-off between avoiding immediate and near-term disruptions and considering future risks. In this context, the preference is usually towards shorter-term incremental adaptation, in which effects are immediately perceptible, protecting existing systems and behaviours –and also securing votes –over long-term transformative pathways. This failure of thinking holistic and sometimes more transformative adaptation options may introduce new risks in the long term (Schipper et al., 2021). Barnett and O’Neill (2010) approach this problem by introducing the “path dependency” concept, where large infrastructures condemn capitals and institutions to trajectories difficult to change in the future. Such path-dependent trajectories, effective, in the meantime, may lead to decreasing flexibility

to accommodate future unforeseen changes in the climate, environment, and economic and social structures. For example, increased fertiliser and pesticide use can undermine human health and environmental systems. Irrigation, sometimes presented as an adaptation to water shortage in dry lands agriculture (IPCC, 2014a), may reduce water availability and quality for domestic and other purposes. These can exemplify maladaptive outcomes eroding sustainable development pathways.

However, neither clear-cut nor widely accepted criterion were developed to identify maladaptation (Juhola et al., 2016). Lines are not objectively drawn about what success is and what failure is in that regard, as what appears to be an effective adaptation for one group hides disastrous events from the lens of other groups. That brings subjectivity to the appraisal of maladaptive outcomes from several perspectives. First, failure of adaptation does not necessarily characterise maladaptation, as it is not even a necessary condition. While failure can be identified as a lack of success in achieving designed goals – irrespective of who framed the goal – maladaptation can achieve these goals but fail to sustainably secure space for future adaptation choices or other groups' choices (Barnett and O'Neill, 2010). Second, while Juhola et al. (2016) purposively exclude the negative outcome of the autonomous adaptation from adaptive outcomes, the IPCC stretches maladaptation to both autonomous and planned adaptation (Noble et al., 2014; Juhola et al., 2016). Finally, as discussed in the previous section, it is not only climate change that can be the object of adaptation but a large quantum of phenomena – including poverty reduction, population growth, environmental degradation, and high sanitation costs – in the social and ecological environment. Thus, does maladaptation only limit to undesired and unintended outcomes from climate change adaptation, or can it extend to all forms of adaptation? To address all these concerns, Magnan et al. (2016)

developed a framework for assessing maladaptive outcomes. That is composed of four dimensions presented as follows (Magnan et al., 2016; Antwi-Agyei et al., 2018):

*i. Maladaptation is a process*

Maladaptation is reputed to influence negatively –rebouncing, shifting, or creating new –vulnerabilities. Nevertheless, vulnerability is dynamic, depending on exposure, sensitivity, and adaptive capacity, which continuously change. Exposure and sensitivity evolve depending on climate variation, institutional mechanisms, and technological dynamics. Adaptive capacity evolves with governance, present and past hazards, and socio-economic dynamics. Maladaptation should thus emanate from an autonomous (spontaneous) or planned “process” that exacerbates the impacts of climate change on the territory, sector, or groups.

*ii. Multiple drivers*

Assessment of climate impacts is usually a complex exercise, concealing cross-discipline dynamics –like environmental science, economics, and psychology– and context-specific analysis. Failure to consider the future impacts of climate change and related uncertainties and neglecting the main drivers of vulnerability to shocks are the factors that drive maladaptation. Thus, only initiatives that would negatively affect the exposure or sensitivity of systems to “climate-related stressors” should be considered maladaptive.

*iii. Temporal scale*

Temporality is a key element to consider when assessing maladaptive outcomes. Maladaptation undermines present and future-potential opportunities and benefits and the system’s adaptive capacities for future adaptation options. As a result, an initiative

can appear sustainable in the short run and yield benefits in the long run and vice versa. Securing enough space to maintain a wide range of possibilities to deal with future climate-related changes is key in developing climate change adaptation interventions.

*iv. Special scale*

The climate change adaptation agenda is out to integrate the risk of maladaptation. Research on the maladaptive outcome has emphasised ex-post assessment, which is necessary but insufficient to address the risk of maladaptive outcomes. What is ideal in an adaptation initiative is to successfully achieve its objectives – especially attenuating the vulnerability of systems in which it is designed – without any collateral effects on downstream or adjacent systems.

***2.1.6.3. The Nexus Between Climate, Maladaptation, and Conflicts***

In the previous section, I asserted that maladaptation undermines the livelihoods of adapting groups in different ways, rebounding their actual vulnerability, introducing new sources of vulnerability, and shifting their vulnerability to other groups or systems. This latter outcome is interesting to investigate – as it relates to at least two agents – for its potential interest discord induced by the spill-over effects it generates. Rainfall irregularity and reduction, an increase in temperature, and climate change drive the scarcity of vital resources for sustaining livelihoods, especially in rural areas (Barnett and Adger, 2007; Benjaminsen, 2012; Burke et al., 2015). That scarcity, magnified by latent socio-economic, demographic, and institutional prevailing context, instates a great competition over access to and use of resources and means of adaptation (Benjaminsen, 2012). Most often, in the context of this spontaneous adaptation, the action of one agent to adjust spontaneously to the conditions of the changes may result in reduced livelihood opportunities, options, or benefits for other individuals or groups (Snorek et al., 2014),

reducing its adaptive capacity. Suitable arrangements provided by the institutional mechanism are necessary to help enhance the adaptive capacity of the agent left worse off. In the absence of that arrangement, maladaptation can result in outcomes between groups that are not always cordial. One outcome of that situation is the *transformation* of the system affected—while permanent or temporary migration of people and cattle to other places is the most likely transformation (Barnett and Adger, 2007), it can also result in the degradation of social capital between groups (Snorek et al., 2014). The case of the Fulani herders migrating towards the south, wetter, and where pasture is available to avoid conflicts but still create new ones with farmers in the new settlement areas exemplify this situation (Dary et al., 2017; Bukari et al., 2020). The second outcome of this spillover effect is the *cooperation* between groups, facilitated by kin relationships (Thébaud et al., 2001; Dary et al., 2017; Snorek et al., 2014). Snorek et al. (2014) suggest that this cooperation hides great inequity, vulnerability, and latent conflicts based on social, ethnic, or religious longstanding discrimination. The third possible outcome of the spillover from adaptation is *conflict*, driven by competition for access to and use of natural resources and stimulated by the upheaval of the social and ecological systems by climate change (Barnett and Adger, 2007; Burke et al., 2015). Snorek et al. (2014) introduced it under what they called “divergent adaptation”—maladaptation—a situation where the adaptation of one user or group cause a subsequent reduction in the adaptive capacity of another user or group in the same ecosystem and drives into conflicts over access and use of natural resources. In regions where people are dependent on climate-sensitive forms of natural capitals—the case of Africa, and the Sahel in its large part—it is more likely that livelihoods bear great risks of climate impacts and emerging conflicts—as the livelihoods will depend less on economic and social capitals and more of natural capital (Barnett and Adger, 2007). In this section the study analyse

this third possible outcome, raising a growing interest in research (PNUE, 2011; Kugbega and Aboagye, 2021) and calling for urgent need to rethink the common property management in the Sahelian region – and particularly in Niger (Thébaud et al., 2001). Conflict is the expression of verbal or violent discords resulting from misunderstanding driven by the competition for the access or the use of households' vital natural resources altered by present and perceived climate impacts.

However, there is a clear consensus in the conflict literature (Salih et al., 2002; PNUE, 2011; Benjaminsen, 2012; Snorek et al., 2014; Dary et al., 2017; Bukari et al., 2020) that climate change is never the cause of conflict per se, rather magnifies an economic, social and institutional context already tense (Thébaud et al., 2001) to trigger discords. The deviation from the climate conditions alters the conditions under which interactions occur and magnifies the likelihood and intensity of conflicts (Barnett and Adger, 2007). In the Sahel in general, and Niger in particular, economic, social, and institutional contexts change prevailed before this observed rise in the climate and conflict dynamics.

Institutional factors are as much to blame as social, economic, and climatic conditions in the rise of the discordant relationship between groups. Literature on conflicts in the Sahel notes an important geographical and institutional marginalisation of herder communities, happening out of the realm of pastoral influence – due to the low representativeness of nomadic groups in the governance arena (Thébaud et al., 2001; Benjaminsen, 2012; Snorek et al., 2014). Certain policies aimed at fighting land degradation, enforced without associating pastoralists, limit grazing movement and access to water and pasture, triggering many conflicts between nomadic and sedentary groups (Dary et al., 2017). Daunted by the complexity of the pastoral question in the west African region, stakeholders – including international organisations, government

institutions, and certain NGOs—are becoming less and less involved in finding appropriate solutions and ways of improving pastoral livelihoods (Thébaud et al., 2001). That is exemplified by the absence of important adaptation and policy mechanisms like mobility and conflicts in the national adaptation plan (NAPA) of Niger, as developed in the literature (see also PNUE, 2011 for more detailed analysis). The State is at the centre of human security, poverty, and entitlement of its population, and in natural resource management conflicts (Snorek et al., 2014). It is responsible for providing opportunities, mechanisms of a stable environment for people to pursue their valued livelihoods and security and protection guarantees when livelihoods contract. Government institutions exercise sovereign rights and legitimate force to mediate between groups by enhancing or undermining groups' livelihoods. Legitimate and effective conflict resolution mechanisms are also persuasive tools in preventing rampant conflicts (Barnett and Adger, 2007). Failure of the state to provide these important tools, or when the tools are undermined by conflicting modes of governance, low accountability, and corruption, leads to the surge of conflicts that will be the mechanism of feedback, and an alternative—in the absence of legal—way for calling for changes in the institutional mechanism (Snorek et al., 2014). Defining clear institutional responsibility at local, regional, and national scales, promoting trust between groups and institutions, and leadership in the continuity of decision and policy is key in resolving environmental resource management conflicts.

## **2.2. Empirical Review**

With the increased scientific understanding of climate change, adaptation, and mitigation, the role played by awareness and perception in reinforcing adaptive capacity is henceforth clearly uttered. Many authors directly link the adaptive capacity of a system to the perception and awareness of that system concerning climate change

(Marshall et al., 2013; Pahl-Wostl, 2009). Theories of adaptive co-management defend that there is an interplay between perception and knowledge. While knowledge shapes perception, perception also shapes knowledge (Nguyen et al., 2016). Knowledge creation occurs in the context of stakeholders' participation in the community of practice in climate change adaptation (Teodoro et al., 2021). As empirically evaluated by many authors in this review, social relations based on mutual respect, understanding, and influence foster common and shared perceptions and adaptive action.

Empirical research has also covered the impacts of climate change and market shocks on livelihoods, including the objective as well as subjective determination of adaptation. Productive and non-productive assets in the form of physical, natural, financial, human, and social capital are essential for households to build resistance to shock and to build back better after a shock. However, many empirical investigations of capital ownership and adaptation articulation are not spontaneous (Grothmann and Patt, 2005; Wolf et al., 2010). Grothmann and Patt (2005) and many other authors have shown that behaviours based on knowledge, experiences, and cost-benefit analysis are central to preventing livelihoods from the negative impacts of shocks.

In climate change literature, maladaptation is also relatively appraised and documented. Maladaptation –a situation where climate change adaptation measures inadvertently end up exposing the people it is supposed to protect or other people living in the same ecosystem to greater risks –occurs in many contexts and takes many forms (Juhola et al., 2016). The outcome is social discourses and violence, which create greater vulnerability or cooperation between groups that usually hide the vulnerability of the most exposed groups. The role-play by formal and informal institutions is important, as conflicts are sometimes seen as an alternative way to call for change. This section

provides empirical understanding of the interconnections of all these topics and how they relate to climate and market shocks.

### **2.2.1. Learning, Perception Fostering and Comforting Climate Change Adaptation**

There is an important interplay between learning—as transformation in the potential of actors as a response to experienced changes—and the level of perception and awareness of climate change. However, capturing and quantifying learning to associate it with increased perception and awareness for better decision-making regarding climate change has greatly divided the research community. The outcome is the diversification of theoretical frameworks, and empirical implementations of the cognitive process leading to adaptation to climate change. At the individual level, the work by Grothmann and Patt (2005) on the socio-cognitive model of the private proactive adaptation to climate change (MPPACC) has given way to testing multiple cognitive processes to the decision of individuals to adapt—or not—to climate change. This process starts with the risk experience appraisal—leading to a perceived probability of risk from past experiences and a perceived severity—and adaptation appraisal. That drives the perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation costs that lead to alternative decisions such as effective adaptation or avoidant maladaptation. Grothmann and Patt (2005) tested and implemented this model through two case studies.

The first case compares the MPPACC results to the socioeconomic model results—including age, gender, and education level. It was implemented on the residents' proactive adaptation in Germany to the risk of river flooding. In this case study, the authors interviewed 150 residents living in the flood-prone areas of Cologne, located on the Rhine River in Germany. The second case tested the farmers' proactive adaptation

in Zimbabwe to the drought risk, examining whether farmers from four villages can use the seasonal climate forecast to change their adaptive decisions and improve their yield (Grothmann and Patt, 2005). The result of the German case showed that MPPACC explained more the variance of the adaptation response – up to 26% to 45% of the variances of adaptation decisions – compared to the socio-economic model – which explained only 3% to 35% of the adaptation decisions. In the second case of Zimbabwe, MPPACC showed that farmers are not changing their decision about the planting periods in response to the climate information. That is not, in fact, due to a lack of adaptation means but due to the lack of cognitive adaptation intention. It has resulted from both subjective risk perception and lower farmers' perceived self-efficacy regarding adaptation.

After three years of implementing education and learning programs that supported regular climate forecasts, farmers that followed the program started changing their planting decisions and patterns in response to the information on climate forecasts. That empirically confirmed that individual cognitive factors could explain people's failure to adapt beyond the objective aspects. Further implementation of the MPPACC includes the empirical work by Mitter et al. (2019) using semi-structured interviews with 29 farmers from Australia. After the MPPACC content analysis based on the adaptation intention and avoidance, four groups of farmers were identified, climate change adaptors; integrative adaptors; cost-benefit calculators, and climate fatalists. Only farmers from the last group – climate fatalists – are not intending to adapt. At the same time, adaptation intention is formed if the farmer is aware of effective adaptation measures and perceives adaptation costs as affordable during adaptation appraisal in the three other groups.

The results clearly showed that farmers' beliefs about the perception of climate change – based on their past experiences – determined their risk perceptions of climate change – risk perception appraisal – and the decision to adapt to the threats posed by climate change. More recent similar empirical results to that of Grothmann and Patt (2005) and Mitter et al. (2019) using the MPPACC were obtained by Zobeidi et al. (2022) by analysing data from 250 interviewed irrigated land farmers from Iran. Two analytical methods – MPPACC and the maximum likelihood estimates of the structural model – were used to investigate the effects of cognitive factors on maladaptation in farmers' incremental adaptation to water scarcity as a climate risk. The result showed that the model explained 49% and 24% of adaptive behaviours and maladaptation variance. These results further demonstrated that information from diverse sources on water scarcity and adaptation determined 12% of farmers' perceived severity of the problem. It determined 53% of farmers' perceived response efficacy – at a 1% confidence level – and significantly determined 38% of farmers' perceived self-adaptation efficacy. Moreover, perceived susceptibility to harm, perceived adaptation costs, and perceived self-efficacy significantly determined the farmers' intention and decision to adapt to water scarcity. That emphasised the MPPACC's power to explain the cognitive decision process of adaptation to climate change.

Those findings are in line with and confirmed by authors that empirically demonstrated that the perception of climate change (Nguyen et al., 2016; Seara et al., 2016; Teodoro et al., 2021), the social networks (Cundill, 2010; Lange et al., 2021; Wolf et al., 2010), and the flow of information (Khan-Abbasi and Nawaz, 2020; Kumasi et al., 2019; Paudel et al., 2020) determine the farmers' behaviours and decision in the face of climate risks. More quantitative empirical work on perception has concerned the assessments of the determinants of farmers' perception of climate change (Mustafa et al., 2019) and the

influence of that perception on the formulation of adaptive actions (Ado et al., 2019; Brüßow et al., 2019; Paudel et al., 2020). With the intent to investigate the importance of awareness and perception for developing strong climate adaptation strategies in Nepal, Paudel et al. (2020) conducted a survey questionnaire on 530 households in three ecological regions of the country. The binary logistic regression model was used to find that farmers' perception of climate change is shaped by socioeconomic and agricultural characteristics. Besides the climate-related variables—temperature change, precipitation changes, increase in droughts, increase in climate-induced diseases and pests—that significantly determine the perception and awareness of farmers. Experienced adverse impacts, shocks and risks from the climate shape the way that farmers perceive and respond to climate change.

Similar results to the ones presented by Paudel were found in the Niger republic. Research by Ado et al. (2019) in the Aguié district of Niger using a Probit model analysis confirmed climate-related information to shape perception and awareness of climate change. Further, the statistical analysis of this paper found that nearly 84% of farmers in Aguié were aware of climate risks but had different perceptions of the climate impacts on crop production and annual revenue. The Probit model confirmed that awareness, perception, education, crop production, and annual revenue significantly determine the adoption of adaptation strategies to face climate disruptions. The final recommendations in that regard were to increase information outreach through media, improve local extension services, and develop water use efficiency. The potential of increasing common perception and action face climate change, as determined by Ado et al. (2019) is confirmed by Mustafa et al. (2019) that found that although farmers are aware of changing climate patterns—temperature, rainfall—there is the need to shape right community's perceptions. The novel result of Mustafa et al (2019) using a binary model

on primary data collected from central and southern Punjab, Pakistan is that awareness is also determined by social networks of environmental communications, and the interrelation of farmers with institutional, geographical and socioeconomic factors.

If the majority of research on awareness and perception confirms a strong causality of these variables with farmers' behaviours regarding climate change, that was not the case in the work by Brüßow et al. (2019) on the link between climate change perception and adaptive decision in Tanzania. Using a binary regression on data collected from 900 farmers in rural Tanzania, they found weak links between farmers' perceptions and their behaviours regarding action. Although farmers' perception of the rising average temperature over time and its disruptive impacts on agriculture are confirmed, some farmers decided not to adapt, and others adopted evasive reactions that will not protect them from damage. Only a small share of the farmers agreed to afford the important investment costs – like irrigation facilities – to successfully prevent damages from climate change.

Despite the role played by the farmers' limited adaptive capacity, the intention to adapt is instrumental in the decision-making process to adopt effective adaptation strategies. The results also stretch on the explanatory power of the MPPACC – through risk appraisal, cost-benefit analysis, and self-efficacy appraisal before decision – to effectively address the subjective and objective determinants of adaptation to climate change.

### **2.2.2. Previous Findings on the Incidences of Multiple Shocks in the Households' Income and Welfare**

Climate change and other unexpected social events – like the death of active household members – upsets the households' consumption structure, undermining households'

sustainability. Shocks undermine households' income and consumption expenditures, driving a large portion of the population under the poverty line – the case of covariate shocks – or leading already poor households into starvation and chronic poverty. Due to the paucity of comprehensive multi-topic empirical data, the assessment of the incidences of shocks to households' livelihoods has long been uncovered, especially in developing countries. That incidence is tested by the social protection unit of the World Bank (Tesliuc and Kathy, 2004) in the context of Guatemala to assess the poverty status of the households. Although they used a cross-sectional data design with multiple analytical frameworks including factor analysis, multivariate logistic regression, and propensity score matching (PSM), they found that droughts significantly reduce households' income both for rural and urban residents of the central region and the rural residents of the southwest region of Guatemala. This effect is more severe for poor rural households and is smaller for wealthier urban households, thanks to their wealth in the central region. Pest infestation is also found to significantly reduce the income of affected urban citizens in the southwest region. At the same time, for households' consumption, the effect is puzzling – reduced consumption of affected households in the northwest region and increased consumption in the south-East and Peten regions.

These results are further confirmed by the PSM model and found that households suffer the most from idiosyncratic shocks – job loss, falling income, accidents of active members – than covariate shocks – droughts, pest invasion, and loss of terms of trade. The impacts of idiosyncratic shocks are also found by Azam and Imai (2012) in the context of Bangladesh to be more severe for rural households than the covariate shocks. Using data from the 'Household Income and Expenditure Survey', a nationally representative household survey, their results confirm that 40% of the households are vulnerable to idiosyncratic shocks, whereas 39% are vulnerable to covariate shocks. In

contrast to the first case study, the impact of idiosyncratic shocks hits more severely well-endowed households and covariate shocks have more impact on poorer households. More recent analysis on the impacts of shocks on households (Amanzadeh et al., 2021; Letta et al., 2018) confirms these analyses, showing how disrupting climate impacts can be on the households' income and expenditures and how these impacts vary between rural and urban areas.

In another setting, Aker (2010) shows that droughts are significantly associated with grain price increases across markets –leading to a decrease in the purchasing power of rural households –and a significant decrease in the per capita grain output in Niger. The analysis of composite data on agricultural production, rainfall, prices, and transaction cost between 1996 and 2006 with a vector autoregressive model (VAR) allowed (Aker, 2010) to conclude that although drought increases crop prices, it reduces price dispersion across markets, suggesting that markets integration is higher in Niger during drought years. Similar results were found by Brown and Kshirsagar (2015), quantifying the impacts of weather disturbances and global price change on monthly food prices in 51 countries –totalising 554 markets –from 2008–2012. The outcome from multiple econometric analyses is that weather disturbances affect 20% of the local market prices globally in the short run, while 4% of the fluctuation originates from weather disturbances and global market price changes. These statistics hide inequalities across food commodities. Over the 160 maize market locations accounted for their study, 29% of the market prices were affected by weather disturbances, while this proportion is about 15% for the 114 rice markets assessed for the study. In contrast, in the Eldoret market in Kenya for the year 2010, for example, favourable rainfall –materialized by a 10% increase of the vegetation index –has derived a 9% decrease in the maize price. In line with these results, Hill and Porter (2017) found that any decrease in rainfall that

provokes drought causes a 9% reduction in household consumption, while price spikes cause a 14% reduction in the consumption of households in Ethiopia.

### **2.2.3. Empirical Implementation of Adaptive Responses to Climate Anomalies and Institutional Supports: Success Stories, Challenges, and Lessons Learned**

Households have multiple coping mechanisms and adaptation strategies, depending on their circumstances, to protect their livelihoods from the detrimental impacts of shocks, as explained by the adaptation, institutions, and livelihood framework developed by Agrawal and Perrin (2009) – see section 2.5.3 of this document. These are storage, mobility, diversification, communal pooling, and market exchange. Based on this theoretical framework, Wang et al. (2013) studied the climate adaptation of multiple herders groups in the Mongolian grasslands between Mongolia and Inner Mongolia. A survey data collection was designed to collect information from local people, government officials, and grassland scientists to gather 51 adaptation strategies that were further categorised into the five coping mechanisms aforementioned here. The data was then collected from 751 herder households based on these coping mechanisms from 15 villages in Inner Mongolia and seven villages in Mongolia. The results revealed that mobility and communal pooling were the dominant adaptation strategies for Mongolia's herders. In that region, 25% of the herder households alter the beginning of their migration period, while 28% alter its duration. These percentages were lower, about 6% and 5%, in Inner Mongolia.

In contrast, about 87% of herder households in Inner Mongolia stopped migrating to manage hardship, while no household adopted this strategy in Mongolia. On the other hand, 25% of households associated with other households dig walls together to water animals and all (100%) pool pastures together for communal use. In contrast to

Mongolia, the main adaptive responses in Inner Mongolia are storage, diversification and market exchange. In that region, 65% of the households improved their storage of pasture for future use, while 43% stall-feed more animals – against 0% in Mongolia – to resist climate conditions. When feed becomes very scarce, households apply different feed varieties and even diversify the animal species to adapt to the feed scarcity. This first strategy was adopted by 68% of herder households in Inner Mongolia, and 59% of these households adopted new animal species to increase their resilience.

Wang et al. (2013) further estimated a multilevel statistical model to predict the forage purchase behaviour of herders. They found that the household's financial capital, environmental variability, and the status of pasture degradation are the main determinants of this adaptation strategy. Institutions are instrumental in catalysing the herders' behaviours, and government, market, and communal institutions were identified to facilitate adaptation strategies. The results of Wang et al. (2013) were confirmed by Fernández-Giménez et al. (2015) in the context of the 2009–2010 winter weather disaster in Mongolia. These authors investigated the role of formal community-based natural resource management (CBNRM) in strengthening the herder adaptive capacity and adaptation strategies between communities with and without CBNRM in response to the Dzud – winter weather disaster. They found that mobility and forage storage is the most adopted adaptive strategies to limit livestock loss. These essential adaptation strategies were found to be determined by resource pooling and market exchange to prevent households from livestock loss.

CBNRM households demonstrated a greater adaptive capacity, especially due to knowledge exchange, access to greater and available information, and risk pooling across households. While 61% of CBNRM member households store winter pasture,

only 47% of their non-member counterparts adopt the same strategy to prevent Dzug risk. The same applies to livestock vaccination, where 91% of CBNRM members adopt, against 85% of non-member households. A similar study with concurring findings to Wang et al. (2013) was carried out by Wang et al. (2016) in Northern Tibet for herder communities' adaptation to climate conditions. They found that migratory grazing has become less feasible in Tibet. Forage storage, forage and animal species diversification, and market exchange have become the dominant adaptation strategies. Their multilevel regression to identify the determinants of the forage purchase behaviours yielded that the total number of livestock and total annual income of the households positively determine forage purchase by households. However, communal pooling—pasture pooled for communal use—and average pasture productivity significantly discourage pasture purchase at the household level. Institutional supports are vital in facilitating adaptation behaviours to climate constraints. Traditional grazing norms, environmental policies, and norms of access to wells and pipelines facilitate mobility.

#### **2.2.4. Characterizing Households' Behaviours Regarding Climate Adaptation**

Households require two instrumental aspects and characteristics to implement these adaptation strategies. The availability of critical assets—human, physical, social, natural, and financial capitals—theorized by the sustainable rural livelihood framework (SRL), to be transformed into adaptive capacity, and the cognitive process—conditioned by awareness and learning—of combining and transforming these assets into adaptation strategies to protect livelihoods from adverse effects of shocks (Bebbington, 2021). The second aspect has been studied in previous sections, and this section will be subjective to asset-based adaptation. That largely consecrated the use of the seemingly unrelated regression (SUR) method in climate adaptation literature.

In the context of Niger, Asfaw et al. (2018) observed the critical lack of these capital assets in the households—adaptation deficit—and identified the main drivers and impacts of labour and crop diversification to adapt livelihoods and moderate this deficit. They used a SUR method with socioeconomic data from the national survey on households' living conditions and agriculture (ECVM/A) of Niger merged with granular climatic information. They found that crop and labour diversification as adaptation strategies significantly correlate with the households' welfare when most vulnerable households rely on it to manage climate variability and cope with short-run market shocks. The foremost drivers of adaptation identified in that study were weather anomalies, with droughts incentivising diversification of income and crops. Similarly, increasing input and food market prices significantly trigger household labour and crop diversification. While households' financial capital and household size—human capital—significantly and positively influence crop and labour diversification, these adaptive strategies are negatively and significantly influenced by agricultural technological assets—physical capital. They are also positively influenced by household heads' years of education and female headship—households' human capital. Social capital, expressed through transportation means and information and communication—ICT—technologies of the households can significantly influence only labour diversification to cope with hardship, with the first inciting labour diversification and the second discouraging it.

Consistent with Asfaw et al. (2018), the adaptation pull effects of climate shocks have been demonstrated by Mulwa and Visser (2020), assessing the determinants and food security effects of crop and livestock diversification in northern Namibia. The authors used the seemingly unrelated regression—SUR—and Tobit models with data from the 'Adaptation at Scale in Semi-Arid Regions (ASSAR) project' over 650 households

across three regions of Namibia. They found that past exposure to climate shocks significantly drives farmers to diversify crop and livestock production for both the models estimated. Social capital—expressed through climate information—is found to play a significantly important role in explaining both crop and livestock diversification. Greater access to information by households lead to higher diversification of their livelihoods. In terms of human capital, more schooled households diversify more in crop farming, and female-headed households are significantly less incentivised to diversify than their male counterparts. As presented in the first study, access to financial capital—expressed by access to credit—in this research consistently motivate households to diversify both crop and livestock. This because households need access new technologies—improved crop and livestock variety—that can be very costly.

A similar study by Asfaw et al. (2019), using a cross-country scheme, analyse the effect of crop and income diversification on households' welfare between Malawi, Niger, and Zimbabwe. They used household data merged with climatic data from the three countries and combined the sustainable rural livelihood framework (SRL) with the non-separable household model as theoretical models. The SUR method was used with income and crop diversification as dependent variables. The first result confirmed that exposure to rainfall anomalies is a significant pull factor for income and crop diversification for all three countries. That means increased climate anomalies like droughts or floods drive households to diversify their crop and labour portfolios. Female headship is also negatively correlated with households' diversification, although the coefficient is only significant with crop diversification in Zambia. Household heads' years of schooling negatively and significantly influence income diversification in Malawi and crop diversification in Zambia, corroborating the findings of Asfaw et al. (2018) in the context of Niger.

In contrast, household heads' years of schooling unexpectedly positively and significantly influence income diversification in Zambia. This result, however, goes in pair with the result of Mulwa and Visser (2020) in the context of diversification in Namibia. The overall conclusion of this study is that diversification is pro-poor in most rural African contexts and emphasizes the need to tailor diversifications to the socio-economic context of the rural populations. Other empirical studies that use the asset-based approach with the SUR method (Arslan et al., 2018; Nguyen et al., 2017) or multiple other methods (Martin and Lorenzen, 2016; Teklewold et al., 2019) can provide more fresh empirical evidence of the determinants and welfare effects of adaptation.

### **2.2.5. Implementation of Climate Adaptation, Maladaptive Outcomes, and Resulting Conflicts between Groups**

There is a wealth of quantitative research linking climate stimuli and conflicts in Africa (M. B. Burke et al., 2009; Crost et al., 2018; McGuirk and Nunn, 2021; Salih et al., 2002) and elsewhere (Crost et al., 2018; Miguel et al., 2004). Most of these studies analyse how extreme heat, rainfall shocks and floods increase the risk of violence. However, empirical literature linking maladaptation and conflicts are scarce, although many authors are interested in seeing how the intention of one user to reduce adverse effects of shocks in an ecosystem ends up exposing other co-users of this ecosystem, driving to multiple conflicts.

From a global perspective, environmental peacebuilding is a recent and novel research field that combines multiple disciplines. Theorists and practitioners argued that environmental change can catalyse peaceful cross-border adaptation and increase solidarity rather than escalate violence (Ide, 2020; Leonardsson et al., 2021). However, based on empirical case evidence from various world regions, Ide (2020) analysed the

‘dark side of environmental peacebuilding’ and discussed six categories of its adverse effects – called the ‘six Ds’ – that one category most importantly interests us here. Within this side effects, adaptation brings about conflicts rather than security and cooperation between stakeholder groups enjoying more or less the same ecosystem services and environmental challenges. Empirical case studies exemplifying this include the construction of the Jonglei canal in southern Sudan in the 1970s yielding from a cooperation between Sudan and Egypt to increase the amount of water flowing northwards through the Nile realizing a positive sum cooperation in a contested river basin. However, other non-associated losing interests arise since the canal threatened to drain the Bahr Al-Jabal and the Bahr az-Zafar wetland sources of rich livelihoods to local communities. As a consequence, the canal installations bears multiple attacks by the Sudan people’s liberation army backed by local population, to cause the suspension of the project.

A more recent empirical case is the Grand Ethiopian Renaissance Dam (GERD) project constructed by Ethiopia on the Abbay River – over the Blue Nile – to sustainably increase food security and renewable energy sufficiency to the Ethiopian – mostly poor – population and adapt to food and energy shortages in the post 2020s Ethiopia. However, Egypt and Sudan threatened by the filling of the Dam to considerably reduce the water stream in the upper side, which provide most of the livelihoods for their population and their countries contested the project, and a dispute erupted between the countries with the losing side calling for Arab league, the UN security council, the US, the EU, and the African Union to put pressure on Ethiopia stop filling the Dam (Aljefri et al., 2019). On the other hand, violence and conflicts escalated in Ethiopia, including the Tigray conflict, which is tentatively linked to the geopolitics of power surrounding the GERD (Aljishi, 2021).

At a micro-level construct, Snorek et al. (2014) described “divergent” adaptation to climate change as the situation in which ‘one user or group’s adaptation causes a subsequent reduction in another user or group’s adaptive capacity in the same ecosystem’. Analysing the complex dynamics of livelihoods between pastoral and agricultural groups in northern and southern zones of Niger, they identified changes in groups’ adaptive capacity driving into conflicts over the access to scarce natural resources – water, pasture, pastoral corridors – where resource governance fails to secure peaceful livelihoods pursuing. Conflicts in this setting are feedback upon the institutional failure to secure rights of control on resources, thus calling for change. Analysing qualitative survey data collected on 77 households and focus group discussions, he found that out of the 20 key adaptation strategies of the groups, four of them undermine pastoralists’ adaptive capacity and entitlement, thus raising the risk for discourses. These maladaptation are:

- **Livestock ownership by sedentary groups:** this adaptation strategy of sedentary groups involves cutting and storing crop residues by farmers, where herders rely on that to feed herds once the lands are officially liberated for them, reducing their adaptive capacity. That also raises competition over access to fodder and its commercialisation which pastoralists cannot afford – due to the large number of their herds – reducing their entitlements.
- **Extending agricultural land into pastoral spaces:** following the soil quality and nutrient loss, the easiest way for farmers to increase agricultural yield is to extend agriculture into marginal lands. Thus northern countries – belonging to the public domain – and other pastoral enclaves (SANI, 2014) – herders’ transhumance corridors and grazing areas – are grabbed by agricultural expansions, undermining herds’ mobility and grazing.

- **Market gardening:** to solve the crucial yield loss and the rapidly growing food demand due to population growth, the government of Niger promotes irrigated market gardening around lakes and valleys where pastoralists can easily access water for their animals so far. Due to this extension of agriculture into valleys and lakes, pastoralists' entitlement to water animals and enjoy public 'bourgou' pastures established along water courses (SANI, 2014) is undermined.
- **Payment for water:** According to Niger legislation, water points belong to public domains and are free access for all groups. However, due to the dwindling of watering points and the competition—among pastoralists and with the sedentary group—over the existing wells, pastoralists are brought to pay for watering herds from private and sometimes public boreholes. That reduces the entailments of pastoral groups.

These are dominant maladaptation—what the authors called divergent adaptation—in Tahoua pastoral areas of northern Niger and the southern agricultural lands. This maladaptation undermines the adaptive capacity of herders and thus fuels conflicts in rural areas.

Although they did not link it directly to climate adaptation, Dary et al. (2017) cited similar practices in the determinants of farmers-herders conflicts in Ghana, confirming the analysis of Snorek et al. (2014) on the dynamics between maladaptation and conflicts. Analysing the triggers of farmers-herders conflicts in Ghana from data collected upon focus group discussions from five key stakeholder groups, they tested the stakeholders' agreements on triggers of conflicts using a non-parametric analysis. Competition over access and use of land and water resources is found to be at the centre of conflicts. Fourteen triggers of farmer-herder conflicts were identified, of which

maladaptation includes all the four strategies mentioned by Snorek et al. (2014), adding to that water bodies pollution externalities by herds. Using the Kendall coefficient of concordance to test the agreement of the stakeholder groups on the triggers of conflicts, the authors reported that significant agreement was only found between crop farmers, chief-traditional rulers, and government agencies. More insights into the empirical literature exemplifying climate change –mal– adaptation and conflicts can be studied more elaborately from the literature (Awazi and Avana-Tientcheu, 2020; Milman and Arsano, 2014) on the adaptation to recent climate change.

## **2.3. Theoretical Review**

### **2.3.1. Knowledge creation, perception and climate change adaptation**

There is a bulk of theories that work on knowledge creation and perception and are applicable to climate change adaptation. The adaptive co-management theory suppose that knowledge emanate from stakeholder participation and action. Learning is central to the transition towards sustainable livelihoods and resilient societies. Exposed to the global changes in the climate and farming systems, farmers and communities learn through interactions and experience, but also their interests and historical background (Nguyen et al., 2016). Baird et al. (2014) conceptualise learning concerning environmental governance and climate change adaptation into three components:

- **Cognitive learning** is doing with the mental process of gaining new knowledge or the restructuration of existing knowledge;
- **Normative learning** is assessed through a shift in viewpoints, values, or paradigms;
- **Relational learning** reveals an improved understanding of others' mind-sets, enhanced trust, and co-operating ability.

Consequently, learning can be viewed as a transformation in the potential for behaviours of actors in response to experienced change (Pelling et al., 2008). This cognitive process builds knowledge that shapes farmers' perception, thus determining how they react through adaptation or avoidant maladaptation (Grothmann and Patt, 2005) to the changes (Nguyen et al., 2016; Seara et al., 2016).

The model of Private Proactive Adaptation to Climate Change (MPPACC) consider that before any decision to adapt to the consequences of climate change, a person goes through a cognitive process of risk appraisal to evaluate the threat probability and damage potential if no behavioural change is made (Grothmann & Patt, 2005). That process yields a risk perception by the individual who then evaluates the sensitivity; the ability to be harmed by the threat, along with the cost of acting to reduce harm through the cognitive adaptation appraisal. Thus, cognitive bias and heuristics especially when households rely on the expectation and efficiency of state intervention to be protected from damages can irrationally misguide one's risk or adaptive appraisal, leading to maladaptation (Grothmann & Patt, 2005). Adaptive action thus starts from learning, and the importance of this cognitive process and resource constraints in undermining adaptation reveals the need to integrate climate change education and communication in adaptation research (Grothmann and Patt, 2005; Nguyen et al., 2016).

The process of social learning is conceived as a shift from expert-based knowledge transmission—top-down implementation— towards transformative community-based learning experiences to transcend social learning, values, and atomistic consideration of scientific or indigenous knowledge in climate change adaptation (Cundill, 2010). This knowledge production aims at mutual learning among those involved in the adaptation initiative to foster the transition toward collective adaptation management (Cundill,

2010; Phuong et al., 2019). It consists of associating inclusively different types of knowledge with transformative governance and informing climate change adaptation (Leonardsson et al., 2021). These include scientific knowledge, bureaucratic and administrative knowledge, practical knowledge, indigenous knowledge, and an association with bottom-up approaches to adaptation –“glocal” implementation (Baird et al., 2014; Leonardsson et al., 2021). It also implies addressing the coloniality of knowledge based on Eurocentrism towards an inclusive perspective of knowledge production. Part of this process of joint learning is transparency and participation at the early stage of the implementation. Participation adds instrumental value to the production of knowledge, implementation, and success of climate adaptation. In this research journey, the study conceptualise education as individual or group –social-learning from multi-level stakeholder interactions and knowledge construction to solve environmental problems.

Pahl-Wostl (2009) conceptualized the dynamic of incremental to transformative adaptation–the change process–as social and societal learning, proceeding stepwise, moving from a single loop to a double loop, onto a triple-loop learning experience. Many authors have successfully applied the concept to explain complex learning processes in the context of climate adaptation and natural resources governance (Cundill, 2010; Armitage et al., 2011; Park et al., 2012; Baird et al., 2014; Thi Hong Phuong et al., 2017). The first stage of the learning process toward sustainability is *single-loop learning*. In this stage, actors perform an incremental improvement to optimise their actions and strategies. Actors in this learning experience interrogate if they do things right –and seek to respond to the question, “How do we improve what we are doing?” The downside effect of limiting to this stage is that it generates path dependence and lock-ins for it fails to interrogate the assumptions underlying the routines (Pahl-Wostl, 2009; Asfaw et al.,

2018; Thi Hong Phuong et al., 2017) – maladaptive outcomes. Interactions and learning in the context of climate change governance in the formal policy cycles are restricted to single-loop learning and have never reached the stage of double-loop learning (Pahl-Wostl, 2009), as characterised by command and control governance regimes. That explains the increasing difficulties institutions, multilateral organisations, NGOs, and local-level households face in addressing the ubiquitous global challenges and market failure. Climate change governance is expected to reach the *double-loop learning* stage and question the assumptions and mental models underlying the choice of the routines climate change governance undergoes – cause effects relations, to avoid path-dependency and lock-in situations. At this stage of *double loop* learning, actors start questioning if they do the right things regarding the practices and responses to climate change. Objectives are systematically revised, and a more effective monitoring and evaluation system is instated for learning toward sustainable system change (Park et al., 2012). That stage correspond to the question “Are we doing the right things?” In *triple-loop learning*, stakeholders call for more fundamental changes in governance norms and protocols (Armitage et al., 2011) by asking how we decide what is right. That involves questioning beliefs and worldviews after a certain threshold where assumptions in a particular worldview no longer hold. In the change process, involvement in governance-supported and community-based activities is necessary to ensure multi-level learning and interaction between stakeholders for a deeper understanding to engage meaningfully in a peaceful adaptation process (Leonardsson et al., 2021).

The theory of planned behaviour is widely used to predict and study the farmers’ intension and behaviour in repose to climate change. According to the theory, three dimensions determine the behaviour intention implementation regarding a certain farmer’s or household’s behaviour (willingness to act). These are:

- The attitude towards the behaviour (ATT), which can be either positive or negative
- The social norms (SN) due to the choice of a particular behaviour, and the social norms surrounding that behaviour
- The perceived behavioural control (PBC) relating to how the farmer think he can handle and control the behaviour he is adopting.

The perceived adaptation efficacy, which is the farmers' perception of the effectiveness of adaptation to lower threats, is a very important factor driving farmers to adapt or not to climate change (Song and Shi, 2020).

### **2.3.2. Rural livelihoods and climate change adaptation theories**

There is many theories that conceptualise adaptation to climate change. The sustainable rural livelihood theory considers that the rural households manage an asset portfolio that they convert into adaptation options available to them to adapt to shocks. Households' access to fivefold capital assets is thus decisive for ex-ante preparedness and ex-post adjustment to multiple shocks (Martin and Lorenzen, 2016; Bebbington, 2021). "Assets" in this conception are households' owned or accessed resources to sustain their livelihoods and income, especially in times of hardship (Martin and Lorenzen, 2016). These households' means of resistance are human capital, physical capital, financial capital, natural capital, and social capital (Martin and Lorenzen, 2016; Wang et al., 2016; Asfaw et al., 2018; Bebbington, 2021). Nevertheless, asset ownership does not necessarily mean greater adaptive capacity until households can transform it into adaptive measures (Adger et al., 2005; Wolf et al., 2010).

- *Human capital* influences the quality and number of people's endeavours, thus influencing their income streams (Bebbington, 2021). Human capital allows households to improve and even change their world as it can be transformed into

- more sustainable resources (IPCC, 2001: chapter 2, p. 132). That manifests as skill acquisition through training and experiences in the households' livelihoods, education, and health (Martin and Lorenzen, 2016). It also includes the number of households' labourers, gender, knowledge, and information (Asfaw et al., 2018).
- **Physical capital** ownership allows households to adjust to anticipate hardship—for instance, selling animals to buy fodder (Wang et al., 2016) for herders—and reorganising aftershocks and damages (Marshall et al., 2011). This research counts under physical capital, tools, and equipment—like tractors, water pumps—livestock, and housing. It also includes basic infrastructure—like roads facilitating access to market and lowering transaction costs, water and sanitation, schools and ITC (Haidar, 2009).
  - **Financial capital** can enhance physical capital accumulation, technology, and crop productivity. Access to financial capital like remittances can provide liquidity that facilitates investments in new activities and new technology and constitute income security in the events of income shocks, as not being correlated with rural households' income sources (Wouterse and Taylor, 2008). Financial capital includes household's on-farm and off-farm incomes, access to credit, and microfinance (Neef et al., 2018).
  - **Social capital** influences positive public health outcomes and climate change adaptation (Wolf et al., 2010). It has been defined as an informal and organised reciprocal network of trust and norms embedded in the social organisation of communities (Moser, 1998). Social capital can be classified into bridging social capital—in the form of the networking between groups—bonding social capital—like linkages between individuals identified by ethnicity, gender, and social classes, access to institutions, associations (Martin and Lorenzen, 2016), and social learning

that enhance the adaptive capacity of the group (Aldrich et al., 2016)–and linking social capital–characterising the hierarchical relationship between institutions, but also the network of relationships of local institutions with external institutions (Adger, 2001; Wolf et al., 2010).

- *The natural capital* endowment is recognised to be an important source of economic wealth essential to improve the adaptive capacity of individuals and Nations (Barbier, 2019). Natural capital consists of individually owned assets– land, on-farm trees–and collectively owned resources–including forests and ecosystem services, water and fisheries, pasture area, and grassland (Martin and Lorenzen, 2016; Nguyen et al., 2017; Barbier, 2019).

In the settings of the adaptation, institution and livelihood framework (AIL), Five (5) major livelihoods coping and adaptation strategies are identified in the context of climate risk (Agrawal, A., McSweeney, C. & Perrin, 2008; Agrawal, 2016). These are storage that pools climate risk across time, livelihood diversification that pools risk across household assets, mobility is adopted by households to pool risk across space, and communal pooling that allows sharing climate risk across households in the community and market exchange that is the most versatile of the adaptation strategies in terms of risk pooling.

- Mobility is considered the most ancient option used to cope with unexpected shocks and hazards. Mobility is effective when households have weather and market information across space. It is used to pool risks across space. Three types of mobility are commonly identified in pooling risks across space, agro-pastoral migration, wage labour migration, and involuntary migration (Agrawal, 2016). Mobility–especially involuntary migration–is argued to be a maladaptive response

to the climate crisis. Today it is clear that migration is an important coping and adaptation strategy to climate risks since it reduces vulnerability through reduced dependency on frail livelihoods and increases livelihood security and stability (Adger, 1999). We argue, along with Heltberg (2008) that climate justice should go past the development assistance to cover topics like labour migration flows and remittances facilitation, peacekeeping, and – agricultural – technology transfer among others.

- Storage is a coping and adaptation mechanism that pools risk over time. Storage is effective even against even complete livelihood failure, when combined with well-constructed infrastructure, low perishability, and high coordination across households and social groups (Agrawal A. and Perrin. P. 2008; Agrawal, 2016; Wang et al., 2016). Particularly in the developing world, where post-harvest losses of food and other perishable commodities, improved storage technologies can potentially improve livelihoods (Agrawal, 2016). Households can store food – including crops, seeds, forest products – to ensure food stability and compensate for the long periods of hardship. Live animals are also an asset that is usually stored by households, to prevent the unexpected situation of risk for household sustainability (Agrawal & Perrin, 2009). To prevent the risk of long dry spells, farmers with cattle (agro-pastoralism) store agricultural crop residues (Thébaud et al., 2001; Filho, 2015: p. 246), while pastoralists diversify by selling some animals to purchase and store fodder to reduce risks (Snorek et al., 2014; Wang et al., 2016). Water shortage represents a great challenge for farmers and herders in the drylands of sub-Saharan Africa. Rainfall and temperature pattern change are responsible for crop failure in most of the single cropping season dry land countries-like Niger – (Filho, 2015: p.

143). In that context, water storage for irrigation and livestock is crucial to diminish the risk of loss of rural livelihoods and income (IPCC, 2014: p. 30).

- Diversification is perhaps the most commonly used coping and adaptation strategy against climate risk, agricultural productivity loss, and market shock by smallholder agricultural rural households in sub-Saharan Africa (Asfaw et al., 2018). Livelihood diversification is viewed as the process by which rural households construct a diverse portfolio of activities and assets to survive (Martin & Lorenzen, 2016). Diversification pools risk across assets class (Neef et al., 2018; Asfaw et al., 2019) to stabilise livelihoods, when the return from certain assets – climate-sensitive livelihoods, marginal and degraded lands – become low. Households diversify the portfolio of productive and non-productive assets, consumption strategies, and employment opportunities in the context of climate risks and unexpected market shocks (Agrawal, 2016). Diversification occurs at different levels of income and wealth, as a deliberate action for wealthy proactive households – progress diversification – or as a strategy to spread risk and reduce vulnerability to natural and social shocks – distress diversification (Martin & Lorenzen, 2016). In this latter form of diversification, households consent to pay an implicit insurance premium in the form of forgone gains of specialisation by adopting a variety of low-return activities, leading to more stable and lower household income. This characterises thus the trade-off poor rural households undergo between specialisation, more prone to risk and more efficient, leading to higher income, and diversification as a risk avoidance strategy (Martin & Lorenzen, 2016).
- Rural household livelihood is closely related to agricultural income. To reduce the high risk related to agricultural income, and the decrease of purchasing power due to market price fluctuations, households diversify their income source. Income

diversification entails the adoption of off-farm income and non-farm incomes. Off-farm income refers to the revenue driven from wage or exchange labour on another farm including labour payment in kind, environmental resource collection firewood, wild fruits. It is to note that all these income sources are correlated with agricultural income, and natural stress like drought can more or less affect these income sources. Non-farm income is more independent from agricultural income and thus is more likely to stabilise households' wealth. It is composed of remittances, salary and non-farm rural wages, self-employment, and transfers to the households (Reardon, 1997; Wouterse & Taylor, 2008; Martin & Lorenzen, 2016). Crop choices improved variety adoption and production technology diversification is an important aspect of livelihood risks pooling in the context of shocks. Drought-resistant and low water-consuming varieties are very efficient to secure households on-farm incomes in the context of Sahel. Climatic pattern changes in this region lead to long dry spells and water stress causing severe damages to the farm output. Investment in production technology is essential to increase agricultural yield and improve food security for rural households (IPCC, 2014a). In the context of the Sahel- plagued by artisanal, non-mechanised exploitation of agricultural land and increasingly obsolete technologies, production technology diversification is essential to pull households out of food insecurity (Asfaw et al., 2018).

- Communal pooling is one of the livelihoods sustaining techniques in the face of diverse risks and shocks. Resource pooling among households and groups in the community spread the risk across households (Fernández-Giménez et al., 2015). Communal pooling is an adaptive response that consists of gathering and centralising resources and assets, labour, or the management of public and common goods to benefit all the community during times of scarcity. Collective joint action towards a

goal is more impactful and effective than what an individual can achieve (Agrawal, 2016). A reasoning example is the labour pooling in rural Niger, “Gayya” in local expression, where all the youth of the village determine a date, gather and collectively cultivate the farms of early identified most vulnerable households in the village – women-headed households, disabled household heads, people experiencing shocks like the death of active members, etc.

- Community labour sharing is the most common resource pooling to face risk and vulnerability in rural African communities, due to the high-value individuals and communities placed on social capital, and the relatively weak integration of the market economy. This manifests through farm labour sharing, public and private facilities, and infrastructure construction, in the community.
- Wild plan contributes substantially to the nutritional intake of rural households in developing countries. Forest and water managements are thus important in the struggle to achieve food security and avoid the tragedy of the commons. Initiative to the participatory community forest management is gaining interest (Wily, 2002) and showing great success in African communities. Communal pooling concerns also community food and pasture storage, especially developed with the proliferation of development assistance in developing countries. Managed by a committee headed by the village chief, community storage allows households to buy food at a lower price than the market price and survive during periods of hardship. Through agricultural cooperatives, rural households gather information, knowledge, and money (mostly women) in the form of tontine to help mutually themselves in case of unexpected shocks. That may be in response to the low access to agricultural credit, and the very high rate of credit interest in developing countries in Africa. However, communal pooling is not effective in the situation of covariate risks and

shocks – like droughts where households are heated in the same way (Agrawal, 2016).

- Addressing climate change impacts through increased agricultural productivity, reduced vulnerability to hazards or reduced greenhouse house gases emission will not reduce households' poverty and vulnerability if market accessibility and stability is not ensured to rural households (Owen, 2020). A holistic climate change adaptation policy, besides reducing hazard-oriented exposure and sensitivity, should include improving market accessibility and quality, reducing market imperfection to influence the adaptive capacity to poor rural households (Aker, 2010; Asfaw et al., 2018; Asfaw et al., 2019). Limited access to the market and unexpected increase in input and food prices will undermine the gains of sustainability and adaptive capacity obtained from coping and adaptation strategies adopted by households in the context of shocks in the developing world (Owen, 2020). Market exchange is the most versatile adaptation strategy to climate change since it can substitute and complement all the four adaptation strategies discussed before (Agrawal A. and Perrin. P. 2008; Agrawal, 2016). Market and exchange-based adaptation occur in an institutional context, that facilitates access to the market by the households, property rights and regulates market failure – adverse selection and moral hazard due to information asymmetry, transaction costs (Hoddinott & Agnes, 2010; Agrawal, 2016). The most commonly site market based adaptation to climate change crop insurance that allows farmers to share the risk of disasters and protect from severe crop damage (Brooks, 2021). Investments in agricultural technology – e.g., tractor acquisition, improved crop varieties adoption – require financial capacity that is not always met with the rural households in developing countries. Agricultural credit market is thus essential to boost the productivity and ensure food security in low-

income countries like Niger (Hoddinott & Agnes, 2010; p. 21). In sum, market exchange based adaptation is to be considered with cautions in low-income countries due limited infrastructural development- like roads and public transports –and the low purchasing power of the households (Agrawal.A and Perrin. P. 2008).

## **2.4. Knowledge Gap:**

A wealth of studies analysed vulnerability and adaptation to climate change in Niger, especially in agricultural production, land restoration, forest and biodiversity preservation. However, very few studies have analysed the individual and households' adaptation to climate change and the cognitive processes that accompany households' adaptation decisions. There is also a lack of knowledge and understanding of how socio-cultural characteristics –gender, ethnicity, schooling– and covariate shocks –market shocks, poverty– compound with climate shocks to increase the households' vulnerability, and what are the options and strategies of the households to adapt and alleviate the risks. There is also need to understand how households' adaptation to climate change improve their livelihoods in the country. Finally, although many authors have documented the limits to rural adaptation through the ongoing maladaptation and conflicts between different livelihoods in Niger –farming, herding, and agro-pastoralism– and the role of the state as a peacekeeper (Bukari et al., 2020; McGuirk and Num, 2021; Snorek et al., 2014; Thébaud and Batterbury, 2001), the study have identified none that empirically analysed the increase in rural vulnerability through maladaptation and conflict. The ambition of this thesis is to fill these gaps by providing comprehensive knowledge and views of climate change awareness and its determinants, the households' adaptive options and response to climate and market shocks and the

understanding of how the process and limits to adaptation drive conflicts between groups and the role of governance in providing life opportunities, promoting peace and security.

## **2.5. Theoretical Framework**

### **2.5.1. The Model of Private Proactive Adaptation to Climate Change (MPPACC)**

Adaptation to climate change has been recognised as crucial in protecting exposed people's lives and valuable assets. Research has largely explored the objective adaptation based on assets, relations and networks, and financial aptitude to increase people's adaptive capacity. However, few studies have considered subjective adaptation based on perception, risk appraisal, and cost-benefit analysis effective in explaining adaptive behaviours and an increased adaptive capacity. The MPPACC presented in this section associates the subjective and the objective adaptation behaviours in explaining the role of perception and awareness in the adaptation and maladaptation process. The MPPACC theory by Grothmann and Patt (2005) it was adapted by adding opportunity appraisal following Mitter et al. (2019) and the four categories of maladaptation (Juhola et al., 2016) as Grothmann and Patt (2005) limited their analysis to the avoidant maladaptation.

#### ***2.5.1.1. Context of the MPPACC***

The MPPACC theory applies in a context of regional geographical and climatic characteristics –local, regional climate, type of soil, and water availability– with which farmers have to deal and which are not under their control. Individuals and households manage their portfolio of assets –schooling, household labour availability, and land, their specific context of vulnerability– that minify or magnify the contexts of risks, shocks, and stresses. These characteristics drive individuals, households, and

communities to a cognitive process, the desired outcome of which is to minimise risks or take advantage of the opportunities, as presented in the following section.

### ***2.5.1.2. Individual Cognitive Processes in the MPPACC***

In the context of global climate change, people go through a process of decision makings based on certain characteristics –like previous experiences and assets ownership– driving the climate change appraisal and the adaptation appraisal.

- **Climate change appraisal:**

The cognitive individuals' climate change appraisal is an adaptation intention stimulant that drives into the “risk appraisal” and “opportunity appraisal” processes. Risk appraisal is a process through which individuals evaluate the threat probability potential from climate change and its damage potential on lives and assets if no protection initiative is implemented (Grothmann and Patt, 2005). Through opportunity appraisal, individuals and households evaluate the probability of potential beneficial impacts from climate change and the extent of these emerging opportunities (Mitter et al., 2019).

- **Adaptation appraisal:**

Adaptation appraisal comes after the climate change appraisal and is conditioned by achieving a certain threshold of risk of damages from climate change. People start contemplating possible actions in terms of adaptation and their competence to undertake them when a certain perceived threshold of the threats is crossed.

Adaptation appraisal has three subcomponents, “*perceived adaptive efficacy*”, which is the households' belief that adaptation response for instance, one's judgment that using improved seeds can prevent drought damages, can effectively protect lives and livelihoods from negative impacts. “*Perceived self-efficacy*” refers to how an individual

or household perceives his ability to undertake successful adaptation initiatives –a poor household with no access to credit will perceive it difficult to pay for genetic seeds and fertiliser to prevent drought stress. Finally, adaptation appraisal is composed of the “*perceived adaptation cost*”. In that step, households evaluate the –personal, financial, and timely– cost of taking adaptive action to prevent climate risks. A higher cost can constitute a drawback for the households to undertake adaptive responses.

### ***2.5.1.3. Adaptive Responses and Maladaptive Outcomes in the MPPACC***

Two general outcomes come from the individuals’ and households’ processes of climate change appraisal and adaptation appraisal; effective adaptation response and maladaptive outcomes. Adaptive responses are those that prevent individuals and households from the damages originating from climate risks. As explained in the adaptation institutions and livelihood framework (Agrawal, McSweeney, and Perrin, 2008; Agrawal and Perrin, 2008), it comprises storage, mobility, diversification, market exchange, and communal pooling. Maladaptation comprises avoidant reactions and wrong adaptations that increase the vulnerability of the people it is intended to protect. Maladaptation comprises rebounding vulnerability, sifting vulnerability, and introducing new vulnerability/eroding sustainable development. Maladaptive responses are a consequence of high-risk perception and low perceived adaptive capacity. Cognitive bias –referring to previous experience as a mental model for climate change– and heuristics –accounting for the government to protect people from floods in flood-prone areas– at the adaptation appraisal and climate change appraisal also irrationally affect households’ perceived adaptive capacity, and under/overestimating their perceived adaptive capacity.

Formulating the adaptation intention is very important when choosing the adaptive response. That is achieved when the person's risk perception is high, combined with a high perceived adaptive capacity. Adaptation intention is distinguished from effective adaptation since people may intend to adapt but fail to transform this intention into effective adaptation. That can be due to the lack of objective adaptive capacity especially the lack of physical, natural, financial, human, and social capital to accompany the subjective adaptation process (Grothmann and Patt, 2005).

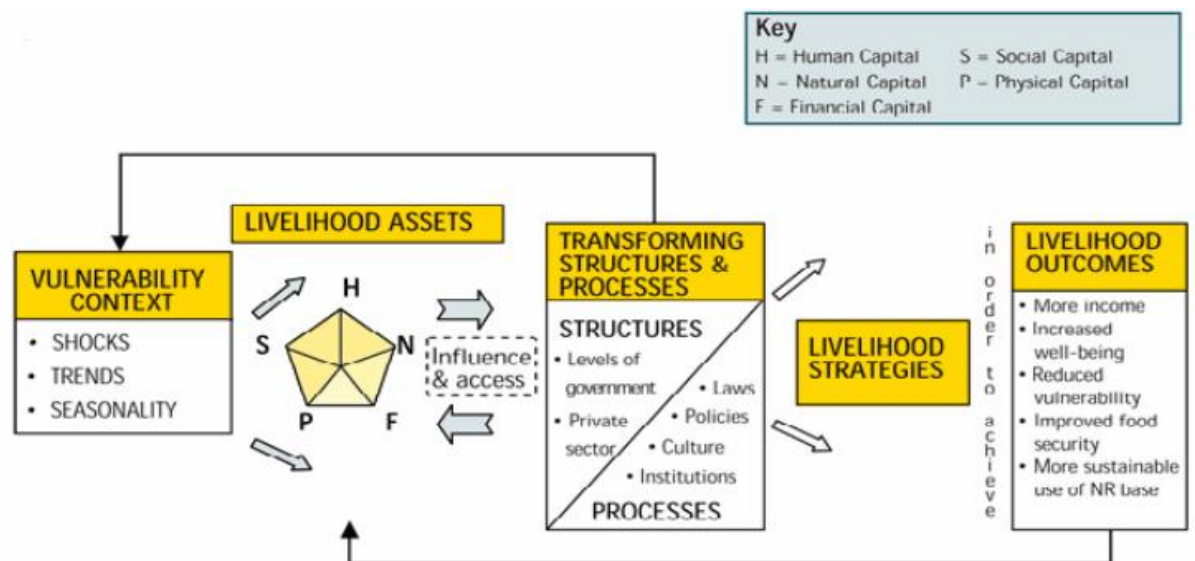
### **2.5.2. Sustainable Rural Livelihood Approach (SRL)**

Sustainable livelihood is a concept that has gained prominence in the rural development debate, building on a clearer understanding of poverty, food security, and livelihoods. It originates from the early works of Chambers in the 1980s and later by Chambers and Conway (1992). The concept is largely adopted and implemented by many development agencies in their efforts for poverty reduction, environmental management, and food self-efficiency, especially in developing countries. Chambers and Conway (1992) state that *“a livelihood comprises the capabilities, assets, and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks”*.

Given a particular context –policy implementation, agroecological settings, socio-economic context–households combine livelihood strategies including agricultural intensification and extensification, livelihood diversifications, and migration for a certain outcome. The achievement –or not– of that outcome is determined by the ability of households to carry out the livelihood strategies mediated by institutional processes –formal and informal institutions and organisations– that govern the regimes of access to resources (Scoones, 1998).

### 2.5.2.1. Characterisation of the sustainable livelihood framework

Many poor households' livelihoods are drowned from the environment and natural resources, especially in developing countries. Yet there is a situation of stresses and shocks –population growth, natural and anthropogenic changes in the climate– which upsets the balance between livelihoods and natural resources, causing additional pressure on the environment and threatening its normal functioning. Sustainable livelihood is thus at the centre of the relations between households and the environment (Scoones, 1998). It is human-centred, multilevel, responsive and participatory, conducted in partnership and sustainability (Haidar, 2009). It can be considered a way of characterising the objectives, scope, and priorities for development (Majale, 2002).



**Figure 2.1: Sustainable Rural Livelihoods Framework**

Source: adopted from Haidar (2009)

### ***2.5.2.2. Livelihood Resources in the Sustainable Livelihood Framework:***

Households have a set of livelihood assets that they combine to pursue different livelihood strategies available to them. These assets are:

- Natural capital: that is, basic natural resources –genetic resources, soil, forests– and environmental services available to people in a particular location.
- Social capital: information networks, membership in organisations, group relationships,
- Physical capital: that count household shelter, number and quality of livestock, but also available infrastructure, including health facilities, roads, schools, water, sanitation
- Financial capital: access to credit, savings, income, remittances
- Human capital: these are the skills, knowledge, and health capable of facilitating the pursuit of livelihood strategies

As a consequence of the social, economic, and environmental trends, stresses, and shocks, assets can be destroyed or created. Institutional processes also greatly influence who can access a particular asset, thus determining livelihood options available to people.

### ***2.5.2.3. Livelihood Strategies Available to People in the Sustainable Livelihood (SL) Framework:***

At the disposal of households is a range of livelihood activities that they combine to achieve a certain expected outcome and mitigate stresses and shocks. These include productive activities like agriculture, herding, off-farm activities. It also include investment strategies, and productive choices like livelihood

diversification depending on their access to productive assets (Haidar, 2009). Migration, transhumance, seasonal migration, and permanent displacements are valid livelihood strategies adopted to mitigate vulnerability context across space.

These strategies can also be combined as a “portfolio of activities” by people. These choices are dynamic and vary according to the vulnerability context, the available asset groups, and the institutional processes.

#### ***2.5.2.4. Policy, Institutions, and Processes (Pips) in the SL Framework***

Formal and informal institutions set the path for people to pursue their livelihoods by shaping policies and processes at all levels. Institutions determine both the conditions of access to resources and assets as well as the substitutability of these assets (Majale, 2002). They determine power relations between people and mediate external funding to improve the livelihoods of the poor (Scoones, 1998).

Haidar (2009) defines that the PIPs include social relations and status –kinship, gender, culture, ethnicity, religion, and history–that affect access to livelihood options and power. It includes social and political organisation –social rules and norms, civic bodies, leadership, power, and authorities–engaged in community organising and lobbying. Governance is a key component in the PIPs as it sets the rules for resource attributions and opportunities pursued across scales. The quality and form of governance include power structures, efficiency, effectiveness, rights, and representations. Service delivery, resource access institutions, policy, and policy processes are also part of the PIPs in the sustainable livelihood framework.

### ***2.5.2.5. Livelihood Outcomes in the SL Framework***

Livelihood outcomes are the goals to which people aspire to pursue combinations of livelihood strategies (Haidar, 2009; Scoones, 1998). They include:

- Increased income;
- Poverty reduction;
- Well-being and capabilities
- Improved food security
- Livelihood adaptation, reduced vulnerability, and improved resilience
- Natural resource-based sustainability

### **2.5.3. Adaptation, Institution and Livelihoods Framework (AIL):**

Climate change impact assessment and related adaptation have been limited in evaluating biodiversity loss, land use and land cover changes, ecosystems and health. It is very recently that the nexus of climate change, human responses and how institutions shape these responses in the context of global development efforts has been documented in the literature.

Spontaneous households' adaptation to climate threats has been successfully carried out by poor rural dwellers, although the recent climate changes will worsen the frequencies and the magnitude of the shocks. The adequacy of the responses will henceforth depend on how formal and informal institutions shape the capacity of rural households to organise their responses for the effectiveness of historical adaptation techniques.

Developed by Agrawal, McSweeney, and Perrin (2008) and Agrawal and Perrin (2009), the adaptation institutions and livelihood framework highlight households' historical adaptation strategies in the context of shocks and the way institutions shape these

households' responses to climate risks. The framework also drives how institutions can facilitate or undermine access to adaptation facilities, assets and capabilities depending on social groups and shape households' vulnerability.

### ***2.5.3.1. Coping Mechanisms and Adaptation in the Context of The AIL Framework***

When faced with climate stress, households historically adopt five classes of adaptation, or a combination, to cope with the contingencies and anticipate the aftermath of the shock. The AIL framework classifies these strategies depending on the type of risk it allows to reduce. The conceptual literature review will present a more elaborate analysis of coping mechanisms and adaptation strategies. These strategies include:

- **Storage:**

Many storage categories exist in the history of adjustment to perceived tough living conditions. Households and communities have adopted food storage for centuries in response to climate conditions. Water storage through dams for irrigation and daily usage, fodder storage by herders, and seeds and forest products by indigenous people can be mentioned as being able to help households resist various shocks in their environment and livelihoods. Storage, associated with good infrastructure, pools risk in time.

- **Mobility :**

Mobility is a class of adaptation that pools risk across space, associated with good information. It includes pastoral mobility, wage labour migration, and involuntary migration. For a long time, mobility, especially migration, has been considered by the scientific community as a maladaptation (McLeman et al., 2021). That explains the

limited proportion of mobility mentioned as adaptation, especially in the UNFCCC coping mechanisms and climate change adaptation datasets (Agrawal, 2016).

- **Diversification**

Households have a portfolio of livelihoods that they manage to sustain their subsistence and face climate change's economic and social impacts. Diversification includes labour diversification, asset portfolio diversification, crop diversification, consumption choices, training, skills development and capacity building, production technology adoption, and animal breeding. Diversification pools risk across livelihood and asset portfolios.

- **Communal pooling:**

Communal pooling involves households and communities merging efforts and resources to prevent and adapt to difficult situations. Pooling reduces risks across households and is sustained by a strong social capital of the communities. Many households' assets can be subject to pooling, including labour pooling, pasture pooling by herders, information gathering, and disaster preparedness. Many international programs and government agencies use this strategy by gathering and storing cereals under the leadership of village chiefs and organised committees to prevent households' and communities' starvation due to climate shocks.

- **Market exchange**

Access to the market is the most important adaptation that can replace all the four other classes of adaptations presented so far. The market exchange goes beyond only adaptation to climate change to cover specialisation, trade and welfare gain by

households. Exchange covers inputs, food purchase, insurance provision, and changing herds' composition to face drought.

### ***2.5.3.2. Institutions in the Adaptation Institution an Livelihood Framework***

Institutions are formal and informal mechanisms governing human behaviours and strategic resource access. Institutions foster the path for the households to pursue their livelihoods and have the monopoly of legitimate violence in case of any violation and abuse. The AIL framework identifies three types of institutions, public, private and civic organisations. These institutions have mainly three types of interventions in rural and poor households to facilitate adaptation to climate change.

First, by regulating and structuring households' interactions among themselves and with external actors, institutions influence how households and communities are affected by climate risks and impact (Agrawal and Perrin, 2009). That concern, for example, the clear definition of property rights and the availability of public infrastructures and markets. Institutions shape how households respond and organise adaptation by determining access to resources and capabilities and, finally, mediate the flow of external resources in the context of adaptation to climate risks.

## CHAPTER THREE

### METHODOLOGY

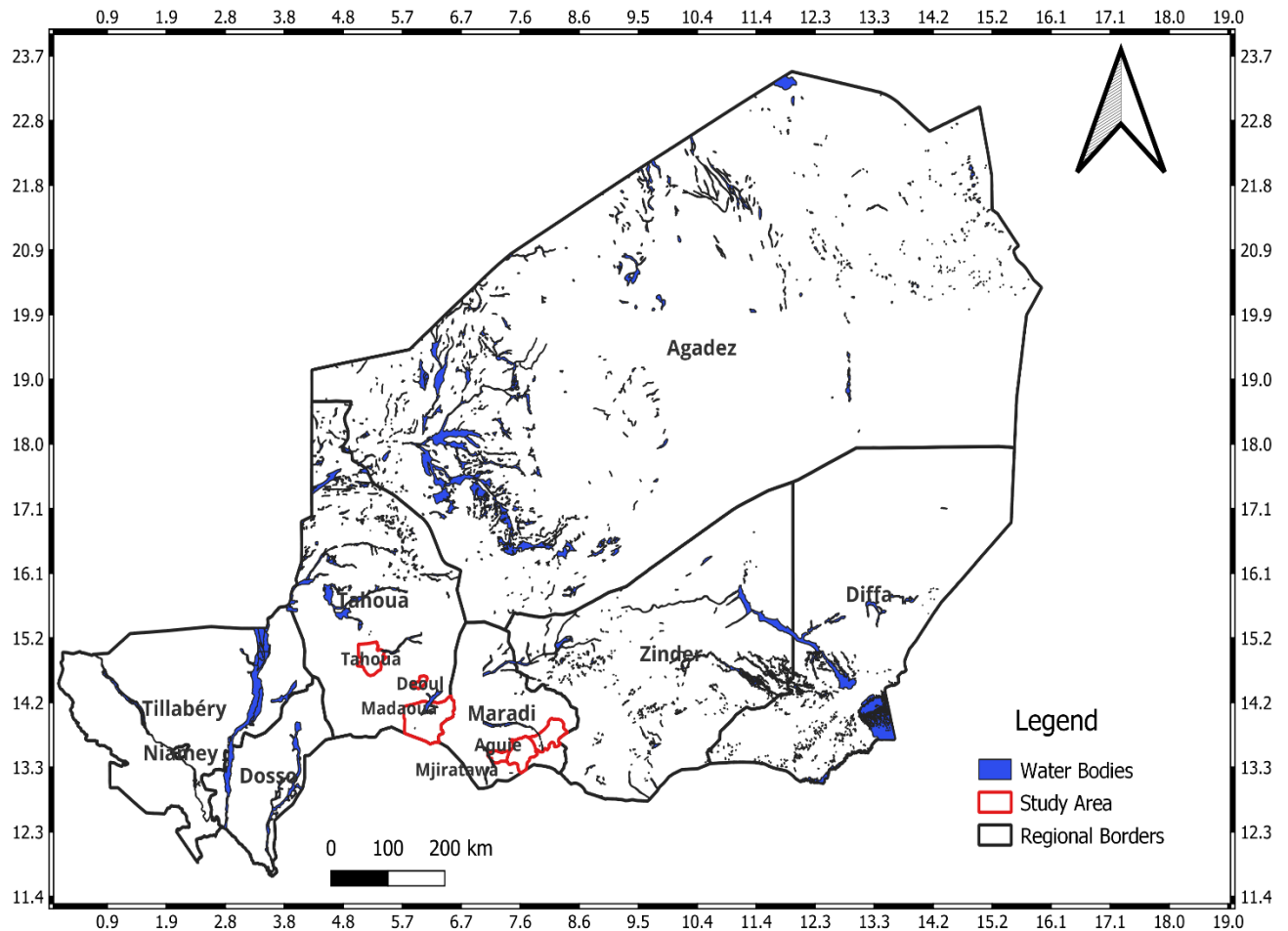
#### 3.1. Research Design

This research uses an empirical mix method, where data is collected from three different sources. A survey was first conducted in the two central agriculture and pastoral areas of Niger to gather primary information on climate change and conflicts in the context of Niger. Second, a panel data from households' living conditions and agriculture survey of Niger (ECVMA) was used. These data were collected by the National Institute of Statistics of Niger in all eight regions of the country, with the assistance of the World Bank. Further details on this data is provided in the subsequent sections. Third, multi-stakeholder data on conflicts and their management in the biggest pastoral region, Tahoua region, of Niger was obtained from the scientific forum on natural resources access-related conflict management.

Descriptive statistics was the first step of data analysis in this research. That allows to assess the reliability of the data and deal with data extremes.

In the inferential analysis, households' awareness and perception of climate change are assessed using a Logit model in a cross-sectional data from the survey conducted in Tahoua and Maradi regions. The ECVMA data are then used in a cohort design –2012, 2015, and 2018– to evaluate the benefits and determinants of adaptation initiatives using seemingly unrelated regression model. Finally, using the ECVMA dataset and the qualitative data from the scientific forum on natural resources access-related conflicts,

maladaptation as a trigger of socio-professional conflicts is assessed using an instrumental variable method.



**Figure 3.1:** Map of the study area

**Source:** author with QGIS, 2023

### 3.2. Households' Awareness and Perception of Climate Change

The awareness and perception of climate change were assessed as critical variables for determining climate change adaptation. The objective is to determine how households' socioeconomic and agricultural characteristics, cognitive processes, and perceived regional biophysical variables enhance or undermines their awareness and perception

of climate change. The data from two Tahoua, the Northern herding zone of Niger and Maradi, the agricultural zone in the south were used

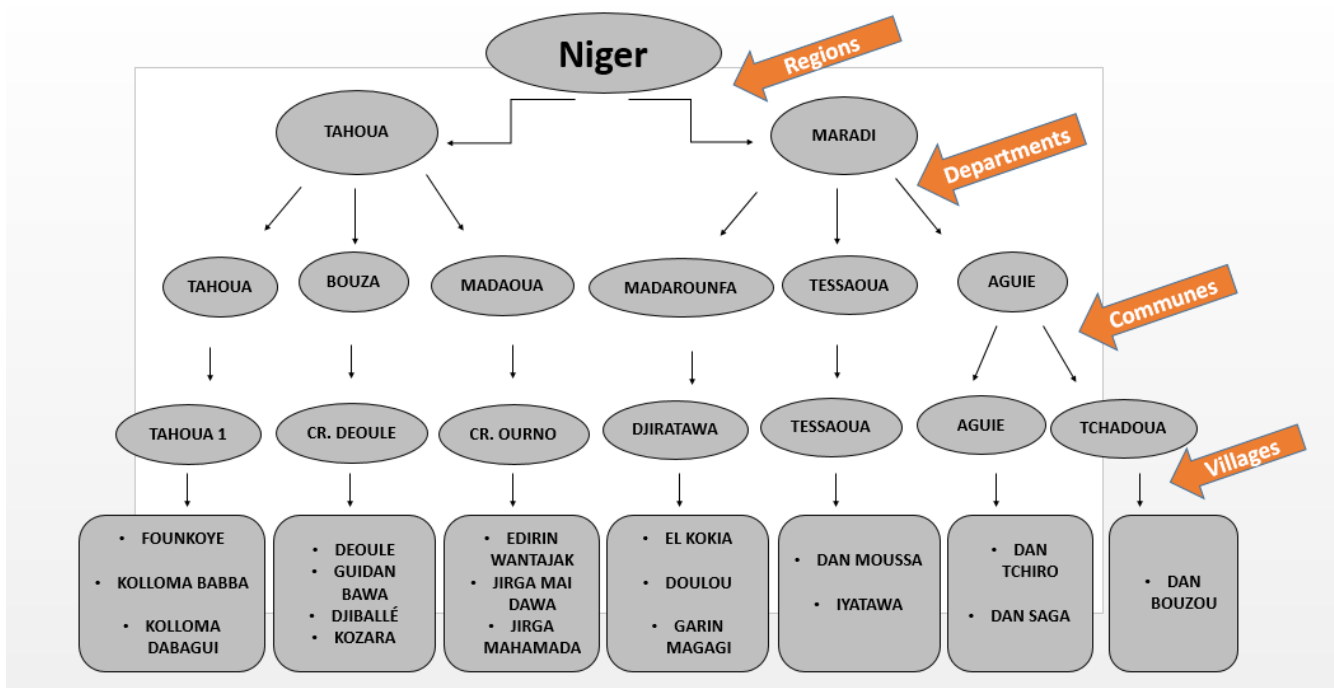
### **3.2.1. Survey Data Collection in Two Regions of Niger**

This data collection has been carried out to understand the rural context of Niger especially the depth of knowledge gaps, adaptation, and households' experience of conflicts.

The first step of this data collection concerns discussion with authorities at the National level, including the ministry of agriculture, the ministry of livestock, the ministry of the environment, the ministry of planning, and many other stakeholders, to mainstream the existing knowledge and dispositions of climate change in the country. At the start of the interviews, in each commune, local authorities are interviewed on how they contribute to environmental management and climate change, how they organise riposte to changes, and whether a collective dynamic is put in place to act collectively through learning, education, and collective action to the observed changes. In each village, focus group discussions were also initiated, with at least six local villagers, including minorities and marginalized groups –women, young, and men– to have the participation of all groups in the surveyed responses. At the same time, survey interviewers randomly visit households to administer questionnaires.

A multistage sampling technique was used to select the survey respondents. First, the two regions, Tahoua and Maradi, were selected using a purposive sampling technic, as the study areas. In the second stage, the departments, communes, and villages (Figure 3.2) were selected using simple random sampling. Finally in the third stage, systematic sampling procedure fixed periodic interval of one household between two interviewed households was used to select the respondents for the interviews, giving each household an equal chance to participate in the survey data collection. As almost 80 to 90% of rural

households draw their livelihoods from agriculture (INS, 2016), all the households can potentially be subject to the interviews. A sample of 835 households was collected, including 14 key informant interviews (one for each commune, especially the local authorities and the village chiefs), and 18 focus group discussions (one focus group for each village).



**Figure 3.2: Multilevel sampling**

### 3.2.2. Binary Logistic Model of Climate Change Awareness and Perception Assessment

A logit model is used to assess the characteristics that determine the households' awareness and perceptions of climate change. This model is suitable for estimating the determinants of the perception of climate change for several reasons:

- A linear model yields absurd results for a categorical dependant variable because it is used to predict continuous values of dependant variables where classification is required.

- While the linear model predicts absolute numbers, the categorical logit model predicts the probability –comprised between 0 and 1 –of an output to occur.
- Linear models are too sensitive to data imbalance to classify categorical models.

Awareness and perception are instrumental in the process and decision of adaptation to protect assets and safeguard livelihoods. The logit model can be written as:

$$Y_i = \sum \delta X_i + \omega_i \quad (1)$$

Where  $Y_i$  represent a household's awareness status of climate change. This is defined as one if the household is aware of climate change and 0 if unaware.  $X_i$  is a set of variables likely to influence household awareness of climate change and  $\omega_i$  the specification error following a logistic function.

A household  $i$  draws an unobserved utility of  $U_i^a$  for being aware of climate change as (DOUKOURE, 2016):

$$U_i^a = a + bX_i + \varepsilon_i \quad (2)$$

and the utility,  $U_i^b$ , if the household is not aware of climate change is given as:

$$U_i^b = c + dZ_i + \varphi_i \quad (3)$$

$Z_i$  Variables to characterize households that are not aware of climate change,  $a, b, c, d$  coefficients to be estimated and  $\varepsilon_i$  and  $\varphi_i$  are error terms. The study define an unobserved latent variable that is the difference between  $U_i^a$  and  $U_i^b$ :

$$Y_i^* = U_i^a - U_i^b = (a - c) + bX_i - dZ_i + (\varepsilon_i - \varphi_i) \quad ;$$

$$Y_i^* = \alpha + \beta X_i + \delta Z_i + \omega_i \quad (4)$$

Household  $i$  get involved in climate information seeking if  $Y_i^* \geq 0$ . The probability of  $i$  being aware of climate change is:

$$P(Y_i^* \geq 0) = P(Y_i = 1) = P(\alpha + \beta X_i + \delta Z_i + \omega_i \geq 0) = P[\omega_i \geq -(\alpha + \beta X_i + \delta Z_i)] \quad (5)$$

The logistic distribution being symmetric, one can write:

$$P_i = P(Y_i = 1) = P(\omega_i < \alpha + \beta X_i + \delta Z_i) = F(\alpha + \beta X_i + \delta Z_i) \quad (6)$$

Where  $P_i$  is the probability of  $i$  being aware of climate change, and  $F$  is the distribution function of the random variable  $\omega_i$ . These can be given as:

$$F(t) = \frac{e^t}{1+e^t}, \text{ and } P_i = \frac{1}{1+\exp[-(\alpha+\beta X_i+\delta Z_i)]} \quad (7)$$

The dependent variable for the empirical study is the awareness of the households on climate change. That is their perception of climate change and its impacts on their livelihoods. Specifically, with a “yes” or “no” response options, the households were asked if they perceive climate change and its impacts on their lives. The variable was then coded “1” if the household perceives climate change and climate change impacts and “0” if otherwise.

The choice of the explanatory variables is based on a large theoretical background of related studies (Ado et al., 2019; Brüßow et al., 2019; Mustafa et al., 2019; Paudel et al., 2020) and the context of the study area. These variables are presented in Table 3.1.

Human capital is the first component of the households’ capital assets as determinants of the awareness of climate change. The age of the household’s head in this specification is proxied for the experience in farming and or herding for the household’s head. It’s measured in years, and it is expected that the higher the age of the household head, the higher the probability of been aware of and perceive climate change and climate change impacts.

The household head’s gender is also selected as an explanatory variable in this setting. Compared to their male counterpart, women have limited access to land, off-farm labour, social networks and information and, more broadly, life opportunities. They are thus more exposed to shocks, including climate vagaries. Considering this variable allows us to see the distribution of the perception of climate change impacts according to gender.

Information is a critical factor in the process of awareness creation and perception shaping in the field of climate change. The variable information and communication technologies are used to capture the flow of information from different sources of the farmers and the influence it has on the perception of climate change in rural areas.

**Table 3.1: Description of the selected variables for the Logistic model**

<b>Dependant variable</b>	<b>Measurement</b>	<b>Expected sign</b>
Awareness of climate change	1 if HH perceive changes in the climate	
<b>Independent: HH social, financial and human capitals</b>		
Age of the HH head	Number of years of the HH head	Positive/Negative
Schooling of the HH head	Years of he schooling of the HH head	Positive
Gender of the HH head	1 if the HH head is a man; 0 otherwise	Positive/Negative
ITC use	1 if the household use an ICT for information ; 0 otherwise	Positive
<b>Independent: HH capital assets</b>		
HH assets	Number of physical assets of the household	Negative
Climate Adaptation	1 if HH adopt soil management practices; 0 otherwise	Positive
Land size owned	In hectares	
<b>Independent: biophysical variables</b>		
Rainfall intensity	0 “no change” 1 “increased rainfall intensity” 2 “decreased rainfall intensity”	Positive
Rainfall distribution	0 “no change” 1 “even rainfall distribution” 2 “decreased rainfall intensity”	Positive
Increased frequency of droughts	1 if HH perceive more frequent droughts; 0 otherwise	Positive
Increased frequency of floods	1 if HH perceive more frequent floods; 0 otherwise	Positive

**Source: Author construct, Fieldwork 2021**

Natural and physical capitals are very important in the process of climate change adaptation and thus awareness raising. Farmers with strong physical and natural assets are more likely to resist shocks, while poor households are more vulnerable. In this category, the study have selected the land plot exploited by the household, measured in

hectares, the physical assets of the household and the adoption of climate change adaptation strategies. The households' perception of the biophysical characteristics of each region is included in this model to determine households' awareness of climate changes and impacts.

### **3.3. Determinants and Welfare Effects of Adaptation in Rural Niger**

As aforementioned in this research, adaptation to climate change involves households transforming their capital assets' endowments into an adaptive capacity to protect livelihoods from unexpected adverse impacts (Bebbington, 2021).

Many empirical assessments of adaptation actions reveal that despite the existence of the households' resistance means, households sometimes fail to carry out effective adaptation majors and even expose themselves and others between avoidant maladaptation and expectations from the state to protect them from adverse impacts (Wolf et al., 2010). The households' cognitive processes were revealed to be instrumental in climate adaptation decision-making. That's why assessing push and pull factors that drive households' allocation of capital and labour to alternative livelihood options is important since it has implications for the welfare of households.

The household resource allocation –adaptation– decision has different implications for its agricultural yield, expected income flows and the severity of eventual shocks to be experienced by the household. The implication of the adaptation returned has important welfare gains for the households. Thus, the importance of assessing the welfare opportunity of different adaptation strategies.

### **3.3.1. The Panel Data on the Household Living Condition and Agricultural Survey (ECVMA) Of Niger**

The National Survey on households' living conditions and agriculture (ECVM/A) original panel socioeconomic data of Niger is used for this objective. The National Institute of Statistics of Niger collected this dataset with technical and financial assistance from the World Bank. It covers the country with multi-topic integrated household. This study build a longitudinal dataset using the data obtained from the six visits, two visits each in 2011/2012, 2014/2015, and 2018/2019. The main objectives of the ECVMA dataset are to:

- Measure the progress (2011, 2014, 2018) made in the search for the achievement of the Development Goals (MDGs, SDGs)
- Allow updating of social indicators used in the formulation of public policies aimed at improving the living conditions of the populations;
- Provide information on the organization and structure of the agricultural sector and breeding and climate change as well as the use of resources entering into the agricultural production activities;
- Provide data on several important economic and social sectors for Niger without necessarily implementing other specific surveys.

### **3.3.2. An empirical model for adaptation drivers**

Seemingly unrelated regression method (SUR), also called the SURE model or Zellner's method was used to determine the drivers of adaptation and its welfare effect in the second stage on the households. The approach was developed by Zellner (1962) and used especially in the case of interdependence and periodic correlations between individuals in two or more equations. It consists of applying GMM to obtain the smallest variance of the estimates. The SUR method have many advantages. First, the SUR

method allows to estimate a system of equations at once (in our case, three equations) while considering heteroskedasticity and contemporaneous correlation of the errors across the equation. As farmers can rely on a mix of these adaptive majors, the different adaptation classes are potentially interdependent, and the choice of this model is not causeless since it accounts for potential interdependences between different adaptation practices (Asfaw et al., 2018). Moreover, although the different equations can be estimated one after the other using ordinary least square estimates, it is not as efficient as the SUR estimates, which give the smallest variance of the model (Éric DOR, 2018; Khan et al., 2014). This model is very important, considering that households can combine a mix of adaptation options. This account for the interdependences between different adaptation classes –storage, diversification, and pastoralism– increasing the diversity of the results.

The method consists spontaneously of the following steps:

- Estimating the N equations of the model by the ordinary least square (OLS)
- Extract the N residues  $z_{it}$  from these equations,
- Estimate the variance-covariance matrix,
- Apply the GMM estimator to get the SUR coefficients.

The empirical model for this study is presented as follows: For  $HH_i = 1, 2, \dots, N$  and  $Year_t = 1, 2, 3$ , the estimation of the panel model is:

$$A_{it,j} = \beta_j K_{it,j} + \gamma_j S_{At,j}^{Cl} + \partial_j S_{it-1,j}^{pr} + z_{it,j} \quad (8)$$

$A_{it,j}$  is the adaptation strategy adopted by individual I at time t;  $j$  representing the index for the three classes of adaptation equations. These are storage, mobility, and diversification.  $K_{it}$  Represents the set of the household-level endowment of human

capital, financial capital, physical capital and natural capital.  $S_A^{Cl}$ , a vector of biophysical variables likely to influence the adaptation decision (see table 4.2).  $S^{Pr}$ , a vector of dummy variables for agricultural inputs and food price shocks.  $\beta, \gamma, \delta$  are factors to be estimated and  $z_{it,j}$  the error terms assumed to be correlated across the three adaptation class equations selected in this research. The overall variance-covariance matrix is given by:

$$E (zz') = \begin{pmatrix} \sigma_{11}I_N & \sigma_{12}I_N & \sigma_{13}I_N \\ \sigma_{21}I_N & \sigma_{22}I_N & \sigma_{23}I_N \\ \sigma_{31}I_N & \sigma_{32}I_N & \sigma_{33}I_N \end{pmatrix} = \Sigma \otimes I_N = \psi \quad (9)$$

### 3.3.3. Empirical model on the effect of adaptation on household's welfare

For the determination of the effect of adaptation on household's welfare, the model will be used in an instrumental variable setting, using residuals from the adaptation estimation from the first stage to avoid simultaneous determination of certain adaptation strategies and the welfare effect.

At any time  $t$ , the household welfare  $W$  in an environment subject to climate shocks  $S$  is represented by:

$$W_t = f[A_t(S_t, K_t), Z_t] \quad (10)$$

Here,  $A_t$  is the adaptation strategy adopted by the household to cover the risk of or deal with climate shock  $S_t$  according to his capital endowment  $K_t$  and unobserved variables  $Z_t$  (SARDAR et al., 2020).

The second stage equation is given by:

$$W_{it} = \delta_{0,it} + \delta_1 stor_{it} + \delta_2 divers_{it} \delta_3 mobility_{it} + \varphi_{it} \hat{A}_{itj} + \partial K_{it} \varepsilon_{it} \quad (11)$$

With  $W_{it}$  The quintiles (20%; 40%; 60%; 80%) of the households' welfare indicator is the per capita household consumption aggregate. The indicator is built from the aggregation of the consumption divided by the household's size to account for the individuals in the household. Then the obtained value is normalized by dividing by a spatial deflator that accounts for living costs between rural and urban areas (INS, 2016a). The indicators for computing the consumption expenditure are food expenditures, non-monetary food consumption –home food production, gifts and in-kind payment– and at the household level, the value of purchased non-durable goods, the value of the rent for dwelling owned by the household or given free to a third party to dwell, and estimated use value of household's durable goods.  $\hat{A}_{itJ}$  is the residuals of the estimation of storage, diversification and transhumance equations obtained from equation (5). The  $\hat{A}_{itJ}$  is included to correct the potential endogeneity issues that can arise between the three dependent variables and the welfare outcome, and  $K_{it}$  households'–Physical, social, natural, financial and human–capital endowments as presented in table 4.2.

### **3.3.4. Variables of the Model of Adaptation Drivers and Welfare Effects of Adaptation**

Adaptation in the context of particular policy enforcement, historical, political, socio-economic, and agroecological conditions is critical for households' sustainable livelihood (Scoones, 1998). Adaptation at a community or regional level is determined by five features that define the community's adaptive capacity: economic wealth, technology, information and skills, institutions and equity and infrastructure (IPCC, 2001b). However, at a micro level, the Sustainable Rural Livelihood (SRL) framework determines a set of resources at the disposal of an individual or a household that supports its adaptation and resilience to climate change (Below et al., 2012; Shisanya and Mafongoya, 2016). These resources can be physical, social, financial or institutional

(Asfaw et al., 2018). This work uses the sustainable rural livelihood theoretical framework to evaluate the drivers and the welfare effect of households' adaptation strategies to climate change. The vulnerability of a household to climate shocks and its aversion to risk determine the decision to adapt, and the adaptive capacity is determined by its capital endowment. This capital endowment is represented by  $K_{it}$ , being the vector of capitals of household  $i$  at the time  $t$  and represented by:

$$K_{it} = \{K_{it}^N, K_{it}^H, K_{it}^P, K_{it}^F, K_{it}^S\} \quad (12)$$

With  $K_{it}^N$  natural capital (cultivated land, livestock, soil fertility);  $K_{it}^H$  human capital (labour force, gender, schooling),  $K_{it}^P$  physical capital (transportation means, tractors),  $K_{it}^F$  Financial capital (access to credit, household income) and social capital (networks, associations) (Scoones, 1998; Below et al., 2012; Asfaw et al., 2018).

The selected variables for this model are presented in Table 3.2. As dependent variables, are counted have food storage, labour diversification, and pastoralism as adaptation strategies to shocks.

As an explanatory variable, human capital includes household size, which is the number of household members who may be able to work on the farm as family labour. In West Africa, agriculture is less mechanised, and family labour plays a crucial role, especially in the context of smallholder poor household agriculture that cannot afford to pay for non-family labour. That variable can thus influence the decision to adapt to the climate. Human capital also includes the number of years of schooling of the household's head. That can improve the quality of household decision-making concerning climate change adaptation. Finally, the gender and age of the household heads are included in this model under the standard of human capital.

**Table 3.2: Description of selected variables for adaptation drivers**

Dependent variables	Measurement
<b>Food storage</b>	Percentage of the harvested agricultural output stored (sacs of 50 kg)
<b>Pastoralism</b>	Distance travelled by the herds from their residential place (in km)
<b>Labour diversification</b>	Access to off-farm or non-farm labour by HH head
Independent: human capital	
<b>HH size</b>	Total number of HH members
<b>Schooling of the HH head</b>	Years of schooling
<b>Gender of the HH head</b>	1=female; 0= male
<b>Age of the HH head</b>	Age in years
Independent: Social capital	
<b>Remittances</b>	Amount of remittances obtained
<b>Agricultural Cooperative</b>	Household head is member of agricultural cooperative (1=yes, 0=no)
Independent: Financial capital	
<b>Access to credit</b>	Household has access to credit (1=yes, 0=no)
Independent: Natural capital	
<b>Access to land</b>	Number of land plots owned by the household (1=yes, 0=no)
<b>Livestock ownership</b>	(1=yes, 0=no)
Independent: Physical capital	
<b>Access to internet</b>	(1=yes, 0=no)
<b>Living and grazing facilities</b>	1 if HH owned animal living and grazing facilities
Independent:	
Risk and perception	
<b>Perceived increase in rainfall</b>	1=yes; 0=no
<b>Perceived more frequent droughts</b>	1=yes; 0=no
Independent: Price shock	
<b>Input price shock</b>	1=yes; 0=no
<b>Food price shock</b>	1=yes; 0=no

**Source:** Author construct, ECVMA household Panel data

Gender is very important in assessing the determinants of adaptation, as it allows us to see how the social and cultural barriers shape adaptation between men and women. On the other hand, age is a proxy for experience. The more the farmer experienced year-by-year farming activities, the better his understanding of the climate vagaries.

Social capital includes remittances and cooperative membership. Remittances are a very strong resistance means to shocks. Remittances allow households to afford input market prices and agricultural technologies in West Africa, where the agricultural credit market

is rationed with high-interest rates, low households' solvency, and a lack of awareness. On the other hand, cooperative membership facilitates access to information and sharing of good cultural practices. It also facilitates access to common pooled resources. All this is very likely to improve adaptation practices by households.

Financial capital in the form of access to credit is very important in improving agricultural productivity and households' income. However, due to the dependence of the agricultural sector on rainfall and the high risk of floods, drought and locust attacks, the sector receives very little financing credit at a very high cost, thus excluding smallholder farmers and poor households.

Natural and physical capitals are resistance means to various shocks, as mentioned by (Moser, 1998). In the category of natural capital, the study selected the households' access to land, represented by the number of land plots –starting from zero– owned by the household and whether or not the household owns livestock. The more the household owns natural capital, the more resistant to shock it will be. Physical capital in this set includes using the ICTs measured by the number of cell phones used in the household and the household's ownership of the living and grazing facilities.

Variables in relation to households' exposure to risks due to previous experiences and the households' perception of the biophysical characteristics, like the amount of rainfall received in the region and the frequency of droughts in the most recent past, are introduced to the model. That will allow us to see how experience and education, based on past exposure to risk and cognitive perception of the biophysical characteristics, shape the households' adaptation to climate change. Finally, market variables related to the input and output price variations are introduced to measure the incidence of the market shocks on the decision adapt.

### **3.4. Estimating the Nexus between Climate Adaptation, Maladaptive Outcomes and Social Conflicts in Niger**

Southern Niger is a zone dedicated to agriculture and is subject to private land ownership, while the northern state domain shelter exclusively pastoralism. In that part of the country, many pastoralists' ethnic groups are set and drive their livelihoods from herding. However, issues, including access to water, grazing space and transhumant corridors, exacerbated by harsh climate conditions (Thébaud et al., 2001), are driving conflicts and negotiations between pastoralist groups and agriculturalists. A set of available adaptation options to the households make other interests worse off (Maladaptation) and trigger discords (Snorek et al., 2014). Government policy around land use and access to water (traditional walls, boreholes) has failed to provide an integrated and satisfactory management system (Snorek et al., 2014), rather exacerbating the situation by reinforcing the alienation of some groups instead of integrating them (Thébaud et al., 2001). Pastoralism was not legally recognised to value the land at the same point as agriculture, and forest management, while agriculturalists use it to largely cross the boundary going into pastoral zones in response to climate conditions (Snorek et al., 2014). The scope of this section is not to analyse the complex dynamics between the social groups in northern Niger but to evaluate the bulk of indigenous and modern scientific adaptation options to draw light on the options that can be considered maladaptation, the source of conflicts between individuals and groups. Following Burke et al. (2015), an instrumental variable model was used to assess the relationship between climate change maladaptation and conflicts. ECVMA dataset and the data from the scientific forum on natural resources access-related conflicts managements in the Tahoua Region of Niger was used to assess the different adaptation strategies that drive social conflicts in rural Niger (Maladaptation).

### **3.4.1. Data from the Scientific Forum on Natural Resources Access-Related Conflicts Management in Tahoua Region, Niger**

On December 14-15<sup>th</sup> 2021, in collaboration with the international organisation for migration (IOM), the University of Tahoua organized the scientific forum on natural resources access-related conflicts management in the Tahoua region, intending to endow stakeholders with means of alleviating conflicts and facilitating peacebuilding processes. The forum has seen the participation of eminent personalities, including the minister of higher education of Niger, the governor of the Tahoua region, the customary leaders, and opinion leaders. These also include stakeholders directly involved in conflicts and their managements, like administrative and traditional authorities, researchers, magistrates in charge of adjudicating between belligerents, and farmer organisations. Three discussion groups were organized accommodating the different professions of participants to collect different stakeholders' views about the types, causes and appropriate resolution channels of the conflicts. The discussion groups include:

- Panel 1: Administrative and customary authorities;
- Panel 2: Technical services;
- Panel 3: Farmer organizations of the Tahoua region (including herders and all other professions holding a stake in the discussions)

Each panel provided responses to the questions including:

- What are the types of conflicts in your communities or areas of intervention?
- What difficulties do you experience regarding access to natural resources in your different localities? NB: Difficulties and proposed solutions

- Do the legal texts make it possible to manage conflicts related to natural resources?
- Make relevant recommendations that will resolve conflicts

Data was produced from each discussion group and compiled in one document for decision-making on conflict management and peace-building processes in that region. Multiple stakeholders' mainstreamed fresh and practical data was then produced to serve as a basis for peacebuilding and conflict management in the Thaoua region. This data is used to aliment discussions on maladaptation and conflicts in the greatest pastoral zone of Niger.

### 3.4.2. Instrumental Variable Method

Consider  $C_{it}$  a conflict that occurs involving household  $i$  at time  $t$ . We have:

$$\begin{cases} C_{it} = \beta_o + \varphi X_{it} + \theta M_{it,j} + \gamma_j S_{At}^{Cl} + \partial S_{it-1}^{pr} + \epsilon_{it} \\ M_{it,j} = \beta_o + \varphi X_{it} + \alpha Risk_{it-1,j} + \delta K_{it} + \mu_{it} \end{cases} \quad (13)$$

$X_{it}$  is a set of explanatory variables likely to influence the conflict behaviour of the households  $i$  at time  $t$ .  $M_{it,j}$  a set of  $j$  maladaptive outcomes from the households' adaptation initiatives to mitigate adverse climate impacts. It is expected certain maladaptive outcomes to be endogenous, hence, correlated with the error term  $\epsilon_{it}$ . Consequently, econometric issues like reverse or simultaneous causalities among other may arise, and the estimate will not be consistent. The purpose of the instrumental variable method is to deal with these issues.  $Risk_{it-1,j}$  represent the set of  $j$  instruments being the past exposure of the household  $i$  to climate risks at the period  $t - 1$  preceding the conflict. Since previous exposure to risk can obviously trigger adaptive behaviour – thus maladaptation – and is not directly correlated to conflict, this is expected to be a

strong instrument between maladaptation and conflicts. However, econometric tests will be driven to test the validity and relevance of the instrument for the study.

### **3.4.3. Variables of the Conflict Model**

The study selected a range of variables based on the sustainable rural livelihood literature, including households' capital asset endowments and the households' perceived biophysical characteristics of the agricultural zone in Table 3.3. For the maladaptive outcomes selection, the study adopted the classification of the maladaptation by Schipper et al., 2021 –namely, rebounding vulnerability, shifting vulnerability to other co-users and eroding sustainable development. In the first category, the variable “cutting of crop residues for feed” is considered.

By cutting the crop residues to feed their animals back home, the farmers shift their vulnerability to the cattle herders (Thébaud et al., 2001) who, after the liberation of the land, drive their animals to benefit from that residues, especially during the dry period where pasture become too scarce. The second component of climate adaptation in this category that can potentially turn into maladaptive outcomes and trigger conflict is “premature transhumance” by herders.

Mobility is a critical adaptive major to the harsh conditions for herders. However, mobility is impossible at specific periods of the year without the risk of crop damage to farmers during the rainy season. As explained in the Nigerien legislation, the southern agricultural land is usually liberated for farmers to drive their animals after crop harvest, between November-December and April-May. Any crop damage at that period –after the official land liberation from agriculture– is not subject to reimbursement by herders.

**Table 3.3: Description of the selected variables for the conflict model**

<b>Dependant variable</b>	<b>Measurement</b>	<b>Expected sign</b>
Conflicts	1 if HH embarked in a conflict within the three years preceding the data collection	
<b>Independent: Maladaptation type: shifting vulnerability</b>	<b>Measurement</b>	
Cutting and storing residues	1 if the HH cut the crop residues to feed animals home	Positive
Premature transhumance	1 if the HH's herds migrated before land liberation	Positive
Land expansion into pastoral enclaves	1 if the HH expand his land into pastoral enclaves	
<b>Maladaptation type: rebounding vulnerability</b>		
Pay to water herds	1 if the HH paid to water the animals at a public free watering source	Positive
<b>Independent: Governance</b>	<b>Measurement</b> 1= yes; 0=no	
Transhumance	1 if the HH drive animals to transhumance after land liberation	
<b>Independent: biophysical variables</b>	<b>Measurement</b>	
Increase in temperature	1 if HH head perceive increase in temperature	Positive
	<b>Decreased precipitations</b>	
More frequent droughts	1 if HH perceive more frequent drought	Positive
More frequent floods	1 if HH perceive more frequent floods	Positive

**Source:** Author construct, ECVMA Agricultural plots Panel data

However, any transhumance before that date raises the potential for crop damage and, thus, farmer-herder conflicts. Maladaptation may also occur when the farmers, to make up for the persistent decrease in agricultural yields, “extend their farms” into pastoral enclaves, including animal tracks, grazing spaces, and pastoral corridors, making the herds’ mobility very difficult and the pastoral livelihoods very precarious. That variable is also selected as a potential maladaptive outcome to trigger conflicts. In the second category, rebounding vulnerability, the study selected the “pay to water animals” variable as potentially maladaptive. Accordingly, due to accessibility issues –crowd around the walls, cultivation around public water sources, animal diseases, conflicting

history with other herder groups or with sedentary groups – herders are brought to pay – in cash or in nature – to be able to use the public facility – wells, boreholes, rivers, and any other catchments – water their herds.

Considering the large amount of cattle herders used to drive, the Nigerian rural context of financial poverty, this is a non-sustainable adaptive major and is rebounding the vulnerability of the herder, thus can trigger conflicts.

The other control variables of this model include the governance regime, the biophysical characteristics and the normal transhumance regime.

Governance is very important to consider when assessing maladaptation and conflict framework. Governance sets the rules and gives the path for people to pursue their livelihoods. It mediates between people in case of discords and between local context and external funding for poverty reduction, adaptation and climate change mitigation. As reviewed in chapter two of this thesis and by many authors (Adger et al., 2005b; Victoria and Renewal, 2010; Juhola et al., 2016; Schipper et al., 2021), governance in the context of climate change needs to be characterised by harmony and participation, justice and equity, efficiency and legitimacy to participate in resolving conflicts, poverty and inequalities between individuals and group. In this section, the study selected the variable related to governance to see how it relates to conflicts in the context of Niger. This variable is proxied by the resolution status of the conflict.

Finally, biophysical cognitive characteristics have been considered in this setting. The biophysical characteristics are perceived –or not– increased temperature, decrease in precipitation, perceived more frequent droughts and more frequent floods. These variables will help us assess how perception and education about climate change can affect discording behaviours between households.

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

#### **4.1. Analytical Data Description**

This section comprises the statistical description of all the data used in this thesis. First, it presents the results on survey data from the two regions of Niger. Second, a descriptive statistics on the ECVMA household panel data on the determinants and households' adaptation to climate shocks was presented. Third, the study described the ECVMA agricultural panel data used to assess the limits to adaptation through maladaptation and conflict.

##### **4.1.1. Survey Data Description**

Table 4.1 presents a description of the survey data collected in the specific context of this research. Most of our sampled households (84%) are from rural areas. Not only is agriculture the mainstay in the rural areas, but also, most poor people are located there and mostly exposed to the incidence of climate shocks. That segment of the population is also more sensitive to these changes as they individually lack resistance means such as—assets, institutional support, and solid social ties, and collectively, no access to markets, lack of government infrastructures like roads, hospitals, schools, and security.

The Table shows that only 19 of households are unaware of climate change. However, it is legitimate to interrogate the accuracy of the awareness of climate change, particularly in the rural area of Niger. Although farmers acknowledge the changes in the properties of the climate, they think that it is only a natural phenomenon and that they

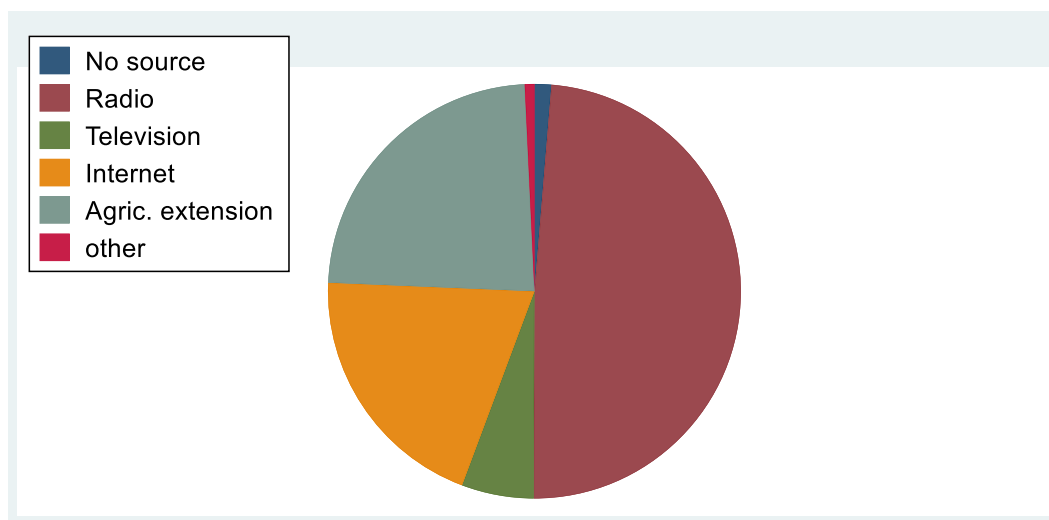
do not have anything to do to prevent their lives and assets from the emanating consequences. Despite the high climate awareness among the households, improving the understanding, particularly on the causes, actions, and adaptation options available to households to protect their lives, livelihoods and assets is necessary.

**Table 4.1: Measurement and description statistics of variables**

<b>Variable</b>	<b>Scales</b>	<b>Mean</b>	<b>SD</b>
<b>Dependent variable</b>			
Awareness of climate change	1= Yes	0.91	0.27
<b>Households' characteristics</b>			
Location	1= urban	0.16	0.37
Gender	1= Male	0.90	0.29
Age of the household head	Years	46.9	13.27
<b>Natural and physical characteristics</b>			
Household assets	Number	3.01	3.38
Household land size owned	hectares	0.71	0.73
<b>Perception of biophysical characteristics</b>			
Rainfall intensity	No change	0.06	0.95
	More rains	0.40	
	Fewer rains	0.53	
Rainfall distribution	No change even	0.32	0.53
	uneven	0.68	
Increased drought frequency	1= Yes	0.54	0.49
Increased flood frequency	1= Yes	0.37	0.48

**Source: Author construct, Fieldwork 2021**

Farm size owned by households determines awareness of climate change as it is positively relates to the technical, financial, and physical adaptation efforts. The smaller the land a household owns, the less effort it needs to deploy to protect its crops from adverse effects caused by climate change. The average land size is 0.71 hectares.



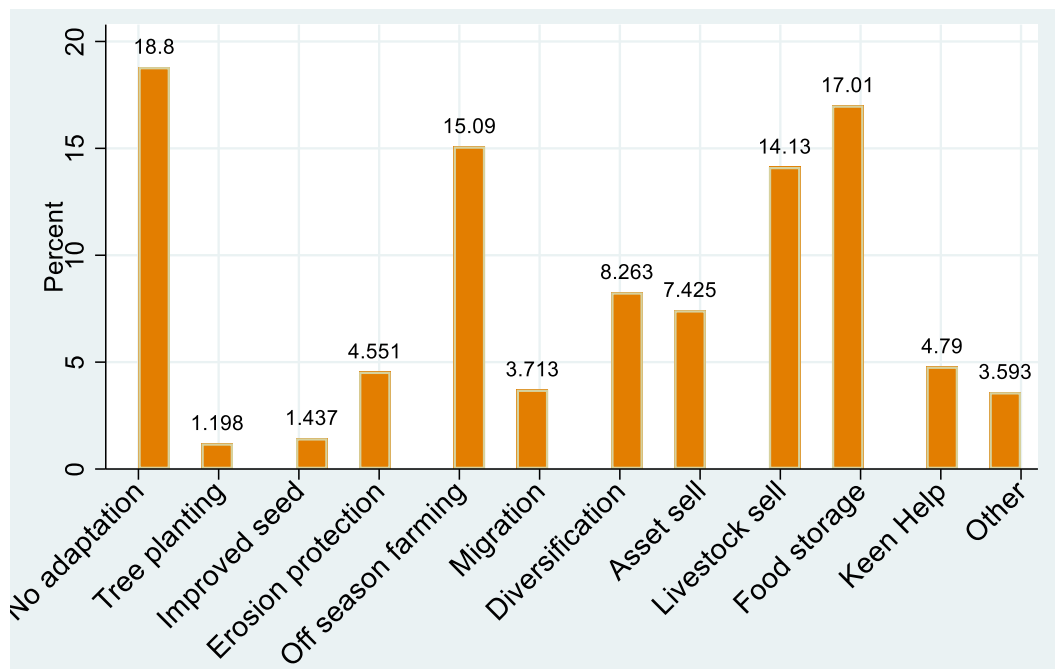
**Figure 4.1: distribution of households' sources of information**

**Source: Survey data, 2021**

It is expected that climate impact will widen farmers' understanding and awareness of climate change. From the result, 53% of the sampled households perceived a significant decrease in annual rain received, while 68% perceived uneven precipitation distribution throughout the year. Furthermore, 54% of the sampled households perceived more frequent droughts in recent years.

Information and communication technologies (ICTs) are instrumental in awareness raising through the broadcast of information and knowledge, weather forecasts, and climate impacts to the population. From the sampled households, almost half of them uses radio as the primary source of information, while the internet and television also have important proportions as households' sources of information. Adaptation to climate change is also closely linked to the awareness of climate change. Households unaware of climate change will see it as a loss to invest in three plantings, improved seed, and erosion protection to protect the crop from climate fluctuation and damage. Figure 4.2 presents the households' adaptation techniques distribution in the sampled regions. Most households use food storage (17%), off-season farming (15%), livestock sales (14.2%),

and livelihood diversification (8.3%) to spread the risk of livelihood failure due to climate change.

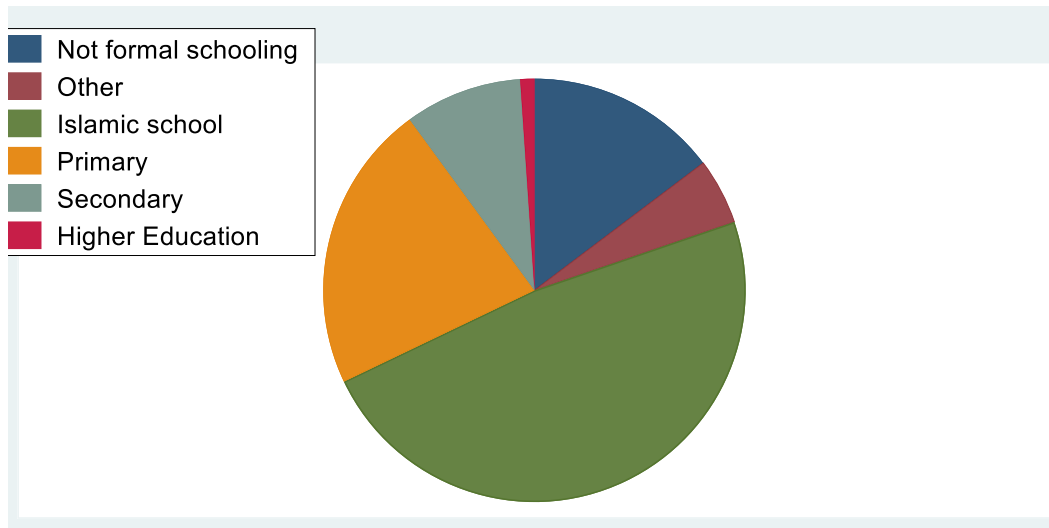


**Figure 4.2: Distribution of households' adaptation technics**

**Source:** Survey data, 2021

An important proportion of the sampled population (19%) adopted none of the adaptation options. That is an important signal in understanding the level of awareness and understanding of the climate among the population. The distribution of the education level of the sampled households is presented in Figure 4.3.

Almost 50% of the sampled population has informal schooling through Islamic curriculum, while a great proportion has primary and secondary levels of education. That urges the country's authorities to recover and regulate the informal education sectors to raise the country's gross enrolment rate significantly.



**Figure 4.3: Distribution of households' head schooling**

**Source:** Survey data, 2021

#### **4.1.2. ECVMA Households' data description**

The survey covers multiple topics on the households' living conditions and agriculture. Three questionnaires were administered during the ECVMA data collection, a household questionnaire, an agricultural questionnaire and a community questionnaire. The household questionnaire collected data on 3,968 households in 2011, throughout the country, 3,617 households in 2014 and 6,024 households in 2018. The study built a household panel of 20,323 observation for our seemingly unrelated regression analysis. The agricultural questionnaire is concerned with data collection on 6,664 agricultural plots in 2011, followed by 10,157 agricultural plots in 2014 and 13,719 agricultural plots in 2018. The study built an agricultural plot panel of 23,750 observations for our instrumental variable model. The community questionnaire was used to collect information on the visited communities. In this section, the study describe the household ECVMA data –used to assess the determinants of climate change adaptation– while in

the next section, the study describe the agricultural ECVMA data –used to evaluate the nexus between maladaptation and conflicts – of Niger.

Rural households store essential parts of harvested crops to prevent eventual hard times. Storage, mostly adopted by sedentary groups, is an important adaptation strategy that pools risks across time

**Table 4.2: Statistical description of households’ characteristics**

<b>Dependant variables</b>	<b>Scale</b>	<b>Mean</b>	<b>Standard error</b>
Food storage	% of harvest	0.64	39.28
Labour diversification	1=yes	3.71	0.18
Pastoralism	1=yes	1.39	0.11
<b>Human capital</b>			
Household head’s Age	year	46.10	14.53
Household size	Person	11.57	21.34
Household head’s gender	1=male	0.85	0.34
Household head’s schooling			
<b>Social capital</b>			
Agricultural cooperative	1=yes	0.67	0.47
Remittances	FCFA	133,586	372,738
<b>Financial capital</b>			
Access to credit	1=yes	0.56	0.49
<b>Physical capital</b>			
Access to internet	1=yes	0.41	0.49
<b>Natural capital</b>			
Livestock ownership	1=yes	0.45	0.49
Access to land	1=yes	0.84	0.36
<b>Climate shocks</b>			
Drought shock	1=yes	0.21	0.41
Flood shock	1=yes	0.05	0.22
<b>Market shocks</b>			
Input price shock	1=yes	0.03	0.16
Food price shock	1=yes	0.24	0.42

**Source: Author construct, ECVMA Household Panel data**

Pastoralism is animals’ mobility for grass and water. Adopted by nomadic groups, pastoralism pools risk across space. In our sample, households store, on average, 64% of their harvest for future households’ use, while less than 2% of the sample practiced pastoralism.

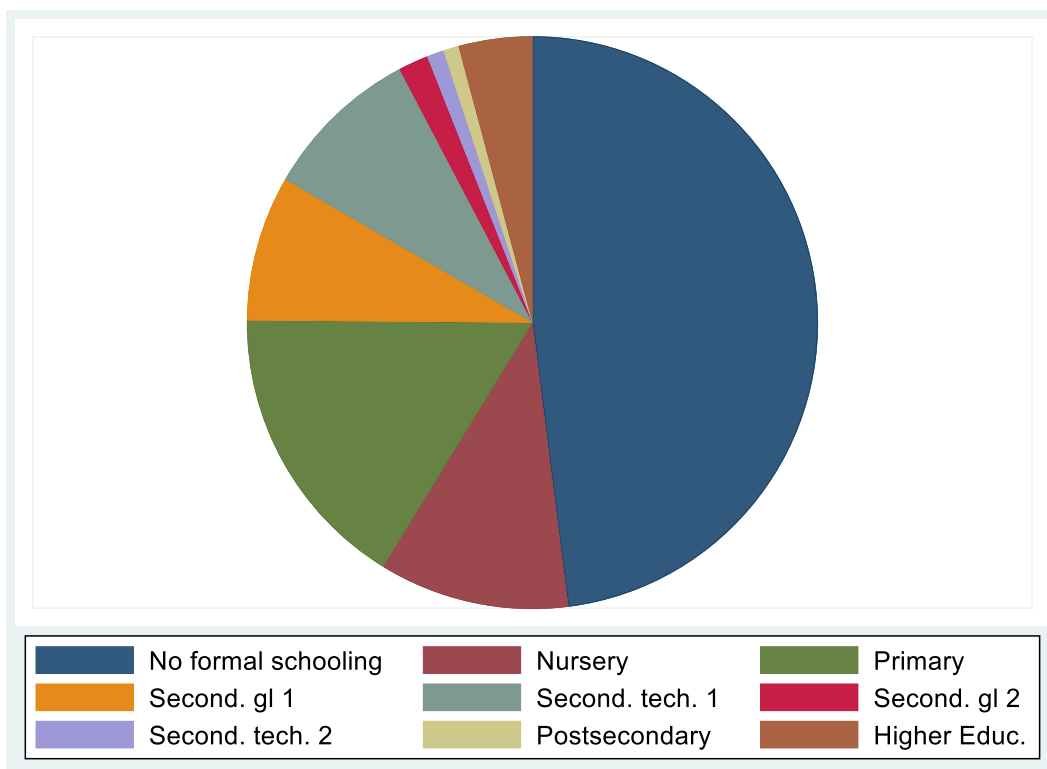
Labour diversification is the ability of the household's members to work off-farm (wage labour on other farms) or non-farm labour (small jobs) to reinforce the household's income. About 3.7% had access to labour diversification to mitigate risks.

Human capital is critical in deciding whether to adapt to shocks and uncertainties. While younger household heads are not averse to changing their livelihood portfolio to respond to the changing conditions of their environment, age can depict agricultural or heading experience for elder household's head which may motivate them to undertake livelihood adjustments to adapt to the new environment. The average age of the household head is 46 years, and 85% are male. The average household size is 12 people per household. In fact, in Niger, households are composed of extended families where children and grandchildren live under the authority of one head.

Social capital is highly developed in the rural Nigerien context. Households share labour and pasture and associate in agricultural cooperation to share good agricultural practices and prevent hardships. Almost 67% of the households are registered in agricultural cooperatives, while the average remittances received by the households is 133,586 FCFA (equivalent of 200 USD) to support local efforts of sustaining livelihoods. Agricultural credit is traditionally in cash. Like remittances, agricultural credit can finance agricultural input and labour and the acquisition of new technologies in modern agricultural development. However, to avoid the risk of insolvency, the financial entities prefer to give it in-kind as agricultural inputs like seeds, fertilizers, tractors, and other agricultural machines to help farmers improve their efficiency.

Access to the internet is important in facilitating households' access to information about agricultural technologies, climate forecasts and disaster risk reduction and management techniques. The rate of internet penetration is 41% in the sample. Households also rely

on livestock provision as a resistance means for times of hardship. In this sample, 45% rear livestock for diverse household use. The majority of the households have access to agricultural land, while 16% of the households do not have access to land. Questions have been asked about climate and market shocks for the year preceding the visit of the survey interviewers (2010, 2013, and 2017). From the sample, 21% of the households experience drought shock and 5% bear flood shock. As for input price shock, 3% of the households reported a shock due to an increase in the price of agricultural inputs, while 24% reported a shock due to high food prices.



**Figure 4.4: Distribution of household head's schooling in ECVMA dataset**

**Source:** ECVMA Household panel dataset

The level of schooling of the households' heads from the ECVMA household panel dataset is presented in Figure 4.4. The depicted image is that the no formal schooling modality includes about 50% of the population, followed by the primary level of schooling and Nursery. That supports the urgent need to raise the level of schooling,

especially by upgrading and formalising the informal Islamic schooling, which occupied about 70% of the no formal schooling modality, as presented in Figure 4.3 above.

#### **4.1.3. ECVMA Agricultural Plots Data Description**

The agricultural questionnaire is concerned with data collection on the agricultural plots owned by the households. As aforementioned in previous sections, institutional mechanisms fail to mediate properly between different professional and ethnic groups sharing agricultural land, water and pasture and involved in the process of climate change adaptation. Consequently, many discords are noticed in rural Niger in the process of climate change adaption, driving to violent conflicts. From the sample, 2% of the farmers had at least one conflict on their land plots. As discussed in the theoretical framework, maladaptation can have several forms, especially rebounding vulnerability in time, creating new vulnerability, and shifting vulnerability to other co-users of natural resources. This research tested the role of some of these maladaptation in magnifying social discords and conflicts in rural Niger. All the maladaptive practices tested in this thesis are drawn from the adaptation, institution and livelihood framework (AIL) and the five classes of adaptation storage, mobility, diversification, communal pooling and market exchange. They are also documented by many authors that studied pastoralism, adaptation, and conflicts (Snorek et al., 2014; Thébaud and Batterbury, 2001) in Niger.

In shifting vulnerability, while the crop residues serve as fodder to pastoralists and the transhumance animals during the dry season and after the land has been officially liberated, some farmers cut and store all these residues to feed their domestic animals, leaving the land without any utility to transhumant pastoralists, shifting their vulnerability to pastoralists. On average, 0.3% of the farmers cut and store crop residues

for domestic animal feeding. On the other hand, pastoralism is legally authorized on land for fodder and water when the crops are harvested, and the lands are officially liberated. However, around 17% of herders that reported adopting pastoralism move their animals onto agricultural lands before the harvesting period and the liberation of lands, with a high risk of crop damage and discords. Another shifting vulnerability to other users is the agricultural land expansion by farmers into the pastoral enclaves to counteract yield losses resulting from climatic variability and market price fluctuations (diversification).

**Table 4.3: statistical description of agricultural farm characteristics**

<b>Variables</b>	<b>Scale</b>	<b>Mean</b>	<b>Standard error</b>
<b>Conflict</b>	1=yes	0.02	0.14
Shifting vulnerability			
<b>Cutting crop residue</b>	1=yes	0.003	0.06
<b>Premature intrusion into agric. lands</b>	1=yes	0.17	0.37
<b>Land expansion into pastoral enclaves</b>	1=yes	0.12	0.32
Rebounding vulnerability			
<b>Pay in public fountains to water animals</b>	1=yes	0.02	0.12
Control variables			
Governance	1=conflict resolved	0.77	0.42
<b>Drought shocks</b>	1=yes	0.21	0.41
<b>Rainfall shock</b>	1=yes	0.05	0.22
<b>Transhumance</b>	1=yes	0.02	0.11
<b>Local-level governance (institutions)</b>	1=conflict resolved	0.77	0.42

**Source:** author construct, ECVMA agricultural panel data

In doing so, farmers reduce herders' adaptive capacity by limiting herds' mobility. The proportion of 12% of the sampled households mentioned expanding their agricultural lands into pastoral enclaves to increase yields. In the second category of maladaptation, rebounding vulnerability consists of unintentionally postponing an existing vulnerability to a later period without proposing an effective solution. In our case, that consists of

herders being required to pay before watering their animals at public fountains, where each user must have free access (market exchange). That reduces their adaptive capacity since, in a longer timeframe, it is unsustainable and will expose herders to greater vulnerability. An average of 2% of the herders report paying at public fountains to water their cattle.

As control variables, the study takes pastoralism, where pastoralists are asked whether or not the cattle are moved to a certain distance to seek water and fodder. An average of 2% of the herders drove their animals into pastoralism. In the end, the study tested the efficiency of the institutional governance by seeing whether the conflict was resolved by a local institution and how best it was resolved. Only 77% of the conflicts were resolved, and 33% are still rampant.

## **4.2. Results and Discussion**

The results of this research are presented in this section. Our contribution to this research consists of analysing, in a first essay, the link between climate change awareness and specific households and farm characteristics, including education and perceived biophysical characteristics of the Nigerien context. In a second essay, the study tested the role of human, social, financial, physical, and natural capital, along with climate and market shocks, to determine adaptation to climate change. Five classes of adaptation were identified by climate change literature: food, water, feed storage; animals and humans mobility; income, crop, and labour diversification; pasture, food, feed, labour communal pooling and market exchange. In this thesis and for econometric constraints due to the very long running time of the model before converging, and the unavailability of all the dependant variables in the dataset, the study estimated only food storage, Labour diversification and animal mobility as adaptation strategies. Finally, in

a third assay, the study investigate the limits to adaptation by evaluating the nexus between maladaptation to climate change and the increasing conflicts due to scarce natural resources in the Nigerien context.

#### **4.2.1. Factors Influencing Household's Awareness to Climate Change**

The result of the binary logit for the determinants of the farmers' cognitive process of climate change awareness is presented in Table 4.4. The model is well fit as the Pseudo R<sup>2</sup> of the estimation is 0.3101, and the probability of correctly classified cases is 93.41%. The wald chi<sup>2</sup> (261.27) is also significant at 1%.

Accordingly to the theoretical predictions, the level of schooling does not fundamentally influence climate change awareness of the household head rather influenced by social, physical and environmental interactions and experiences by the households in their farming activities.

Studying the drivers of livelihood diversification in the context of climate and price shocks in Niger, Asfaw et al. (2018) found that schooling does not significantly determine diversification. In our case, the household heads' schooling level is insignificant in explaining climate change awareness. To be more explicit about the role of education in the awareness of climate change, the study decided to split the variable into several modalities in our model. That allowed us to see that only higher education can significantly determine climate change awareness. The higher education level increases the probability of being aware of climate change by 7% (see marginal effects of the estimation). That can be explained by the fact that environmental and climate change education has been included in the curricula of the primary and secondary education of Niger as recently as 2015 and that the impact is still ineffective.

**Table 4.4: Determinants of awareness of climate change (Logit regression)**

<b>Dependent variable</b>		Awareness of climate change	
<b>Explanatory variables</b>		<b>Coefficients</b>	<b>Marginal effects</b>
<b>HH characteristics</b>			
Localisation		- 0.54 (0.4637)	0.03 (0.0262)
		1.60***	0.09***
GENDER (1=male)		(0.4297)	(0.0239)
ICT/ climate information		2.18*** ( 0.4621)	0.12*** (0.0215)
<b>SCHOOLING (Basis=no formal schooling)</b>			
<b>1</b>		- 0.54 (0.3978)	- 0.3 (0.0211)
	Islamic school		
<b>2</b>		0.53 (0.5350)	0.02 (0.221)
	Primary		
<b>3</b>		0.32 (1.0793)	0.01 (0.0443)
	Secondary		
<b>4</b>		12.59*** (1.7741)	0.07*** (0.0164)
	Higher education		
<b>5</b>		- 0.19 (1.0661)	- 0.09 (0.0674)
	Other		
<b>Natural and physical characteristics</b>			
HH assets		- 0.15*** (0.0391)	- 0.008*** (0.0022)
HH land size owned		0.27 (0.3983)	0.02 (0.0223)
Adaptation to climate change		0.16*** (0.0484)	0.009*** (0.0026)
<b>Perception of biophysical characteristics</b>			
		- 0.77*** (0.2372)	- 0.04*** (0.0120)
Rainfall intensity			
More frequent droughts		0.68* (0.3755)	0.03* (0.0208)
More frequent floods		0.20 (0.3284)	0.01 (0.0181)
		0.68* (0.3863)	0.03* (0.0209)
Rainfall distribution			
Constant		-5.41*** (1.2394)	0.09 (0.0080)
Number of observations: 835			
Wald chi2 (17) =		261.27	Pseudo R-square = 0.3101
Prob. > F =		0.0000	Correctly classified cases = 93.41%

**Level of significance:** \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1; **NB:** Robust standard errors in parenthesis

Environmental information –social interactions– has a strong and significant effect on the households' awareness of climate change, as reported by its coefficients in table 4.4. Owning a TIC (radio, television) increases the probability of the households' awareness by 12%. A similar result is obtained by Teodoro et al. (2021), quantifying the stakeholder learning process in adaptation, Mustafa et al. (2019) in the context of the determinants of climate change awareness in Pakistan, and Ado et al. (2019) in the same context of the assessment of the level of awareness and adaptation in Niger.

A household headed by a man has a probability of 9% higher of being aware of climate change than a female head household. Households' adaptive action is associated with an increased probability of awareness of climate change. This result is confirmed by the work of Ado et al. (2019) in the context of Niger and Teodoro et al. (2021) assessing the effects of social networks on climate change perception.

Households' assets have a negative and significant association with the awareness of climate change. The more asset the household owns, the lower its probability of being aware of climate change. The reason may be that assets represent wealth and shocks resistance mean. The richer a household is, the less concerned it is about climate shocks and the less aware of climate change. Asset ownership decreases the probability of being aware of climate change by 0.8%.

Households' perception of climate extremes is instrumental in shaping their awareness of climate change. In this thesis, four variables were selected depicting the perception of the household in association with its awareness. Households who perceive no change or an increase in the yearly amount of rain are associated with a lower probability of being aware of climate change than their counterpart who perceive a decrease in the annual amount of rainfall received. In the same trend, households who perceive more

frequent droughts than before are more likely to be aware of climate change than those who think differently. That is because drought is one of the major changes observed, especially in the Sahelian region, because of the increase in the temperature over the region. That made west Africa and other African regions chronically food deficient. An unexpected result is obtained about the distribution of rain, where households who perceive a bad rainfall distribution are associated with a lower probability of being aware of climate change than those perceiving no change or a better distribution of the rain throughout the growing period in their area. Many authors (Mitter et al., 2019; Nguyen et al., 2016; Teodoro et al., 2021) studying the interplay between the perception of biophysical events and the –cognitive learning–awareness of climate change have presented the same findings.

Characteristics like being a rural or urban household and the perception of more frequent floods do not significantly determine the household's awareness of climate change in the context of our sampled households.

#### **4.2.2. Drivers of Adaptation to Climate Change**

In this section, food storage, Labour diversification, and pastoralism representing selected households' risk adaptation strategies were tested on the households' characteristics, assets and shocks. It is essential to understand that opportunities for off-farm activities are very limited in rural areas of developing countries and consist of smithing, carpentry, small trade or sending family members into rural exodus or migration. That may explain the negative impact of the social capital on storage and labour diversification in our estimate, with remittances as an alternate source of income and agricultural cooperatives as social security nets mediating external funding and assistance to facilitate adaptation to various shocks. Similar results are presented by

(Wolf et al., 2010), where people's reliance on social networks and government intervention divert their preventive majors and hinder their adaptive capacity against heat waves in the United Kingdom. Pastoralists and herders – especially agro-pastoralists – diversify labour by engaging some household members to gather and drive other household animals into the bush for grazing, against weekly payment in kind or cash. That allows the household to cope with droughts and livestock loss.

The first striking outcome is the role played by climate and market shocks in incentivizing households' adaptation. Drought shock significantly incentivizes food storage, labour diversification and pastoralism to cope with the contingency with a very slow rate of destocking supported by the income generated off-farm and prevent the post drought crop failure, livestock loss, and food and feed scarcity. The size of the impacts is large, witnessing how rural households concomitantly use labour diversification, food storage and pastoralism as coping mechanisms and adaptation to climate anomalies in the mid and long run. This hypothesis is as much confirmed as the effect of abundant annual rain in our estimates significantly discourages all three adaptation technics. A good year of rain in Niger is synonymous with a perceived abundant harvest where households have enough food and sell proportions to face social events and other households' needs, discouraging ex-post labour diversification. The percentage of the stored food is then drastically and proportionally reduced. The same applies to pastoralism, where a good year of rain comes with abundant grass, feed and water and saves pastoralists from running long distances to nourish animals. Similar results are obtained by Asfaw et al. (2018) for the drivers of livelihood diversification in the same case of Niger and by Asfaw et al. (2019) for the west African cross-country analysis of the drivers of livelihood diversification.

Market shock is also an essential trigger of climate change adaptation. Market shock may be simulated by an ex-post climate change crisis resulting from food shortages and dependence on the global agricultural input value chains (Aker, 2010). Input price shocks trigger food storage and labour diversification to protect the stored food against ex-post harvest contraction due to market fluctuation and rely on off-farm labour to cope with the purchasing power loss. It also triggers pastoralism, especially for agro-pastoralists, who can rely more on developing animal protein in the midterm to compensate for agricultural harvest loss. The same applies to food price shock that drives households to adapt and mitigate ex-post risk by protecting the stored food from destocking and allocating their marginal time to off-farm labour to cope with the short-run income loss generated by the food market fluctuation.

Human capital has an important role to play in adapting to climate change. Human capital is essential in transforming households' physical assets and capabilities into adaptive capacities. While education can enhance farmers' understanding of environmental issues, age is assimilated into the farming experience and thus helps the household head's understanding of the stake behind adjusting the household's livelihoods to the changing environment. It is observed that female-headed, elderly headed and not formally schooled-headed households are positively correlated with food storage and negatively correlated with labour diversification and pastoralism. That implies that all the vulnerable and disadvantaged groups – female, elderly, and not formally schooled – rely on food storage. That is more stable and less risky but with less return compared to ex-ante preparedness, coping mechanism and adaptation to climate shock, as they have fewer opportunities than their male, young and schooled-headed counterparts. On the other hand, household size is negatively correlated with food storage and favours labour diversification and pastoralism. That is an expected result

since households with a big size will find it more difficult to store their food for longer, while the size can allow the household to send some members into pastoralism or to off-farm activities and keep others on the farm.

Similarly to social networks, Access to credit – financial capital – improves climate change adaptation by providing households with funding to finance the acquisition of agricultural inputs and technology. The same applies to our estimates, where credit allows households to improve their agricultural yield and consequently have more ability to store a more significant proportion of their harvest to prevent disastrous situations due to shocks. It also incentivises labour diversification to provide resources for credit payment and save the agricultural output from paying the agricultural credit. Financial capital, especially access to credit, is inconvenient with nomadic adaptation strategies since a stable home is required as a guarantee for the financial institution. However, credit is convenient with agro-pastoralists and reduces their probability of engaging in pastoralism. Thus, nomadic households who had access to credit are less likely to have pastoral activities, probably because they may invest such credits into crop production for higher income. Access to the internet incentivise both pastoralism and labour diversification in our estimates. It is a strong and cheap way of accessing media and information. That allows households to be informed about the available labour opportunities, new developments in agricultural technology, climate forecasts and market prices. It also informs herders of the official liberation of land for pastoralism and the quantity and quality of pasture down to their destinations. The effect is, however, very small for both the adaptation strategies and is even negative for food storage as a coping mechanism to shocks households who had access to internet would less likely store food, but diversified their labour and engage in pastoral activities.

**Table 4.5: Drivers of climate change adaptation (SUR regression)**

N : 20,323 households	Dependent variables		
	Storage	Pastoralism	Labour diversification
Explanatory variables	Coefficient	Coefficient	Coefficient
<b>Human capital</b>			
Household head's Age	0.1400*** (0.0016)	- 0.0405*** (0.0169)	- 0.0223*** (0.0061)
Household head's schooling	3.0420*** (0.0257)	- 1.5495*** (0.2659)	- 0.7431*** (0.0971)
Household size	- 0.6366*** (0.0087)	0.5879*** (0.0788)	0.2920*** (0.0315)
Household head's gender (ref. Is no formal schooling)	0.7705*** (0.0226)	- 5.0322*** (0.2369)	-2.5808*** (0.0858)
<b>Social capital</b>			
Agricultural cooperative	- 0.0009*** (0.0000)		- 0.0001*** (0.0000)
Remittances	- 0.0015*** (0.0000)		- 0.0003* (0.0001)
<b>Financial capital</b>			
Access to credit	4.5703*** (0.0294)	- 1.2339*** (0.1173)	0.1047 (0.0789)
<b>Physical capital</b>			
Access to internet	- 0.0004*** (0.0000)	0.0012*** (0.0002)	0.0006*** (0.0000)
Livestock grazing facilities		- 0.2671*** (0.0199)	
<b>Natural capital</b>			
Livestock ownership	0.1028*** (0.0014)		- 0.0917*** (0.0042)
Access to land	- 0.0040*** (0.0000)	- 0.0022*** (0.0000)	- 0.0015*** (0.0000)
<b>Climate shocks</b>			
Drought shock	9.2024*** (0.0706)	0.2329*** (0.0089)	0.1592*** (0.0055)
Abundant annual rain	- 3.2800*** (0.0129)	- 3.4797*** (0.1328)	-1.5258*** (0.0429)
<b>Market shocks</b>			
Input price shock	32.7927*** (0.1301)	34.8186*** (1.3304)	15.2688*** (0.4305)
Food price shock	0.6523*** (0.0520)	0.5986 (0.5411)	0.3736* (0.1969)

**Level of significance:** \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1 **NB:** standard errors are in parenthesis

Households with elaborate livestock facilities –physical capital– will find it more challenging to move to other places in search of water and pasture. That applies to our estimates as livestock grazing facilities like shelters significantly deter pastoralism.

Finally, livestock ownership by farmers promotes food storage and discourages labour diversification, while access to land demotes all three adaptation technics. Animal traction is mostly privileged by smallholder farmers, especially in rural Niger, because of their low-income level and lack of access to modern agricultural technologies. Poor households also use livestock as backup assets to sell in case of shocks and sustain household livelihoods. It thus reduces the households' vulnerability and comfort adaptation to climate change.

#### **4.2.3. Welfare Effects of Climate Change Adaptation**

As a consequence of climate change adaptation, there is an important welfare effect that households draw on their livelihoods. To capture that effect, the study developed four quintiles of the welfare indicator presented in (section 3.4.) and estimated these effects on different social layers of the sampled population from the poorest to the richest ( $q = \{0.2; 0.4; 0.6; 0.8\}$ ). the model is estimated using the quintile *qreg2* STATA command (Machado et al., 2011).

The objective is to see how the adaptation options affect the welfare of the households. In our case, food storage, labour diversification and pastoralism as adaptation strategies have significant and heterogeneous welfare effects on households across social layers. Table 4.6 presents these effects for the three adaptation options, while the full regression table is shown in the appendix. Although all the social layers benefit from the adaptation strategies –except the wealthiest class for pastoralism and the two wealthiest classes for labour diversification– the storage is more pro-rich and endowed. In contrast,

pastoralism and labour diversification are more pro-poor and middle-class adaptive options. Table 4.6 shows that the effect of storage is positive for all the welfare classes, but the magnitude of the effect is higher for the rich and lower for the poor. That is an expected outcome since storage as an adaptation to shocks needs not only upstream production but also enough production to go through the entire lean period and withstand shocks. That is not the case for the agricultural output of the smallholder agricultural households of Niger, which lasts four months for an average household and is lower than that for a significant proportion of low-income families (Dan-Baki et al., 2019). As observed in the previous section, despite its low return for poor groups, storage is used by vulnerable and disadvantaged groups to the detriment of higher return labour diversification and pastoralism due to their social status.

On the other hand, pastoralism's welfare effect decreases as the quintile class increase. This effect is three (3) times ( $1.90/0.62$ ) greater for the poorest class compared to that of the second wealthiest class (60%), while the effect is not significant for the wealthiest class of the quintile. Pastoralism benefits the most vulnerable households in Niger. That is because cattle constitute a vital component of households' dietary supply, especially for the most vulnerable households in Niger. In the deepest rural areas, where the currency is poorly penetrated, households eat directly from cattle meat and milk but also barter it against cereals, oil and other food staff.

Labour diversification has an important welfare effect to the households because it generate supplementary income to the household. The strategy benefit more poor households as the effect decreases with the increasing welfare class. That may be explained by the fact that due to the low level of schooling, the rural Nigerien context provided mostly unskilled labour and benefit more the poor classes.

**Table 4.6: welfare effects of climate change adaptation (quintile regression)**

Independent Variables	Quintiles of Welfare indicator (q)			
	20%	40%	60%	80%
Storage	0.0027*** (0.0005)	0.0037*** (0.0005)	0.0049*** (0.0005)	0.0051*** (0.0004)
Pastoralism	1.9864** (0.2655)	1.0336*** (0.2459)	0.7772*** (0.1847)	0.0696 (0.1327)
Labour Diversification	0.1182*** (0.0378)	0.2100* (0.1136)	- 0.2044* (0.1156)	- 0.0018 (0.1177)

**Level of significance:** \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1; **NB:** standard errors are in parenthesis

This strategy prevents the household from food destocking and provides the household with remittances to prepare for the next agricultural season. The insignificant effect of the diversification to the richest welfare classes is due to the kind of labour supplied in the context of rural areas. As mentioned in the previous section, rural households provide force demanding unskilled labour and may not apply to the richest groups as an adaptation technic.

By improving access to quality pasture and water, herds' mobility enhances the quantity and quality of milk and meat supplied by the herds, thus improving the welfare outcome of the more vulnerable households.

#### **4.2.4. Constraints to Adaptation, Maladaptation and Conflicts in Rural Niger**

Adaptation can be constrained by certain local practices intended to provide welfare gains, but that fail to do so and, most of the time, negatively affect the livelihoods of other individuals in the same environment. These are described as local practices maladaptation (Antwi-Agyei et al., 2018; Barnett and O'Neill, 2010; Juhola et al., 2016; Magnan et al., 2016), and these can trigger discords and conflicts between groups in the rural setting. Conflict is a common plague for Niger, with sometimes a transnational

configuration. Magnified by weak governance, conflicts in this region takes multiple forms such as religious, intercommunity or inter-profession and often leads to political unrest and unconstitutional changes of governments. In the context of this thesis, the study analyse the effect of maladaptation to climate change on conflicts occurrence between herders themselves and farmers using instrumental variable method. Only the second-stage regression is reported in this section.

The outcome of this analysis is presented in Table 4.7. Three tests are performed to investigate the fitness of the model and the validity of the obtained coefficient. The first test consists of testing the null hypothesis that all the coefficients are equal to zero and that the instruments are weak. Three test statistics are reported for this category. All the statistics are significant at the 1% level, meaning the null hypothesis is rejected, hence, the instruments are robust. The second test is the Sargan over-identification restrictions (Sargan, 1958). The joint null hypothesis of this test is that the instruments used in the regression are valid and not correlated with the terms of error. That means the excluded instruments are correctly excluded from the estimation. The p-value of the test is not significant –greater than 10%– meaning that the study cannot reject the null hypothesis, confirming the validity of our instruments (Hayashi, 2000). Finally, we tested the under-identification of the equation using the Anderson Canon under-identification test. The null hypothesis of this test is that our equation is under-identified. The p-value of the test is significant, meaning the study cannot accept  $H_0$ . The equation is not under-identified.

The first result in this estimation is the role of local governance in magnifying/minifying conflicts in Niger. Governance is meant to create rules and regulation and set punishments for anyone who break these rules. Governance is also meant to mediate

between people and has the monopoly on legitimate violence. However, in the case of rural Niger, due to corruption, governance rather magnifies conflicts between communities (McGuirk and Nunn, 2021; Snorek et al., 2014; Thébaud et al., 2001). In fact, in our estimates, the coefficient of local governance is positive and significant with conflict. That means the way conflicts are handled by local governance magnifies the discords between groups rather than solving them. Conflicts a feedback on the social context prevailing and the governance that accompanies that situation. When conflict resolution mechanisms are non-existent or tainted by low accountability and corruption, the conflict will be the alternative way to call for change in the institutional mechanism (Barnett and Adger, 2007).

The climate variables per se significantly mitigate conflicts in Niger. Drought shocks and abundant rainfall negatively affect social discords and conflicts. Climate variables do not induce conflicts but change the conditions of access to and use of the resources, making the competition rough between different groups (Snorek et al., 2014).

As mentioned, two categories of maladaptation, rebounding vulnerability and shifting vulnerability to others, are tested in this essay for their triggering effects on conflicts. In the category of shifting vulnerability, while as a control variable, Pastoralism significantly reduces conflicts between groups, premature herd mobility –animal movement inland before land liberation– has a reputation for triggering conflicts because of the increasing risk of crop damage by cattle.

Pastoralists make the farmers worst off by grabbing the croplands while passing a large amount of animals. Farmers can also make herders worse off by expanding the lands into pastoral enclaves (diversification) –farming the surroundings of the walls, fountains, and animal corridors– essential for herders to increase their adaptive capacity.

**Table 4.7: Maladaptation and determinants of conflicts (instrumental variable model)**

<b>Variables</b>	<b>Coefficient</b>	<b>Standard error</b>
<b>Shifting vulnerability</b>		
Cutting and storing crop residue (STORAGE)	0.00*	0.00
Animal premature transhumance (MOBILITY)	0.01***	0.00
Land expansion into pastoral enclaves (DIVERSIFICATION)	0.33*	0.77
<b>Rebounding vulnerability</b>		
Pay in public fountains to water animals (MARKET EXCHANGE)	1.58***	0.52
<b>Control variables</b>		
Local-level governance (institutions)	0.12***	0.00
Drought shocks	- 0.06***	0.00
Rainfall shock	- 0.05***	0.00
Livestock	0.88***	0.00
Transhumance	- 0.05***	0.00
Robust inference for weak instrument tests of the significance of the endogenous repressors $B_i$		
$H_0: B_i = 0$		
<b>Anderson-Rubin Wald test</b>	<b>F(10,16384)= 67.76</b>	
<b>P-value=0.0000</b>		
<b>Anderson-Rubin Wald test</b>	<b>Chi-square (10)= 638.14</b>	
<b>P-value=0.0000</b>		
<b>Stock-Wright LM S statistic</b>	<b>Chi-square (10)= 614.24</b>	
<b>P-value=0.0000</b>		
Anderson Canon under identification test		
$H_0: \text{The equation is under-identified}$		
<b>Anderson canon. corr. LM statistic :</b>	<b>22.955</b>	
<b>Chi-square (7) P-value</b>	<b>= 0.0017</b>	
Sargan test of over-identification restrictions of all instruments		
$H_0: \text{Over-identification restrictions are valid}$		
<b>Sargan test statistic :</b>	<b>8.767</b>	
<b>Chi-square (6) P-value</b>	<b>= 0.1871</b>	

**Level of significance:** \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1

Land expansion in our essay has a positive and significant effect on the conflicts. That because farmers use to diversify and expand their land into pastoral enclaves and restrict the mobility of herders which sustain pastoral livelihoods. Another type of maladaptation is cutting and storing crop residues to feed local animals. Pastoralists and

some domestic animal breeders rely on crop residues on land to feed their animals, especially during droughts when the pasture is dried up or unavailable. However, farmers have started rearing heads of animals to take precautions about shocks.

To feed these animals, farmers cut and store the crop residues, despite official prohibition, as stated in our first chapter, making herders worst-off. As maladaptation, cutting and storing crop residues positively affects conflict in the sampled regions. Rebounding vulnerability consists of households or states taking majors to adapt to climate change, but these majors postpone the vulnerability of that household. That is the case in Niger, where due to some reasons –non-membership to the hosting community, a conflicting situation with community members, and animal diseases– the process of watering animals passes by the market mechanisms. Herders are brought to pay very high to water their animals in rural economies where the usage of money is very scarce. As maladaptation to changes, this situation is found to have positive and significant effects on conflicts between farmers and herders in Niger.

#### **4.2.1. Limits of the Study**

Similarly to any scientific work, certain limits of the study are to be highlighted for future studies to take them into account and improve the significance of the study results for better implementation of the climate change policy for smallholder rural households.

- The first limit of this study is our incapability to consider all the five classes of adaptation –as theorised by the AIL framework– as dependent variables of our model of the determinants of adaptation to climate change; the study instead considered only three classes of adaptation –storage, diversification and mobility– due to the availability of the dependant variables in the secondary data, and challenging convergence issues of the model.

- Furthermore, although our dataset allows us to have richer information about the portfolio of adaptation techniques and assets compared to cross-sectional analysis, it is limited to only three cohorts with a vast individual dimension. That contributes to our first limitation that the econometric SUR model can't function well and support more adaptation options as dependent variables. However, in collaboration with the World Bank, the national institute of statistics of Niger is working on producing more cohorts of the EHCVMA dataset, starting with the cohort 2022, that the study will not have the opportunity to integrate.
- Finally, the absence of certain variables that are determinants for our research in the ECVMA dataset. That has been one of the reasons that the study failed to use an integrated unique dataset throughout the research objectives.

These limits mentioned above are not exhaustive, but are some of the many constraints faced during this journey. More limits of this study can be highlighted and integrated to improve the quality of similar research projects.

## CHAPTER FIVE

### SUMMARY, CONCLUSION, AND RECOMMENDATIONS

#### 5.1. Summary

Rural Niger has a vital role in the country's food security in a context of rampant demography and a climate crisis that create chronic food deficit in the Sahel and trigger a conflicting coexistence between rural communities. The international legal frameworks on climate change identify sub-Saharan Africa and the Sahel as a region that is highly exposed to the impact of climate change. These impacts will hamper the efforts the national and international communities consented to combat poverty. This research tested the question, how does climate change adaptation contribute to determining sustainable rural livelihoods in rural Niger, where poverty is relatively high?

In responding to that question, the study first assess the level and determinants of the awareness of climate change in Niger. For that purpose, the study surveyed two pastoral and agricultural regions of Niger, identified in the north by Tahoua and in the south by Maradi, from May to August 2021. The sample size was 835 households, and a logit model accompanied by descriptive statistics was used to analyse the data. In the second move, the study evaluated the drivers and welfare effects of climate change adaptation in rural areas. This study adopted the secondary data of the survey on the households' living conditions and agriculture (ECVMA). The survey was constituted into two separate datasets, a household data set and an agriculture and plots data set, with three cohorts (2011-2012; 2014-2015 and 2018-2019) that the study constituted into panels, a

household panel and an agriculture and plots panel. In this second assessment, this study used the household panel dataset with a seemingly unrelated regression model to assess a mix of adaptive household strategies. In a final assessment, the study evaluated how adaptation, compounded by a lack of monitoring and weak local governance, can turn into maladaptive outcomes and trigger conflicts between rural communities. The agriculture and plots panel ECVMA dataset was constituted and adopted with an instrumental variable model for this analysis.

The results show that only higher education among educational levels can significantly determine climate change awareness. The sources of information in the household also significantly impact environmental education. The analysis of the awareness of climate change concerning gender shows that men have more probability of being aware of climate change than women. Finally, the perception of biophysical characteristics of the environment determines the climate awareness of households.

Climate anomalies and market fluctuations highly incentivise adaptation through labour diversification, food storage and pastoralism. Agriculture being sensitive to the amount of rain in the Sahel, droughts trigger food storage and labour diversification to face ex-post crop failure. It also incentivises pastoralists to drive the herds towards the wetter south to prevent animal starvation and loss. The exact opposite effect is observed in the case of abundant annual rain for all three adaptation classes. Household members are not incentivised to diversify labour, and pastoralists have easier access to pasture and water.

Market food and input price fluctuation significantly determine rural households' adaptation. In the context of input and food price shocks, households anticipate a decreased agricultural output and rely on the ex-ante stored food to compensate for the

ex-post food shortage. That is also combined with labour diversification to compensate for the loss of the purchasing power of the household. Pastoralists and agro-pastoralists also adapt by compensating for the harvest loss with better animal protein and engaging family members in labour diversification through paid animal husbandry. All the adaptation options are positively correlated with the households' welfare.

The estimates highlight the limited capabilities of vulnerable and disadvantaged groups concerning climate change adaptation. The social status of women, the elderly and household heads with no formal schooling, characterised by limited access to assets and opportunities, drives them to settle for food storage. This adaptation strategy is less risky but with a far low return for poor households, as they cannot roam long distances with animals, are incapable of working for wages, or do not have the opportunity to do so.

Finally, our last estimations show that all four tested potential maladaptive strategies positively correlate with conflicts. Maladaptation essentially depicts how adaptation to climate change can shed light on the differentiated access to institutional mechanisms, assets and entitlements and limit the adaptive capacity of other groups. The outcome of that process will be either violence and conflicts or long-lasting cooperation that can hide rampant conflicts. Yet, three of the four strategies are legally prohibited by the rural code of Niger, as presented in the socio-environmental context of our study, which brings us back to the effective implementation of the rural code and pastoral code that reduces the adaptive capacity of groups and peaceful rural development through accountable governance.

## 5.1. Conclusion

This study concludes that there is important room for improvement about climate change adaptation in rural Niger. Rural households are found to be aware of climate change, although the understanding was very low and vary much between households. Many factors are found to the likelihood of awareness of climate change, including higher level education, climate information and the perception of biophysical characteristics by the households.

Important adaptation decisions are being made by households, including food storage, labour diversification, pastoralism and probably more other adaptive majors that are out of the scope of this research. The adaptation techniques tested in this research revealed to have important non-learn positive effects on the households' wellbeing.

However, this process of adaptation reveal also to be marred by important maladaptive processes that end up triggering conflicts between groups. These are illegal land expansion into pastoral enclaves, cutting and storing crop residues to feed animals, demanding payment for watering animals, and premature pastoralism into agricultural lands.

Interestingly, while the lawful inland roaming of the animals does not trigger conflicts, premature animal roaming increases the probability of conflicts between groups. In the end, the biophysical variations of the climate in all the study areas do not trigger conflicts per-se, rather compound an environment of high competition in a context of low governance to trigger conflicts. The latter is not but a signal of the malfunctions in the governance regime and an alternate way of calling for change.

## 5.2. Recommendations

Important policy implications can be drawn from our results for a lightened decision on climate change awareness, adaptation and conflicts between groups for sustainable rural livelihoods. That will be summarised in this section as follows:

The study recommend that the awareness raising about climate change must be integrated in the National policy on adaptation especially the National Adaptation Plan. Particular attention should be paid to households headed by women, as they are less likely to be aware of climate change due to limited access to information, opportunities and assets.

Food storage, pastoralism and labour diversification as adaptation strategies were revealed to have significant welfare effects, particularly in the country's rural areas. The government should modernise and develop the capacity of the traditional storage facilities used by the households to avoid perishability, as storage is the most important adaptation technic used by households.

Integrate these three (3) adaptation options documented in this thesis in the National adaptation Plan as households' adaptation techniques regarding climate and market shocks. Invest in pastoral livelihoods, which has been accorded little attention, including in the National Adaptation Programme of Action (NAPA) and the national adaptation Pan (NAPs). Particular attention needs to be placed on vulnerable and disadvantaged groups as leftovers in adaptation to climate change as they settle with low-risk but low-return adaptation technics.

Opt for more inclusiveness by associating other ministries in the evaluation of the needs, and elaboration of the NAPs, including the ministry of livestock and herding, the ministry of planning, NGOs and private sector and other relevant stakeholders.

Policy intervention in the rural area should consider rebuilding a solid and accountable governance regime based on equity, efficiency and inclusiveness for agriculture, land use, pastoralism and access to the commons to implement the existing policy mechanism through the rural code for both agriculture and pastoralism.

Increase the sensitisation of the stakeholders on their role to play in the process of building peace and promoting social values. That includes the actors involved in the conflicts themselves, the traditional rulers to whom the law has accorded essential responsibilities in resolving conflicts through customary, the National gendarmerie and the mixed comities for conflict resolution in the rural areas.

Ensure flexibility in the institutional mechanisms to conciliate the needs of agricultural and pastoral communities and build back from lessons learned from past mistakes. These institutions should promote –a collective–adaptation that builds the community’s social capital and trust between groups to eradicate discords and conflicts.

### **5.3. Contribution to Knowledge**

The contribution to knowledge about climate change education through this research is multi-fold and addresses both the households, local and central government’s roles on improving climate change adaptation. The study provides empirical knowledge of the cognitive –subjective– and objective process of households’ adaptation to climate change in rural Niger. It provides empirical knowledge on the level of awareness of climate change and what influences it in the country. It also highlighted how socio-cultural characteristics of the households and other covariate shocks like market shocks compound the vulnerability to climate shocks and the options and processes households go through to adapt to these shocks, protect their lives, and sustain their livelihoods. Finally, the study empirically demonstrated how certain adaptation practices

compounded by conflicting modes of governance, corruption and low accountability undermine the adaptive capacity of other groups –maladaptation– and lead to violent conflicts between groups and what is to be put in place to promote peaceful adaptation in the rural areas.

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## APPENDIX

### 3.4. Appendix One: Household survey questionnaire

#### Questionnaire Ménage

Q00.

/\_\_\_/\_\_\_/\_\_\_/

Q01. Région : 1. Tahoua 2. Maradi

/\_\_\_/

Q02. Village :

\_\_\_\_\_

Q03. Circonscription 1. Urbaine 0. Rural

/\_\_\_/

Q04. Non de l'enquêteur \_\_\_\_\_

N°	Questions/Modalités	Code
<b>S1</b>	<b>Ménage</b>	
	<b>Profil du chef du Ménage</b>	
Q1	Sexe du chef du ménage 0. Féminin 1. Masculin	/___/
Q2	Age du chef du ménage	/___/___/
Q3	Niveau d'instruction du chef du ménage 0. Aucun 1. Primaire 2. Secondaire 3. Supérieur 4. Autre_____	/___/
Q4	Etat matrimonial du chef du ménage 0. Célibataire 1. Marié 2. Séparé/divorcé 3. Autre_____	/___/
Q5	Quel est le nombre de personnes dans le ménage	/___/___/
Q6	Quel est le nombre de personnes actives du ménage	/___//___/
Q7	Quelle est l'activité principale du chef du ménage ? 0. Agriculture 1. Elevage 2. Autre _____	/___/
Q8	Le chef du ménage a-t-il une activité secondaire 0. Non 1. Oui	/___/
Q9	Si oui, laquelle ?	_____
Q10	Au cours des trois derniers mois, y a-t-il des membres du ménages qui sont parti en exode ? 0. Non 1. Oui	/___/
Q11	Si oui, Combien d'hommes et combien de femmes ?	Hommes /___//___/ Femmes /___//___/
Q12	Quelle est la raison principale de l'exode ? 0. Manque d'opportunités, 1. Diversification des revenus du ménage, 2. Faible rendements de l'agriculture, 3. Autre	/___/
Q	Quelles sont les destinations de l'exode ? 0. Tahoua, 1. Agadez, 2. Nigeria 3. Lybie, 4. Algérie 5. Autre	/___/

Q13	Combien de temps la première personne est restée en exode 0. 0-3 mois 1. 3-6 mois 2. 6 mois-un an 3. Plus d'un an	/___/
Q14	Combien de temps la deuxième personne est restée en exode 0. 0-3 mois 1. 3-6 mois 2. 6 mois-un an 3. Plus d'un an	/___/
Q15	Combien de temps la troisième personne est restée en exode 0. 0-3 mois 1. 3-6 mois 2. 6 mois-un an 3. Plus d'un an	/___/
Q16	Est-ce que les transferts font partie des revenus de votre ménage ?	
<b>Dépenses Alimentaires du ménages</b>		
Q17	Est-ce qu'il y a un marché dans le village ? 0. Non 1. Oui	
Q18	Si non, A quelle distance se trouve le marché le plus proche ? (Km)	
Q	Quel type de piste mène vers ce marché ? 0. Voie goudronnée, 1. Voie latéritique, 2. Piste sableuse 3. Autre	/___/
Q19	Pour les 30 derniers jours, avez-vous acheté les produits suivants :	<b>Montant</b>
Q19.a	Le Riz	
Q19.b	Le mil	
Q19.c	Le sorgho	
Q19.d	Le haricot	
Q20	Pendant les 7 jours passés, avez-vous acheté les produits suivants :	<b>Total :</b>
		<b>Montant</b>
Q20.a	Tourteaux d'arachide	
Q20.b	Soumbala (base d'oseille ou de niébé)	
Q20.c	Feuilles de Baobab	
Q20.d	Oignon, sel, piment, autres épices	
Q20.e	Tubercules	
Q20.f	Autres dépenses alimentaires	<b>Total :</b>

<b>Agriculture, élevage, écosystèmes</b>		
<b>Agriculture</b>		
Q21	Est-ce que le ménage ou l'un de ses membres possède une parcelle qu'il exploite pour l'agriculture ? 0. Non 1. Oui	/___/
Q22	Est-ce que le ménage ou l'un de ses membres exploite, pendant la contre saison précédente ou cette saison pluvieuse, un champ qui ne lui appartient pas ? 0. Non 1. Oui	/___/
Q23	Si Q14 ou Q15= OUI, Quelle est la superficie de la parcelle exploitée (hectares) ?	/___/___/
Q24	Quelles sont les spéculations que vous avez produites cette année ? 0. Mil 1. Sorgho, 2. Haricot 3. Arachide 4. Mil et haricot 5. Sorgho et haricot 6. Autre _____	/___/
Q25	Quelle quantité de semences avez-vous utilisé (kg)	/___/___/
Q26	Quelle quantité de fumure organique avez-vous utilisé ?	/___/

	0. Pas utilisé 1. Un sac 2. Un tas 3. Une charrette asine 4. Une Charrette bovine 5. Autre _____	
Q27	Quelle quantité d'urée avez-vous utilisé (kg) ? 0. Pas utilisé 1. Un sac de 50 kg 2. Une Tiya 3. Un Tas 4. Autre _____	/__/_/
Q28	Quelle quantité de NPK avez-vous utilisé (kg) ? 0. Pas utilisé 1. Un sac de 50 kg 2. Une Tiya 3. Un Tas 4. Autre _____	/__/_/
Q29	Quelle quantité de pesticide avez-vous utilisé (kg) ? 0. Pas utilisé 1. Deux litres 2. Un bidon de 4 Litres 3. Autre _____	/__/_/
Q30	Combien de personnes de la famille ont travaillé pour la préparation du sol sur cette parcelle ?	/__//__/_/
Q31	Pendant combien de jours cette main d'œuvre a-t-elle été employée ?	/__//__/_/
Q32	Avez-vous utilisé une main d'œuvre non familiale pour la préparation du sol sur cette parcelle ? 0. Non 1. Oui	/__/_/
Q33	Si oui, combien de personnes ?	/__//__/_/
Q34	Pendant combien de jours cette main d'œuvre a-t-elle été employée ?	/__//__/_/
Q35	Avez-vous bénéficié de travail collectif des villageois (Gayya) 0. Non 1. Oui	/__/_/
	Quelles est la quantité produite la dernière récolte ? (Sacs de 50 kg)	/__//__/_/
Q36	Avez-vous connu des pertes de production cette saison ? 0. Non 1. Non	/__/_/
Q37	Si oui, quelle en est la cause 0. Sècheresse 1. Inondations 2. Attaque d'insectes 3. Maladies des plantes 4. Autre _____	/__/_/
Q39	Pratiquez-vous de culture de contre saison ? 0. Non 1. Oui	/__/_/
Q31	Si oui, quelles sont les spéculations que vous avez produit la dernière saison ? 0. Tomate 2. Salade 3. Chou 4. Laitue 5. Combinaison de plusieurs spéculations	/__/_/
Q40	Etes-vous membre d'une coopérative agricole ? 0. Non 1. Oui	/__/_/
Q41	Avez-vous accès a la vulgarisation agricole ? 0. Non 1. Oui	/__/_/
Q42	Avez-vous bénéficié du crédit agricole ? 0. Non 1. Oui	/__/_/
Q	Avez-vous bénéficié de la subvention d'intrants de l'Etat ou des organismes ? 0. Non 1. Oui	/__/_/
<b>Elevage</b>		
Q43	Au cours des 12 derniers mois, le ménage a-t-il possédé des animaux ? 0. Non 1. Oui	/__/_/

Q44	Si oui, combien d'animaux	/__//__/
Q45	Au cours des 12 derniers mois, le ménage a-t-il élevé des animaux qui ne lui appartienne pas ? 0. Non 1. Oui	/__/
Q46	Si oui, combien d'animaux	/__//__/
Q47	Le ménage a-t-il confié des animaux a d'autres ménages ? 0. Non 1. Oui	/__/
Q48	Si oui, combien d'animaux	/__//__/
Q49	Où est ce que ces animaux sont abreuvés ? 0. Au puits local 1. A un point d'eau approximatif 2. Au forage 3. Autre_____	/__/
Q50	Les animaux sont-ils conduits en brousse pour le pâturage 0. Non 1. Oui	/__/
Q51	Quelle est l'état de la disponibilité du pâturage dans la région ? 0. Rare 1. Très rare 2. Disponible	/__/
Q52	Quelle est la qualité du pâturage dans la région ? 0. Très faible qualité 1. Faible qualité 2. Qualité moyenne 3. De bonne qualité	/__/
Q53	Avez-vous des couloirs de passage dans la région ? 0. Non 1. Oui	/__/
Q54	Avez-vous des espaces de pâturage ? 0. Non 1. Oui	/__/
Q55	Est-ce que la mobilité des animaux est possible 0. Non 1. Oui	/__/
Q56	Quelles sont les contraintes pour le déplacement des animaux 0. Rétrécissement des couloirs de passages, 1. Longues distances à parcourir, 2. Manque d'eau pour les animaux, 3. Autre_____	/__/
Q57	Avez-vous un puits dans le village ? 0. Non 1. Oui	/__/
<b>Ecosystèmes communs</b>		
Q58	Avez-vous un bien commun outre que le puits dans le village ? 0. Non 1. Oui	/__/
Q59	Si oui, lequel ? 0. Foret commue 1. Cours d'eau 2. Autre_____	/__/
Q60	Comment est t-Il géré ? 0. Non géré 1. Comite 2. Chef du village 3. Autre_____	/__/
Q61	Avez-vous une fois eu un conflit relatif à votre activités agricoles, d'élevage, d'accès à un bien commun ou à la terre ? 0. Non 1. Oui	/__/
Q62	Si oui, quelle est la cause du conflit ? 0. Limites de parcelles 1. Problème d'héritage 2. Problème de vente 3. Problème d'hypothèque 4. Problème avec les éleveurs 5. Autre	/__//__/
Q63	Comment le conflit aurait-il été réglé ?	/__/

	0. Chef du village/hakimi, 1. A l'amiable, 2. la gendarmerie, 3. La justice 4. Autre	
<b>Education et Changements climatiques</b>		
Q63	Connaissez-vous (avez-vous conscience) le changement climatique ? 0. Non 1. Oui	/___/
Q64	Si oui, où comment est-ce que vous avez appris à propos du changement climatique ? 0. Radio, 1. Télévision, 2. Coopérative, 3. Agents de vulgarisation agricole	
Q65	Autours des 5 dernières années, avez-vous observe les changements suivants ?	
Q66	Pluviométrie 0. Pas de changements 1. Moins de pluie 2. Plus de pluie	/___/
Q67	Répartition des pluies dans l'année 0. Pas de changements 1. Mauvaise répartition 2. Meilleure répartition de pluie	/___/
Q68	Sècheresses plus fréquentes 0. Non 1. Oui	/___/
Q69	Inondations plus fréquentes ? 0. Non 1. Oui	/___/
Q70	Retards dans le démarrage des saisons de pluie 0. Non 1. Oui	/___/
Q71	Saisons de pluies s'achèvent plutôt 0. Non 1. Oui	/___/
Q72	Périodes des grandes chaleurs 0. Pas de changements 1. Moins longues 2. Plus longues	/___/
Q73	Suite à ces changements, quelles sont les stratégies adoptées ? 0. Aucune technique 1. Plantation d'arbres 2. Semences améliorées 3. Protection contre l'érosion 4. Culture de contre saison 5. Migration des membres du ménage 6. Diversification des sources de revenu 7. Vendre certains actifs du ménage 8. Vendre les bétails 9. Stocker les céréales jusqu'à certaines périodes 10. Assistance de la famille et des proches 11. Autre_____	/___/
Q74	Quelles sont les sources de l'information du ménage ? 0. Aucune source d'information 1. Radio 2. Télévision 3. Internet _____ 4. Vulgarisation agricole 5. Autre _____	/___/
Q75	Autours des 2 ans passées, est ce que le chef du ménage ou l'un de ses membres a suivi une formation ou sensibilisation sur le changement climatiques ? 1. Non 1. Oui	/___/

Merci de votre collaboration

### 3.5. Appendix two: Welfare effects of climate change adaptation

WELFARE EFFECTS OF CLIMATE CHANGE ADAPTATION				
INDEPENDENT VARIABLES	Quintiles of Welfare indicator (q)			
	0.2	0.4	0.6	0.8
<b>CONSTANT</b>	-	-	-1.1194***	-
	0.9779**	1.1766**	(0.3074)	0.0437**
	*	*		*
	(0.2725)	(0.3094)		(0.2899)
<b>STORAGE</b>	0.0027**	0.0037**	0.0049***	0.0051**
	*	*	(0.0005)	*
	(0.0005)	(0.0005)		(0.0004)
<b>TRANSHUMANCE</b>	1.9864**	1.0336**	0.7772***	0.0696
	(0.2655)	*	(0.1847)	(0.1327)
		(0.2459)		
<b>LABOR DIVERSIFICATION</b>	0.1182**	0.2100*	- 0.2044*	- 0.0018
	*	(0.1136)	(0.1156)	(0.1177)
	(0.0378)			
<b>RESIDU_STORAGE</b>	0.0429**	0.0629**	0.0736***	0.0674**
	*	*	(0.0041)	*
	(0.0035)	(0.0036)		(0.0041)
<b>RESIDU_PASTORALISM</b>	-	0.1627**	-	-
	0.1273**	*	0.1635***	0.1428**
	*	(0.0211)	(0.0209)	*
	(0.0176)			(0.0174)
<b>RESIDU_DIVERSIFICATION</b>	0.1980**	0.2359**	0.21457**	0.1808**
	*	*	* (0.0458)	*
	(0.0389)	(0.0465)		(0.0374)
<b>HAGE</b>	0.0012	-	-	-
	(0.0014)	0.0027**	0.0060***	0.0075**
		(0.0013)	(0.0013)	*
				(0.0011)
<b>HEDUC</b>	0.1957**	0.0724**	- 0.0209	-
	*	*	(0.0231)	0.0759**
	(0.0173)	(0.0216)		*
				(0.0222)
<b>HSIZE</b>	-	-	-	-
	0.0934**	0.1031**	0.0826***	0.0516**
	*	*	(0.0073)	*
	(0.0073)	(0.0067)		(0.0073)
<b>SEXE</b>	-	-	-	-
	0.2042**	0.3034**	0.3087***	0.2674**
	*	*	(0.0471)	*
	.033945	(0.0351)		(0.0305)
<b>INTERNET</b>	0.0000**	0.0001**	0.0001***	0.0000**
	*	*	(0.0000)	*
	(0.0000)	(0.0000)		(0.0000)

<b>AGRIC_COOP</b>	0.0000** (0.0000)	0.0000** * (0.0000)	0.0000*** (0.0000)	0.0000** * (0.0000)
<b>ACCESS_CREDIT</b>	- 0.2231** * (0.0344)	- 0.3302** * (0.0400)	- 0.4210*** (0.0401)	- 0.3912** * (0.0354)
<b>REMITTANCE</b>	0.0006** * (0.0001)	0.0008** * (0.0002)	0.0009*** (0.0001)	0.0007** * (0.0000)
<b>ACCESS_LAND</b>	- 0.0000 (0.0000)	- 0.0000 (0.0001)	0.0003*** (0.0001)	0.0001 (0.0001)
<b>LEVEL OF SIGNIFICANCE ***P &lt; 0.01; **P &lt; 0.05; *P &lt; 0.1; NB: STANDARD ERRORS ARE IN PARENTHESIS</b>				

### 3.6. Appendix three: Awareness of climate change estimations

#### AWARENESS AND MARGINS ESTIMATIONS

```

Logistic regression                               Number of obs   =       835
                                                  Wald chi2(15)   =       261.27
                                                  Prob > chi2     =       0.0000
Log pseudolikelihood = -162.60781                Pseudo R2      =       0.3101
  
```

AWARENESS	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]
ADAPTATION	.1684661	.0484516	3.48	0.001	.0735028 .2634294
TIC	2.18247	.4321391	5.05	0.000	1.335493 3.029447
superficie	.4781362	.3983734	1.20	0.230	-.3026614 1.258934
PLUVIOMETRIE	-.7741945	.237231	-3.26	0.001	-1.239159 -.3092303
URBAIN	-.5406299	.4637696	-1.17	0.244	-1.449602 .3683417
GENDER	1.608422	.4279637	3.76	0.000	.7696287 2.447215
SECHERESSE	.6833259	.3755489	1.82	0.069	-.0527363 1.419388
REPARTITION_PLUIE	.6848392	.3863677	1.77	0.076	-.0724276 1.442106
HH_ASSETS	-.1564919	.0391884	-3.99	0.000	-.2332997 -.0796842
INNOND	.2044063	.3284286	0.62	0.534	-.4393019 .8481145
SCHOOLING1					
Autre	-.1902849	1.066136	-0.18	0.858	-2.279874 1.899304
Ecole Coranique	-.5442979	.3978096	-1.37	0.171	-1.32399 .2353945
Primaire	.5380107	.5350066	1.01	0.315	-.510583 1.586604
Secondaire	.3265593	1.079393	0.30	0.762	-1.789013 2.442131
Superieur	12.59806	1.074133	11.73	0.000	10.49279 14.70332
_cons	-5.416484	1.239409	-4.37	0.000	-7.845681 -2.987288

Note: 0 failures and 8 successes completely determined.

```
. margins, dydx(SCHOOLING1)
```

```

Average marginal effects                       Number of obs   =       835
Model VCE      : Robust
  
```

```

Expression      : Pr(AWARENESS), predict()
dy/dx w.r.t.   : 2.SCHOOLING1 3.SCHOOLING1 4.SCHOOLING1 5.SCHOOLING1 6.SCHOOLING1
  
```

	dy/dx	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]
SCHOOLING1					
Autre	-.0098358	.0574476	-0.17	0.864	-.122431 .1027595
Ecole Coranique	-.031228	.021155	-1.48	0.140	-.072691 .010235
Primaire	.0223454	.0221669	1.01	0.313	-.0211008 .0657917
Secondaire	.0144549	.0443023	0.33	0.744	-.072376 .1012859
Superieur	.0693955	.0164313	4.22	0.000	.0371908 .1016002

Note: dy/dx for factor levels is the discrete change from the base level.









### 3.7. Appendix Four: Estimation of the maladaptive out

#### ESTIMATION OF MALADAPTATION AND CONFLICTS

Weak-instrument-robust inference

Tests of joint significance of endogenous regressors B1 in main equation

Ho: B1=0 and orthogonality conditions are valid

Anderson-Rubin Wald test            F(10,16384)= 63.76            P-val=0.0000  
 Anderson-Rubin Wald test            Chi-sq(10)= 638.14            P-val=0.0000  
 Stock-Wright LM S statistic        Chi-sq(10)= 614.24            P-val=0.0000

Number of observations            N = 23750  
 Number of regressors            K = 9  
 Number of endogenous regressors    K1 = 4  
 Number of instruments            L = 15  
 Number of excluded instruments    L1 = 10

IV (2SLS) estimation

Estimates efficient for homoskedasticity only  
 Statistics consistent for homoskedasticity only

		Number of obs =	23750
		F( 9,16390) =	5.5e+05
		Prob > F =	0.0000
Total (centered) SS	=	222010.6667	Centered R2 = 0.9967
Total (uncentered) SS	=	222010.6667	Uncentered R2 = 0.9967
Residual SS	=	728.2771048	Root MSE = .2107

CONFLICT	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
CROP_RES_FEED	.0010034	.0005982	1.68	0.093	-.0001691 .0021759
perm_transhumance	.0138608	.000091	15.23	0.000	.0120771 .0156445
land_expansion	.1392368	.0771146	1.81	0.071	-.0119051 .2903786
PAY_ANIM_WATERS	1.583275	.5269719	3.00	0.003	.5504292 2.616121
GOVERN	.1273105	.002752	46.26	0.000	.1219168 .1327042
DROUGHT_SHOCK	-.0647659	.0075279	-8.60	0.000	-.0795203 -.0500115
FLOOD_SHOCK	-.0576755	.0060023	-9.61	0.000	-.0694398 -.0459112
LIVESTOCK	.8873009	.000792	1120.36	0.000	.8857486 .8888531
TRANSH	-.0558223	.0020423	-27.33	0.000	-.0598251 -.0518194

Underidentification test (Anderson canon. corr. LM statistic): 22.955  
 Chi-sq(7) P-val = 0.0017

Weak identification test (Cragg-Donald Wald F statistic): 2.297  
 Stock-Yogo weak ID test critical values: <not available>

Sargan statistic (overidentification test of all instruments): 8.767  
 Chi-sq(6) P-val = 0.1871

Instrumented: CROP\_RES\_FEED perm\_transhumance land\_expansion  
 PAY\_ANIM\_WATERS  
 Included instruments: GOVERN DROUGHT\_SHOCK FLOOD\_SHOCK LIVESTOCK TRANSH  
 Excluded instruments: RAINFALL\_SHOCK RISK SUPERF ACCESS\_CREDIT ACCESS\_LAND  
 PHY\_ADAP INTERNET EXTENSION\_SERV COMMUN\_POOL DISTANCE

### 3.8. Appendix Five: Seemingly Unrelated Regression Outcome

#### SEEMINGLY UNRELATED REGRESSION ESTIMATION

Seemingly unrelated regression (SUR) in panel data set

One-way random effect estimation:

Number of Group variable:	5	Number of obs	=	20323
Panel variable: HHID		Number of eqn	=	3
Time variable : PASSAGE		Number of panels	=	5

Random effects  $u_i \sim \text{Gaussian}$   
 $\text{corr}(u_i, e_{it}) = 0$  (assumed)  
 Panel type : unbalanced

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
<b>STORAGE</b>						
HAGE	.1400377	.0016197	86.46	0.000	.1368631	.1432122
HEDUC	3.042029	.0257421	118.17	0.000	2.991575	3.092482
HSIZE	-.6366578	.0087049	-73.14	0.000	-.653719	-.6195965
SEXE	.7705522	.022691	33.96	0.000	.7260787	.8150256
INTERNET	-.000445	.0000238	-18.71	0.000	-.0004917	-.0003984
AGRIC_COOP	-.0009667	.0000114	-84.84	0.000	-.0009891	-.0009444
ACCESS_CREDIT	4.570379	.0294882	154.99	0.000	4.512583	4.628175
REMITTANCE	-.0015316	.000079	-19.39	0.000	-.0016864	-.0013768
LIVESTOCK	.1028116	.00142	72.40	0.000	.1000284	.1055948
ACCESS_LAND	-.0040017	9.84e-06	-406.83	0.000	-.004021	-.0039825
SHOCK_SECH	9.202421	.0706486	130.26	0.000	9.063952	9.34089
SHOCK_INNOND	-3.280016	.0129679	-252.93	0.000	-3.305433	-3.254599
FOOD_price_SHOCK	.6523013	.0520926	12.52	0.000	.5502017	.7544008
INPUT_price_SHOCK	32.79277	.1301556	251.95	0.000	32.53767	33.04787
<b>PASTORALISM</b>						
HEDUC	-1.549592	.2659994	-5.83	0.000	-2.070941	-1.028243
HSIZE	.5879669	.0788961	7.45	0.000	.4333334	.7426004
HAGE	-.0405709	.0169281	-2.40	0.017	-.0737493	-.0073924
SEXE	-5.032278	.2369456	-21.24	0.000	-5.496683	-4.567873
ACCESS_LAND	-.0022601	.0000691	-32.71	0.000	-.0023955	-.0021247
ACCESS_CREDIT	-1.233984	.117374	-10.51	0.000	-1.464032	-1.003935
LIVE_FACILITY	-.2671009	.0199215	-13.41	0.000	-.3061464	-.2280554
INTERNET	.0012914	.0002488	5.19	0.000	.0008038	.0017791
DROUGHT_SHOCK	.23294	.0089977	25.89	0.000	.2153048	.2505752
SHOCK_INNOND	-3.479716	.1328277	-26.20	0.000	-3.740053	-3.219378
INPUT_price_SHOCK	34.81861	1.330423	26.17	0.000	32.21103	37.42619
FOOD_price_SHOCK	.59861	.5411603	1.11	0.269	-.4620448	1.659265
<b>LABOR_DIVERSIFICATION_30J</b>						
HAGE	-.0223737	.00613	-3.65	0.000	-.0343882	-.0103591
HEDUC	-.7431396	.0971359	-7.65	0.000	-.9335224	-.5527568
HSIZE	.2920813	.0315264	9.26	0.000	.2302908	.3538718
SEXE	-2.580833	.0858529	-30.06	0.000	-2.749101	-2.412564
INTERNET	.000612	.0000903	6.78	0.000	.0004351	.000789
AGRIC_COOP	-.0001606	.0000313	-5.12	0.000	-.0002221	-.0000992
ACCESS_CREDIT	.1047323	.0789912	1.33	0.185	-.0500875	.2595521
REMITTANCE	-.0003402	.0001734	-1.96	0.050	-.0006801	-2.64e-07
LIVESTOCK	-.0917202	.0042351	-21.66	0.000	-.1000208	-.0834195
ACCESS_LAND	-.0015361	.0000303	-50.64	0.000	-.0015956	-.0014767
DROUGHT_SHOCK	.1592682	.0055934	28.47	0.000	.1483053	.1702312
SHOCK_INNOND	-1.525814	.0429372	-35.54	0.000	-1.60997	-1.441659
FOOD_price_SHOCK	.3736664	.1969081	1.90	0.058	-.0122663	.7595991
INPUT_price_SHOCK	15.26884	.4305032	35.47	0.000	14.42507	16.11261
sigma_u	see e(sigma_u)					
sigma_e	see e(sigma_e)					

Dependent variables: STORAGE PASTORALISM LABOR\_DIVERSIFICATION\_30J  
 Independent variables: HAGE HEDUC HSIZE SEXE INTERNET AGRIC\_COOP REMITTANCE  
 LIVESTOCK ACCESS\_LAND SHOCK\_SECH SHOCK\_INNOND  
 FOOD\_price\_SHOCK INPUT\_price\_SHOCK LIVE\_FACILITY  
 DROUGHT\_SHOCK ACCESS\_CREDIT

### 3.9. Appendix Six: Quintile regressions

#### QUINTILES REGRESSIONS

.2 Quantile regression  
R-squared = .28426662  
Number of obs = 13351  
Objective function = .33229864

Heteroskedasticity robust standard errors

q_welfare	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
STORAGE	.0027519	.0005521	4.98	0.000	.0016697	.0038341
PASTORALISM	1.986431	.2655983	7.48	0.000	1.465821	2.507041
LABOR_DIVERSIFICATION_30J	.1182103	.0378331	3.12	0.002	.0440521	.1923685
RESIDU_Diver	.1980954	.0389353	5.09	0.000	.1217766	.2744142
RESIDU_STORE	.0429758	.0035046	12.26	0.000	.0361062	.0498454
RESIDU_TRANS	-.1273387	.0176293	-7.22	0.000	-.1618946	-.0927827
HAGE	.0012038	.0014045	0.86	0.391	-.0015493	.0039569
HEDUC	.1957185	.0173257	11.30	0.000	.1617577	.2296793
HSIZE	-.0934514	.0073893	-12.65	0.000	-.1079355	-.0789673
SEXE	-.2042628	.033945	-6.02	0.000	-.2707999	-.1377258
INTERNET	.0000779	.0000194	4.01	0.000	.0000398	.000116
AGRIC_COOP	.0000297	.0000122	2.43	0.015	5.71e-06	.0000537
ACCESS_CREDIT	-.2231299	.0344818	-6.47	0.000	-.2907191	-.1555407
REMITTANCE	.0006324	.000191	3.31	0.001	.000258	.0010068
ACCESS_LAND	-.0000436	.00004	-1.09	0.276	-.000122	.0000348
_cons	-.9779726	.2725304	-3.59	0.000	-1.512171	-.4437744

.4 Quantile regression  
R-squared = .28613367  
Number of obs = 13351  
Objective function = .47966857

Heteroskedasticity robust standard errors

q_welfare	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
STORAGE	.0037206	.0005574	6.67	0.000	.002628	.0048132
PASTORALISM	1.033634	.2459418	4.20	0.000	.5515532	1.515715
LABOR_DIVERSIFICATION_30J	.2100185	.1136299	1.85	0.065	-.0127122	.4327492
RESIDU_Diver	.2359188	.0465519	5.07	0.000	.1446705	.3271671
RESIDU_STORE	.0629386	.0036704	17.15	0.000	.0557441	.0701331
RESIDU_TRANS	-.1627407	.0211836	-7.68	0.000	-.2042635	-.1212178
HAGE	-.0027472	.0013553	-2.03	0.043	-.0054037	-.0000906
HEDUC	.0724966	.0216194	3.35	0.001	.0301196	.1148736
HSIZE	-.1031522	.0067601	-15.26	0.000	-.116403	-.0899015
SEXE	-.3034937	.0351691	-8.63	0.000	-.3724301	-.2345573
INTERNET	.0001036	.0000183	5.65	0.000	.0000677	.0001396
AGRIC_COOP	.0000517	.0000168	3.08	0.002	.0000188	.0000846
ACCESS_CREDIT	-.3302599	.0400206	-8.25	0.000	-.408706	-.2518139
REMITTANCE	.0008448	.0002292	3.69	0.000	.0003955	.001294
ACCESS_LAND	-.0000746	.0001028	-0.73	0.468	-.0002761	.000127
_cons	-1.176628	.3094916	-3.80	0.000	-1.783276	-.5699804

.6 Quantile regression  
R-squared = .28278134  
Number of obs = 13351  
Objective function = .47610208

Heteroskedasticity robust standard errors

q_welfare	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
STORAGE	.0049838	.0005482	9.09	0.000	.0039092	.0060583
PASTORALISM	.7772251	.1847273	4.21	0.000	.4151333	1.139317
LABOR_DIVERSIFICATION_30J	-.2044883	.1156678	-1.77	0.077	-.4312136	.022237
RESIDU_Diver	.2145752	.0458903	4.68	0.000	.1246237	.3045267
RESIDU_STORE	.0736793	.0041495	17.76	0.000	.0655458	.0818128
RESIDU_TRANS	-.163515	.0209481	-7.81	0.000	-.2045762	-.1224538
HAGE	-.0060347	.0013304	-4.54	0.000	-.0086425	-.0034269
HEDUC	-.0209792	.0231817	-0.90	0.365	-.0664186	.0244603
HSIZE	-.0826545	.0073069	-11.31	0.000	-.096977	-.068332
SEXE	-.3087751	.0471388	-6.55	0.000	-.4011738	-.2163763
INTERNET	.0001125	.0000285	3.95	0.000	.0000567	.0001684
AGRIC_COOP	.0000692	.000011	6.27	0.000	.0000475	.0000908
ACCESS_CREDIT	-.4210752	.0401099	-10.50	0.000	-.4996963	-.3424542
REMITTANCE	.0009398	.000137	6.86	0.000	.0006714	.0012083
ACCESS_LAND	.0003478	.0001054	3.30	0.001	.0001412	.0005543
_cons	-1.119405	.3074543	-3.64	0.000	-1.722059	-.5167512

.8 Quantile regression  
R-squared = .27714703  
Number of obs = 13351  
Objective function = .32646268

Heteroskedasticity robust standard errors

q_welfare	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
STORAGE	.0051482	.0004186	12.30	0.000	.0043276	.0059687
PASTORALISM	.0696026	.132792	0.52	0.600	-.1906885	.3298938
LABOR_DIVERSIFICATION_30J	-.0018841	.1177729	-0.02	0.987	-.2327357	.2289674
RESIDU_Diver	.1808046	.0374363	4.83	0.000	.1074242	.254185
RESIDU_STORE	.0674085	.0041256	16.34	0.000	.0593218	.0754953
RESIDU_TRANS	-.1428272	.0174329	-8.19	0.000	-.1769981	-.1086563
HAGE	-.0075485	.0011571	-6.52	0.000	-.0098166	-.0052804
HEDUC	-.075902	.0222482	-3.41	0.001	-.1195116	-.0322925
HSIZE	-.0516209	.0073219	-7.05	0.000	-.0659728	-.037269
SEXE	-.267422	.0305586	-8.75	0.000	-.3273213	-.2075227
INTERNET	.0000858	.0000145	5.94	0.000	.0000575	.0001141
AGRIC_COOP	.0000684	9.46e-06	7.22	0.000	.0000498	.0000869
ACCESS_CREDIT	-.3912828	.0354943	-11.02	0.000	-.4608567	-.321709
REMITTANCE	.0007721	.0000973	7.94	0.000	.0005814	.0009628
ACCESS_LAND	.000161	.0001072	1.50	0.133	-.0000492	.0003711
_cons	-.0437714	.2899815	-0.15	0.880	-.6121764	.5246335