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TOPIC: Assessing gender dimensions in adaptation practices of climate change in agriculture sector in Africa: Case of Niger

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DEDICATION

I dedicate this research work to my mother Hadiza Moussa, my husband Mr Abdramane Mahamane and my lovely son Mohamed Aymen.

In memory of my late father Mr *Jabir* Assaliha

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ABBREVIATION

CCAFS: Climate Change Agriculture and Food Security

CNEDD: Conseil National pour l'Environnement et le Developpement Durable

CSA: Climate Smart Agriculture

CSV: Climate Smart Villages

FAO: Food and Agriculture Organisation

FBOs: Farmer-Based Organisation

FRM: Fractional Response Model

GDP: Gross Domestic Product

GEI: Gender Empowerment Index

GPI: Gender Parity Index

GLM: General Linear Model

IIA: Independence of Irrelevant Alternative

IFPRI: International Food Policy Research Institute

INS: Institut National de la Statistique

IPCC: Intergovernmental Panel on Climate Change

MNL/ MNP: Multinomial Logit/ Multinomial Probit

NAPs: National Adaptation Plans

PCA: Principal Component Analysis

QMLE: Quasi Maximum Likelihood Estimation

SWC: Soil and Water Conservation

UNDP: United Nations Development Programme

UNFCCC: United National Framework Convention on Climate Change

ABSTRACT

This research aims to contribute to the analysis of the gender dimension in climate change adaptation in Niger. Climate change negatively impacts agriculture, on which the economies of developing countries such as Niger are heavily dependent. This exacerbates the situation of vulnerable groups, in particular the elderly, women and children in rural areas. The Multiple Choice Method randomly selected 707 farmers from 353 households for primary data collection. The proportion test, multinomial logit, principal component analysis, ordinal logit regression and fractional logit model are used for the analysis. The results show that climate change adaptation practices are differentiated by gender. However, women have a lower level of adaptation, with fewer determining factors than men. Socio-economic characteristics determine farmers' level of constraints and adaptation to climate change. Constraining factors include institutional, public, high input costs, land tenure issues, education levels, religious beliefs and customs, labor and financial constraints. Men and women did not attain the empowerment score, with more women less empowered. However, Koranic education, agricultural income and selling at moderate prices, among other benefits, affect the gender empowerment index of women. In order to improve the level of adaptation and empowerment of women in the agricultural sector, special attention should be paid to women in development projects/programs in Niger.

Keywords: climate change, level of adaptation, constraining factor, level of constraint, gender empowerment index, Niger

RESUME

Cette recherche vise à contribuer à l'analyse de la dimension de genre dans l'adaptation au changement climatique au Niger. Le changement climatique impacte négativement l'agriculture, des pays en développement tels que le Niger dont les économies dépendent fortement. Cela aggrave la situation des groupes vulnérables, en particulier les personnes âgées, les femmes et les enfants dans les zones rurales. La méthode du choix multiple a permis de sélectionner au hasard 707 agriculteurs de 353 ménages pour la collecte de données primaires. Le test de proportion, le logit multinomial, l'analyse à composantes principales, la régression logit ordinale et le modèle logit fractionnaire sont utilisés pour l'analyse. Les résultats montrent que les pratiques d'adaptation au changement climatique sont différenciées selon le genre, les femmes ont un niveau d'adaptation plus faible, avec moins de facteurs déterminants que les hommes. Les caractéristiques socio-économiques déterminent le niveau de contraintes et d'adaptation des agriculteurs face au changement climatique. Les facteurs contraignants sont institutionnelles, publiques, le coût élevé des intrants, les problèmes fonciers, les niveaux d'éducation, les croyances religieuses et les coutumes, la main-d'œuvre et problèmes financières. Les hommes et les femmes n'ont pas atteint le score d'autonomisation, les femmes sont plus nombreuses à être moins autonomes. Cependant, l'éducation coranique, le revenu agricole et la vente à prix modérés, entre autres avantages, améliorent l'indice d'autonomisation des femmes. Afin de renforcer le niveau d'adaptation et d'autonomisation des femmes dans le secteur agricole, une attention particulière devrait être accordée aux femmes dans les projets/programmes de développement au Niger.
Mots clés: changement climatique, niveau d'adaptation, facteur contraignant, niveau de contraintes indice d'autonomisation genre, Niger

General Introduction

Climate change affects negatively the human being and the ecosystem through extreme events such as sea level rise, soil degradation, loss of biodiversity, drought, floods, variability of rainfall patterns, storms, etc. African countries highly dependent on agriculture sector, are the most vulnerable to these extreme events of change which have consequences on the loss of productivity, shortage of food and job, and higher instability of prices. According to FAO, between 2004 and 2014, 26% of total damage and losses caused by climate-related disasters in developing countries were absorbed by the agriculture sectors(FAO, 2018). In addition, with global warming of 1.5°C and increase further of 2°C, climate-related risks to food security, livelihoods, water supply, human security, overall health, and economic growth are projected to increase (IPCC, 2018).

Agricultural production remains the main source of income for most rural communities. Therefore, the adaptation of the agricultural sector to the adverse effects of change will be imperative to protect the livelihoods of the poor and to ensure food security. Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderating potential damages, and helping them to cope with adverse consequences (Bryan et al., 2009). Though, climate change impacts are not only physical and economic but also social and cultural. Because of gender differences in social and economic roles and responsibilities, the effects of climate change affect men and women in varied ways, and often women more severely.

According to UNDP, women and girls become more vulnerable to the effects of climate change because of their responsibility of collecting for the households or communities. Thus, a greater proportion of women in poor countries engage in subsistence farming and water collection, exposing them more adversely to the effects of environmental degradation in the form of food shortages and malnutrition (UNDP, 2015). Furthermore, unequal access to resources and decision-making processes, along with limited mobility, exposes women in rural areas to more of the negative effects of climate change. Often, because of the traditionally limited role of women in decision-making processes at the household, village, and national levels in most cultures, their needs, interests, and constraints are poorly reflected in policy-making processes and government programs aimed at poverty reduction, food security, and environmental sustainability(FAO, 2015).

Therefore, many reports from United Nation agencies highlighted the disproportionate burden of the long-term impacts of climate change on women in various regions of the Global South. These impacts are human health, agriculture and food security, and indoor pollution. They further highlight the importance of incorporating the differential impacts of long-term climate change on women, and thereby encourage the participation of women in decision-making processes at the local level (Sen Roy, 2018).

According to Egyir et al., (2014), women are active agents who have developed locally adapted, appropriate, and sustainable coping strategies and responses to climatic shocks. Indeed, their knowledge can influence adaptive mechanisms in the most vulnerable areas. Hence, gender-based roles and responsibilities are linked to distinct knowledge and skills that, when harnessed through participatory and inclusive planning processes, can contribute to successful adaptation interventions (UNFCC, 2015). Thus, in the context of adaptation, gender refers to how the socio-political relations between men and women affect the planning and implementation of adaptation actions, access to resources (including material resources and capacity building), how climate change impacts and adaptation measures differentially affect men and women, and how men and women contribute differently to adaptation actions. Of particular significance in this regard are the differences that exist between the access, control, and opportunities of men and women on issues such as land, resources, work opportunities and wages, time spent in both productive and household roles, and leadership and participation in decision-making processes (UNFCC, 2015).

To achieve the end of hunger by improved food security under climate-ricks it is necessary to promote sustainable agriculture. Then FAO developed Climate-smart agriculture (CSA) which is an approach to developing the technical, policy, and investment conditions to achieve sustainable agricultural development for food security under climate change. The three main pillars of CSA: increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions where possible.

Considering that women farmers have less access than men to resources (land, finances, seeds, agricultural materials…), services, and information this hindered their ability to adopt the new technologies of climate change adaptation such as CSA. Therefore, in 2015 the world bank and

FAO initiated a gender-responsive to CSA which reduce gender inequalities and ensure that men, women, boys, and girls can equally benefit from CSA interventions and practices, thus achieving more sustainable and equitable results(FAO & World Bank, 2017).

Sahelian country, Niger is situated in West Africa. It is the largest country with 1,267,000 km2 in West Africa and three-fourths (3/4) of this area is covered by the desert. The climate is arid in the north zone(desert) and tropical in the south zone, with Sudan savanna vegetation. The rainy season lasts for only three months, maximum temperatures are high (45°C in the shade in April–May). The vegetation cover is sparse, and nomadic agriculture is dominant. Niger's economy is heavily dependent on agriculture, despite the arid climate and the fragility of its ecosystems, agriculture contributes 41% of the Gross Domestic Product (GDP) and employs more than 75% of total working population. Though, this agriculture is traditional and the production level is just for subsistence with a low level of productivity and limited investments, due to the poverty of the population. In addition to this, is added the effects of climate change such as droughts, irregular rainfall patterns, poor and degraded soils, floods, higher temperatures, and storms. These constraints the development of agriculture and contribute to increasing poverty and food insecurity of the population in Niger.

In Niger like many developing countries, it’s women who are responsible for collecting water and energy for cooking to satisfy their family’s needs. Supply of drinking water is very low in the country, especially in the rural areas where the women have to walk and go far to have water which become rare due to drought. The use of traditional cooking stoves contributes to the advance of desertification and consequently to climate change. Hence, the adaptation practices used by farmers to cope with climate change are living hedges, dead hedges, stone cordons, windbreaks intercropping to limit wind speeds in crop-growing areas. As strategies the use of half-moons, stone barriers, and drainage trenches to facilitate optimal and efficient water management for crops and to recharge the water supply. There is also adaptation measures to maintain and/or restore soil fertility through mulching and agroforestry (Ministere du Plan, 2018).

Therefore, farmers in Niger are using a large number of techniques to adapt to the effects of climate change. These methods include: zaï pits, stone cordons, half-moons, micro-dams, grass strips, filter dikes, mulching, multiple cropping systems, crop rotation, fallows, zero tillage, agroforestry, farmer-assisted natural regeneration, the use of fire-breaks, the planting of wind-breaks, the stabilization of sand dunes, the application of manure or compost, micro doses of chemical fertilizers, early planting and the development of contracts with livestock farmers to keep their animals in the fields to provide additional manure (Sheil & Bargués Tobella, 2021).

The Sustainable Development Goals (SDGs) promote social, economic, and environmentally sustainable development. Thereby, Sustainable Development Goals five (SDG 5) is to promote gender equality and empower women. Its emphasis on gender mainstreaming methodology, which consists of integrating a gendered approach into development and environmental efforts includes women's participation in existing strategies and programs. Thus, the multiple dimensions of inequality hamper women ability to manage daily risks as well as shocks, limiting their adaptive capacity. Because, women farmers are more exposed than men to climate variability and extreme events, because of limited rights and assets, combined with limited access to the social and natural resources required for adaptation and enhancing resilience (FAO & CARE, 2019). Nonetheless, women have great potential to contribute to climate change adaptation but they are restrictive by four gender myths: the first myth is 70% of the world's poor are women; the second myth is due that women contribute 60–80% of the world's food production; the third myth is about land ownership, women own 1% of the world's land; and finally, women are better stewards of the environment. This further hinders the achievement of the SDGs' goal 5 which aims to attain Gender Equality and Empower all Women and Girls(C. Doss et al., 2018).

Nong et al., (2020) argued that households with female as heads are more vulnerable to climate variability and natural disasters than male heads in term of livelihood strategies and food. This is because female-headed households do not have employment outside the community so largely depend on agriculture for income and have a smaller land area for agriculture production than male-headed households. Furthermore, women and men farmers are both vulnerable to the negative impacts of climate change, but women are less likely to act to reduce vulnerability. Given that women typically have less access to resources, including labor and money, less secure tenure, and less information and services extension. Thereby women are fewer in taking up new practices such as CSA to be more resilient to climate change(Jost et al.,2016, Kristjanson et al.,2017).

According to literature, male-headed households are more likely to undertake agricultural adaptation, due to their main role being the planning and operation of the farm to improve productivity and maintain the well-being of their family. Accordingly, they are more likely to seek and adopt new knowledge and technologies (Asfaw and Admassie, 2004; Buyinza and Wambede, 2008). In the same line, Temesgen et al (2014) found that male household heads had a better opportunity to take an adaptation measure than female household heads. Male-headed households have also a better opportunity of adapting to climate change by involving in agronomic practices and by adopting agricultural inputs to their farm. Diiro et al (2016) found that a lower proportion of female heads of farm households than male heads implemented adaptation practices. They argued that female heads of farm households were constrained by a lack of money and access to labor and land.

According to the FAO, in the least developed countries 79% of economically active women report agriculture as their primary economic activity, while rural women play an increasing role in smallholder agriculture as a result of the out-migration of males. Women make up 43% of the global agricultural labor force. Nevertheless, women represent 50% of the agriculture labor force in Sub-Saharan Africa, they have less access than men to productive resources and opportunities. However, the gender gap in agriculture exists across a range of assets and resources. Women have less access to financial capital and key resources such as water, livestock, grazing, and fisheries. They have less capacity to capture beneficial environmental services; less participation in decision-making; and lower levels of access to labor, technology, training, information, and agricultural advisory services. Thereby, closing the gender gap in agriculture would generate significant gains for the agriculture sector and society. If women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent. This could raise total agricultural output in developing countries by 2.5–4 percent, which could in turn reduce the number of hungry people in the world by 12–17 percent (FAO, 2011; Huyer et al., 2016; Onwutuebe, 2019).

In Sub-Saharan Africa, women face serious constraints in all facets of life. Low asset ownership and low levels of education reduce rural women's bargaining power within the household and limit their voice in implementing collective action in their communities and the wider agricultural sector. Women's weaker status is reflected in high rates of domestic violence and other indicators such as lower literacy and high maternal mortality rates, in large part due to poor education and health services and malnutrition. "Modernizing forces" such as male migration from rural to urban areas can create opportunities for women who remain on the farm, but limited land ownership and access to services often lock women into poverty(World Bank, 2017).

Though, rural women, in particular, are at high risk of negative impacts from climate change due to increases in both household responsibilities and agricultural work from male out-migration. Therefore, the gender-differentiated impacts of climate change occur in the failure of subsistence crops, this constrains woman to sell their assets such as small livestock or seek other means of generating income to provide for their family. When these crops fail lead men to temporary migration. A smaller income base due to crop failure may cause a household to decrease consumption or deplete their savings as coping strategies, affecting the well-being of the members of the household, but with gendered nuances. Women and children may suffer more food insecurity than men, children may drop out of school when school fees can no longer be afforded, and more women may become heads of households when their husbands migrate in search of work, which may additionally burden them. Hence, women appear to be less adaptive due to: financial or resource constraints; male domination in receiving information and extension services, and because available adaptation strategies tend to create higher labor loads for women. (Agwu & Okhimamhe, 2009; Goh, 2012; Jost et al., 2015).

Thus, most times the effects of climate change are not differentiated between men and women at communal household and intrahousehold levels. The effect of climate change may impose stress on household members' daily activities depending on the gender relations within the household, thus affecting household security and livelihoods. While people are born either male or female, later they are taught appropriate norms at household, community, and workplace levels to be girls and boys who then grow into women and men (Nagasha et al., 2019). Then, women are likely to be affected disproportionately due to their overwhelming dependency and low technical knowledge to adapt to the abrupt situation. Women are more vulnerable to climate disasters than men through their socially constructed roles and responsibilities, and their relatively poorer and more economically vulnerable position. Gender inequalities for the enjoyment of human rights, political and economic status, land ownership, housing conditions, exposure to violence, education, and health (in particular reproductive and sexual health) make women more vulnerable before, during, and after climate change-induced disasters(Baten et al., 2016).

However, gender-based inequalities in access to resources and services, along with stressors like poverty are more likely attributed to divergent perceptions, than inherent differences between men and women. Nevertheless, those differences were not to be inherent, fundamental, and natural differences between females and males, but rather to be in the context of inequity in which those perceptions were established and shaped. Then, women may perceive the risk of environmental change to be more acute due to a lack of gender equity and differentiated political power (Djoudi et al., 2016). Furthermore, women's participation in the political, economic, social, and agricultural domains is restricted, and preventing them from being empowered to contribute by taking part in the decision-making process, thus restraining the attainment of equality between men and women. This highlights that political and social participation is an important part of technological adoption and so it is also relevant to capture this change. In the context of development planning, involvement in the decision-making process and access to inputs and resources can provide a powerful empowerment factor. The promotion of participation involves a change in social and cultural boundaries, which creates an empowering environment (Hariharan et al., 2020).

Some studies made evidence the relationship between gender empowerment and the adoption of adaptation strategies like CSA. They conclude that men farmers are more empowered than women in four out of the five domains of empowerment. They argued also that closing the empowerment gap between women and their spouses would positively influence the adoption of agroforestry. Moreover, women’s empowerment is positively associated with greater participation of women in production decisions about the adoption (or disadoption) of new technology, the acquisition of women to credit, and extension services (Oyawole et al., 2021 ; Seymour et al., 2016).

Considering the importance of the agriculture sector in Niger’s economy, this analysis will be specially focused on adaptation practices in the agriculture sector. Even though women are majority than men in rural areas, they participate less and less in agricultural activities. Their proportion in agriculture has decreased from 40% in 2006 to 11% in 2012. Likewise, according to the Census General Agriculture: Gender Dimension, the total area intended for agricultural production in Niger (6534,681 ha) is used 95% by male heads of household and 5% by female heads of household. As for the area under individual management, it is 84.4% managed by male members of households agricultural and 15.6% by female members (FAO & ECOWAS, 2022).

Thus, this study is important in the case of Niger due that it's faced the negative effects of climate change which increase the poverty and inequality of the population in the country. According to the national institute of Statistics in 2014, the rate of poverty was 45.4% with 67% of women. Further gender inequality index of Niger is 0.713, higher than the average of Sub-Saharan Africa which is 0.503 (UNDP, 2015). According to Vincent in 2004, ten African countries which Niger is part of, are the most vulnerable to climate change, in almost all of these women make up 40 percent or more of the agricultural labor force (African Development Bank, 2011). This situation continuous to make the households most vulnerable by decreasing their situation of food security.

Meanwhile, it's found that food insecurity is higher among female-headed households. Because, in developing countries particularly in Niger, women have an average lower income; limited access to paid employment, and limited access to credit and agricultural land than men. Face in this situation, households headed by women are generally composed of a high dependent proportion of children and elderly people and women are the only providers of household resources (FAO & ECOWAS, 2022). Along the same line Zakari et al.,(2022) found that in Niger, climate change effects such as drought and flooding impact negatively household crop yields, female-headed households are significantly more likely to be considered food insecure than male-headed households.

Thus, the analysis from five countries (Ethiopia, Malawi, Niger, southern Nigeria, and Uganda) of the value of total crop output per hectare compared across plots managed by men and women. The result found gender gaps in productivity when simply comparing the differences in the value of output. Thus, the gender gap increases from 19% to 66% in Niger while it disappears in Nigeria (South), a gender gap of 46% results in Nigeria (North), and a gap of 33% in Uganda(C. R. Doss, 2017). Moreover, for agricultural productivity in Niger, it is found that plots managed by women on average produce 20 percent less per hectare than plots managed by men. So, the gap increases to 33 percent for female-managed plots. Though, the distance between the plot and the household is correlated with a higher gender gap. Female-managed plots tend to be further away from the household than male-managed plots. These plots may be of lower quality, or the longer distance to the household may result in less regular or less productive maintenance, with the impact of the latter exacerbated for women due to the mobility constraints they face, particularly in rural areas(World Bank, 2019).

Though, strategies and practices have been developed to mitigate and/or adapt to climate change like CSA. Many studies conducted to see if women and men have the same equality to adopt the new technology of adaption to climate change. But all these studies are aggregate concerning all countries in Sub-Saharan countries, such as the study on understanding gender dimensions of agriculture and climate change in smallholder farming communities, the authors found that in sub-Saharan Africa, women have less information on the adoption of improved agricultural technologies in comparison to man (Jost et al., 2015). To close the gender gap in agriculture the CSA must be gender-sensitive (Huyer et al., 2015). The case study of Côte d'Ivoire on the project of CSA-sensitive practices that contribute to reducing greenhouse gas, in food processing of fish smoking, is done by women. Through, the project the women have improved their health, livelihoods, and capacity to enhance the food security of their families. (World Bank, FAO, and IFAD, 2015).

The United Nations Framework Convention on Climate Change (UNFCCC) Technical Guidelines on National Adaptation Plans (NAPs) recognize the importance of a gender-responsive plan, noting the value of equal participation of men and women in decision-making, the need to avoid exacerbating gender inequalities and the likelihood that addressing gender leads to better adaptation and more resilient communities. Thus, the NAPs defined gender-responsive NAP as a program that includes three criteria: (i) recognizes the gender differences in adaptation needs, opportunities, and capacities; (ii) ensures the equitable participation and influence of women and men in adaptation decision-making processes; and (iii) ensures gender equitable access to financial resources and other benefits resulting from adaptation investments (Dazé & Dekens, 2019).

Besides, women's participation is essential to sustainable development and adaptation to climate change. To achieve this, it is important to empower women by providing the opportunity for equal control over the factors of production and equal participation in the process of development. In particular, it means involving women in the decision-making process to balance the control of production factors between men and women. Thus, assessing the gender dimension in the decisions of adaptation practices within and across households is critical importance in order to provide better information on the factors driving adaptation practices to climate change and gender empowerment index in agriculture in Niger will be helpful for the decision-making and policies to better gender mainstreaming of the country in order to reduce the poverty and inequality in Niger. Therefore, this thesis raises the questions for investigation as follow: the main research question of this thesis is what is the gender dimension of adaptation practices in the agricultural sector to climate change in Niger?

Specifically:

1. Is adaptation in the agricultural sector to climate change in Niger gender differentiated?
2. what are the determinants and constraints of adaptation practices to climate change of men and women in farming decisions in Niger?
3. What are the influencing factors of the gender empowerment index across women and men farmers in farming households in Niger?

Hence the main objective of this thesis is to assess the gender dimension of adaptation practices in the agricultural sector to climate change in Niger. Specifically, we aim to:

1. To analyze different practices of adaptation to climate change used by women and men farmers in Niger.
2. Determine the factors behind climate change adaptation practices and their constraints for men and women farmers in Niger.
3. Analyze the determinants of the gender empowerment index for women and men farmers in Niger.

Therefore, to tackle the objectives of this thesis the research hypotheses are formulated as follow:

1. There is gender-differentiated in agriculture practices to the adaptation of climate variability in Niger;
2. There are no determining factors for climate change adaptation practices nor for constraints in agricultural production for men and women in Niger.
3. Certain factors affect the gender empowerment index in agricultural production in Niger.

Thus, this thesis uses primary and secondary data. So, the test of proportion is used to analyze the adaptation practices between women and men farmers. To tackle the second objective, this thesis uses the multinomial logit model (MNL) and ordered logit model (OLR) to determine the influencing factors on the level of adaptation and constraints according to the gender, and the principal component analysis (PCA) uses to determine the constraining factors between women and men farmers in farming decision in Niger. Finally, to investigate on third objective, this study computes the gender empowerment index, and uses econometric approach like fractional response model to determine the influencing factors on it.

After general introduction, this dissertation is organized in three chapters: chapter one literature review which provides the conceptual, theoretical, and empirical of relevant literature. Chapter two methodology, it presents the details of the study area, sampling design, data collection, and analysis. Chapter three results and discussion of the empirical findings of each objective in this thesis. Finally, conclusions, and policy implications of the study.

Chapter One: Stylized facts

The vulnerability of Niger is due of the persistence of poverty, climate hazards and the advance of desertification, because of that agricultural productivity and food security remain a big challenge in Niger. This chapter presents and describes the general characteristics of the country, agriculture sector linked to gender, trend of precipitations and temperature, climate risks, and adaptation practices to cope with climate change in Niger.

1.1 General characteristics of Niger

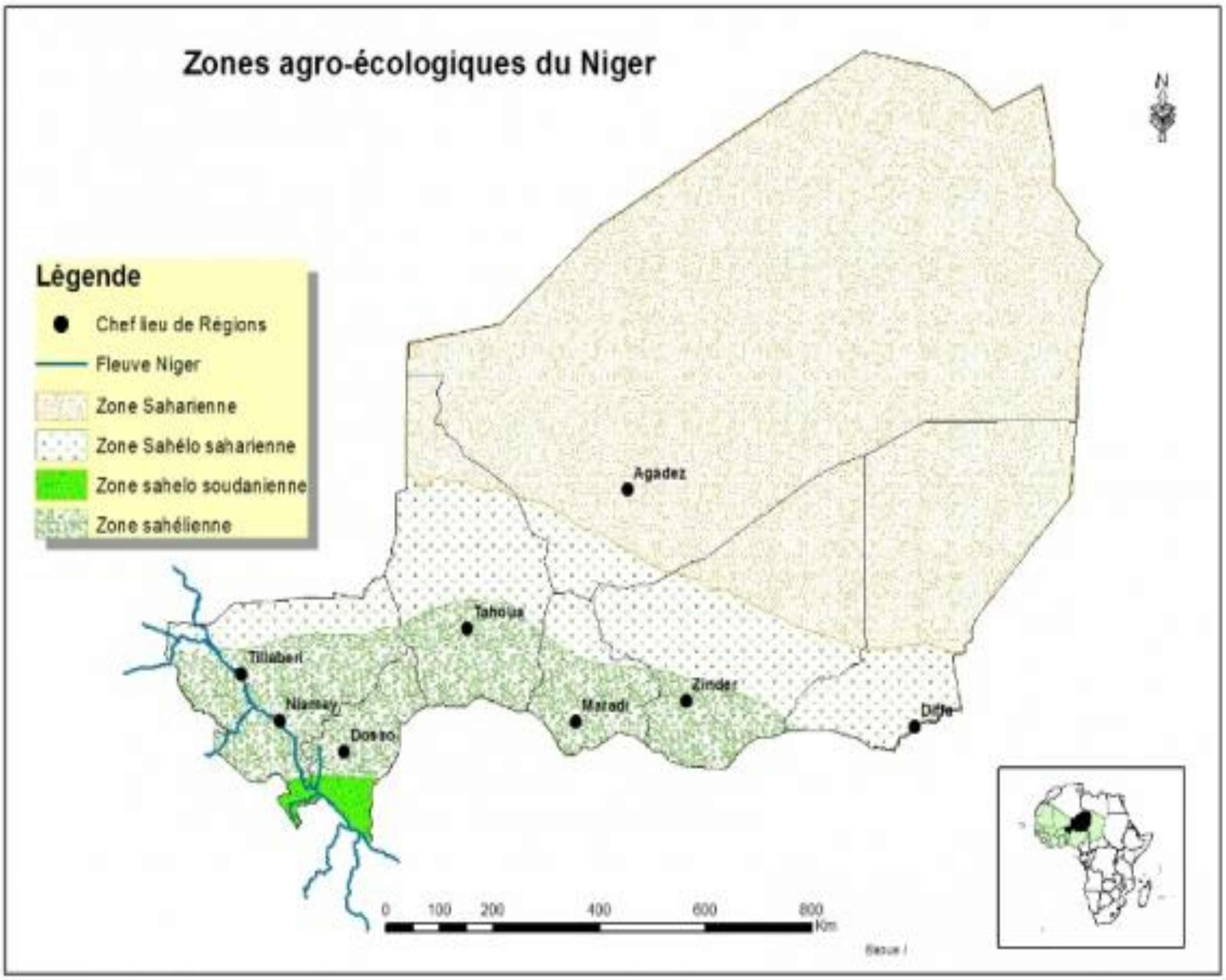

Figure 1:Agro-ecological zone of Niger
Source: Moussa et al, (2022)

Niger is a landlocked Sahelian country with 1.27 million square kilometers situated in Western Africa. It is located between 11 ° 37 ’and 23 ° 33’ North latitude and 0 ° 06 ’and 16 ° 00’ east longitude. It is bordered by Chad in the east, Libya and Algeria in the North, Mali, and Burkina Faso in the West, and Nigeria and Benin in the South. Niger is one of the hottest (45 ° in May) areas on the planet. There is only one rainy season which is very short (three months) however, the amount of rainfall varies from less than 100 mm per year in the north to more than 600mm per year in the south.

Though, the agricultural production system in Niger is small farms with a maximum of one hectare. It is composed of a plant production system and breeding. It is relatively diverse and remains dependent on climatic conditions. The performance of the agriculture sector remains insufficient taking into account the declining yields following the gradual drop in fertility when the land is cultivated marginally, the absence of fallow, and the deficit of the water balance. Only a quarter of the 15 000,000 ha of cultivable land including 80% dune and 15 to 20% moderately clayey hydro-morph is highlighted. In addition, 70,000 to 80,000 ha of new land are occupied annually by agriculture at the expense of forests and livestock itself strongly extensive. Agriculture is essentially rainfed and cereal food crops form the basis of production (FAO, 2016).

Thereby, land degradation is a big issue because only 12% of the land is suitable for cultivation to feed the population in Niger whose population growth rate is 3.9% the highest in West Africa.

The economy remains dependent on the agriculture sector with 43,2% in Gross Domestic Production (GDP), and around 87% of the population activities have relying on crop production and livestock growth for their livelihoods. About 14% of Niger’s GDP is generated by livestock production, including camels, goats, sheep, and cattle. Farmers in Niger produce mainly for their own consumption. While millet, sorghum, and cowpeas are the main subsistence crops, onions constitute the main export crop (National Statistical Institute, 2013). High poverty is associated with low productivity and low returns to agriculture, contributing also to high rates of food insecurity.

1.2 Agriculture in Niger

Among farming households, 45% are poor. The vast majority of household heads have no formal education (86.4%). It is also important to mention that agriculture in Niger is still archaic. Indeed, 35.3% of households use modern agricultural equipment such as plows, compared with a high use (64.7%) of traditional equipment such as the hilar. The graph below shows the growth rates of agricultural real GDP per worker and non-agricultural GDP per worker. Finding that agricultural GDP growth per worker is on average slightly lower than non-agricultural GDP growth per worker (0.8% and 0.9%). This means that productivity in the agricultural sector is lower (INS, 2019).

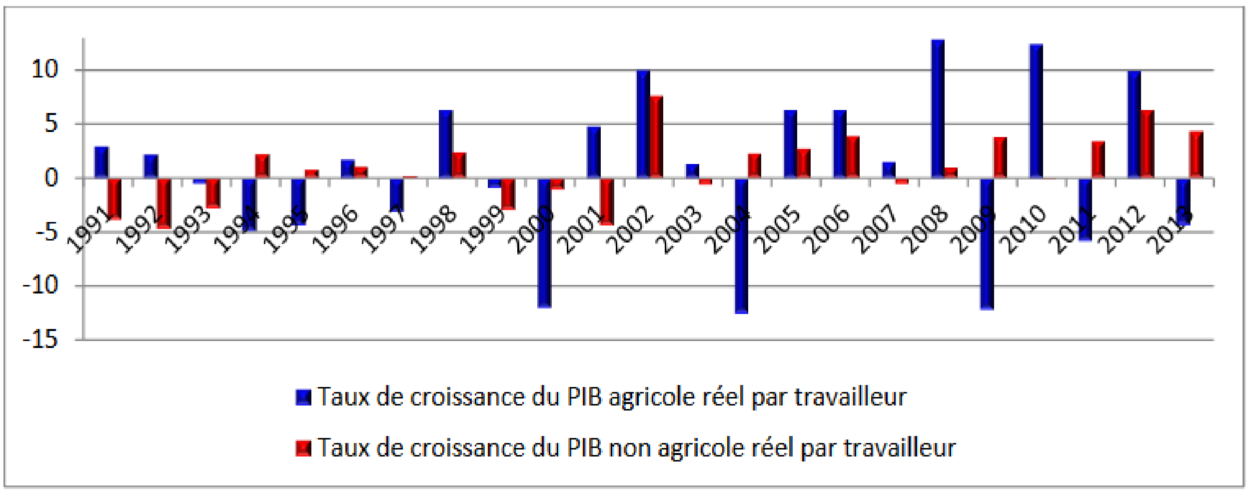

Figure 2: Comparison of the growth rates of agriculture real GDP per worker and non-agriculture GDP per worker

Source: INS

However, Niger's economy is highly dependent on agriculture, thereby the contribution of agriculture to national revenue is high, as shown in the graph above. However, the level of agriculture's influence remains stable (INS, 2019)

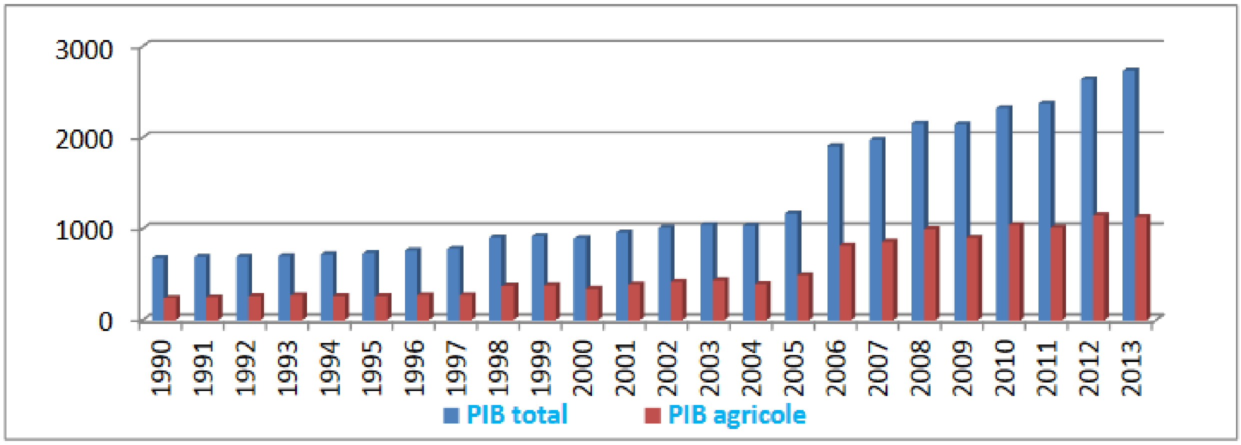

Figure 3:Evolution of the real GDP and agricultural GDP (in billions of F CFA)
Source: INS

1.3 Gender in Agriculture sector in Niger

As shown in table 1, food insecurity is higher among female-headed households. This is due to the fact that women are the only providers of resources, while there is normally a high percentage of non-working dependents (children, the elderly), and that these households are mainly supported by women, whose average income is lower than that of men. Added to this is their limited access to paid employment, credit and above all agricultural land in developing countries, notably Niger. Finally, the family responsibilities of female heads of household (child-rearing, domestic chores, etc.) mean that they have to take on economic activities and jobs that are compatible with their obligations. However, these economic activities and jobs are not very profitable, because they are generally in the informal sector, and because of the partial availability of female heads of household to devote themselves fully to them.

Table 1: Population distribution (%) by gender of household head, classified by food insecurity level

	Sévère	Modéré	A risque	En sécurité
Sexe chef de Ménage				
Masculin	1	10,9	26,2	61,8
Féminin	2,3	22,2	34,9	40,6

Source: (FAO & ECOWAS, 2022)

In Niger, for a total of 1,627,294 farming households, 93.4% of households are headed by men, compared with 6.6% headed by women. Thus, women remain clearly in the minority of agricultural and livestock activities, regardless of the status of the head of household.

Table 2:Distribution of farm households according to principal activity and sex of head of household at national level

	Chef de Ménage Homme				Chef de Ménage Femme			
Activité Principale	Effectif Total	(%) Niger	(%) Homme	(%) Activité Principale	Effectif Total	(%) Niger	(%) Femme	(%) Activité Principale
Agriculture	172 172	10,6	11,3	95,3	8 434	0,5	7,8	4,7
Elevage	151 203	9,3	10,0	84,4	27 966	1,7	25,9	15,6
Agriculture et Elevage	1 195 769	73,5	78,7	94,3	71 749	4,4	66,3	5,7
Total	1 519 144	93,4	100,0		108 150	6,6	100	

Source: (FAO & ECOWAS, 2022)

Women are 86.7% self-employed in both agricultural and non-agricultural sectors, although women's main activity is seasonal farming.

Table 3:Type of job for women (aged 15-49) in %

Caractéristique de l'emploi	Travail agricole	Travail non agricole	Ensemble
Employée par un membre de la famille	10,8	6,2	6,6
Employée par quelqu'un qui n'est pas membre de la famille	2,4	6,6	6,2
Travaille à son propre compte	86,7	86,7	86,7
NSP/ND	0,1	0,5	0,5
Total	100	100	100

Source: (FAO & ECOWAS, 2022)

1.4 Trend of precipitations and temperature in Niger

The rainy season in Niger is monomodal. The quantity of rain and the duration of the rainy season decreases towards the north. Annual average rainfall totals range from practically 0 mm to 800 mm from the north to the south of the country. The trend of interannual anomalies over the period 1960-2010 shows that rainfall patterns are highly variable. After almost two decades of rainfall deficit, a return to rainfall abundance was observed in the 1990s. However, the most significant aspect of this period is the alternation of dry and humid seasons, which increases the interannual variability of rainfall(SARR & HOUNGNIBO, 2015).

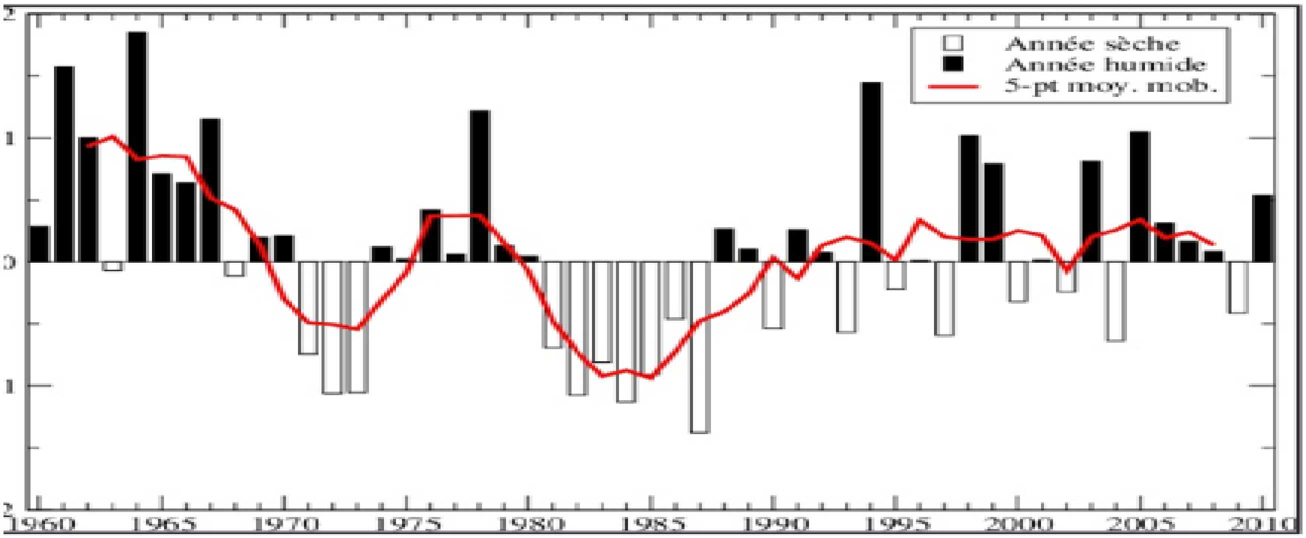

Figure 4:Interannual variability of annual rainfall in Niger

Source: SARR & HOUNGNIBO, (2015)

The trends in annual rainfall over the period1990 to 2019 in the study area show that the average rainfall in Dosso is 569 mm, with a slightly upward trend. Annual deviations from the 30-year average range from -211 mm in 2011 to +301 mm in 1994. In Maradi it is 513 mm, with a slightly upward trend. Annual deviations from the 30-year average range from -150 mm in 1993 to +124 mm in 2018. The average rainfall in Tahoua is 366 mm, with a declining trend. Annual deviations from the 30-year average range from -160 mm in 2004 to +270 mm in 1994. In Zinder, the average rainfall is 432 mm, with an upward trend. upward trend. Annual deviations from the 30-year average range from -167 mm in 1990 to +291 mm in 2018 (CNEDD, 2020).

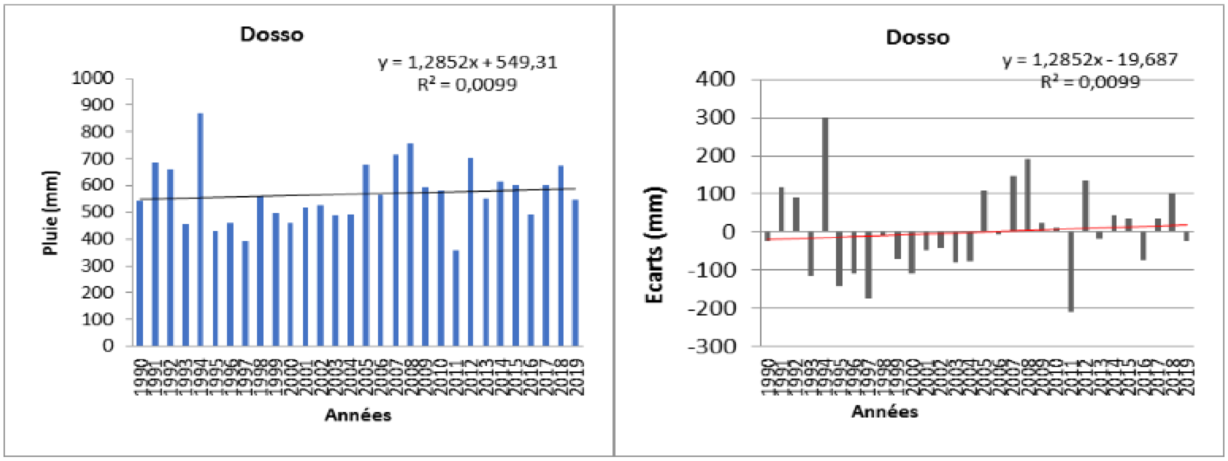

Figure 5: trends in annual rainfall of Dosso over the period 1990-2019
Source: CNEDD, (2020)

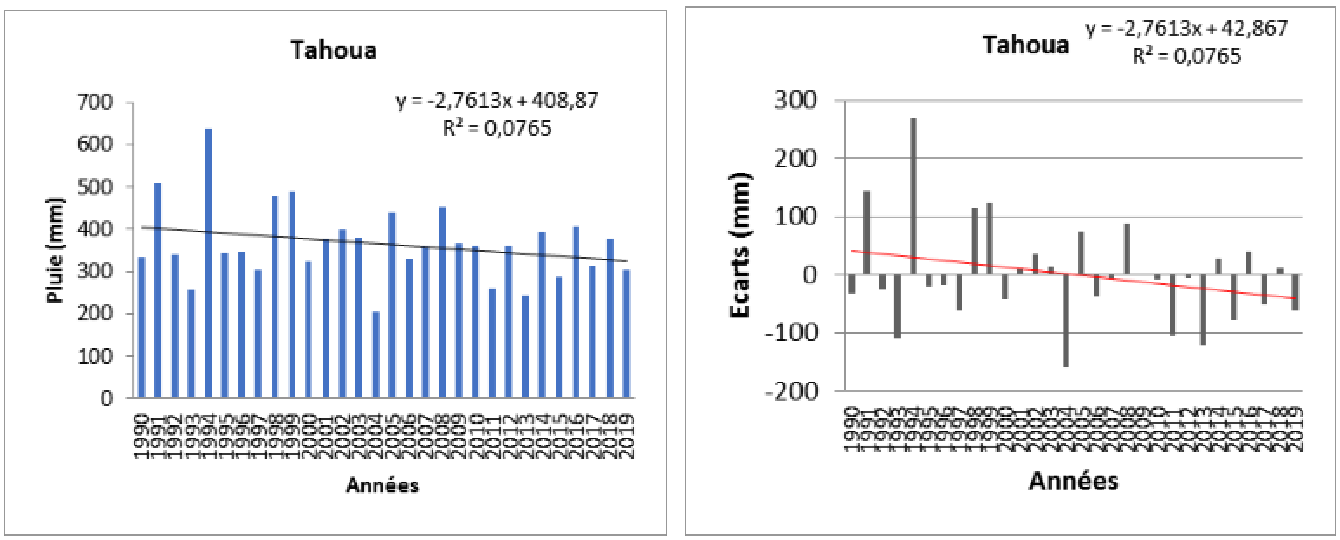

Figure 6: trends in annual rainfall of Tahoua over the period 1990-2019
Source: CNEDD, (2020)

However, in Niger the increase in temperature has been continuous since the 1980s for minimum temperatures and the 1990s for maximum temperatures. The rise in minimum temperatures is estimated at +1.2°C, compared with +0.48°C for maximum temperatures between 1991 and 2010. The temperature increase is more marked between November and March than between June and October (SARR & HOUNGNIBO,2015).

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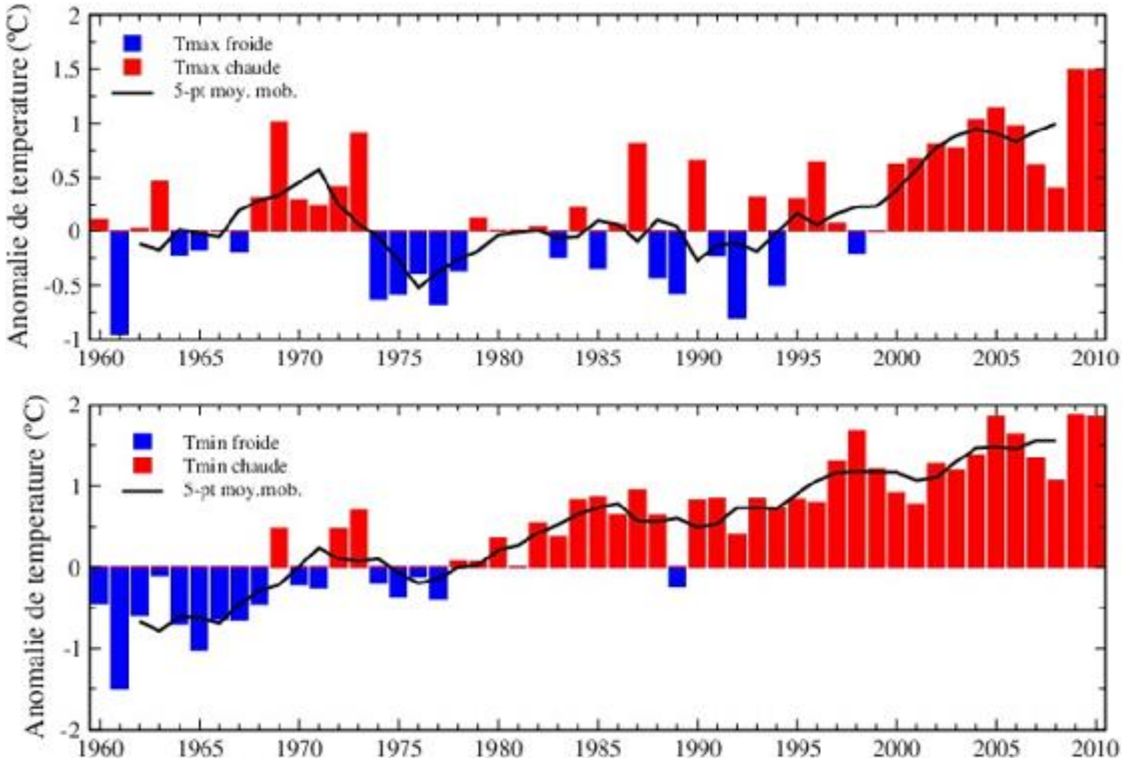

Figure 7:Variability of maximum and minimum temperature anomalies in Niger
Source: SARR & HOUNGNIBO, (2015)

1.5 Climate Change in Niger

Climate change is manifesting in various ways in Niger: more frequent and prolonged droughts (probability of occurrence > 66%), higher and more irregular maximum and minimum temperatures (probability of occurrence > 95%), increased inter-annual variability in rainfall, shorter and more unstable rainy seasons (probability of occurrence > 90%), more frequent and more intense flooding, and stronger winds. Desertification is one of the most visible effects. In recent decades, desert cover has increased from 66% to 77% of the country's surface area(FIDA, 2013).

Thus, the most climate-related risks are recurring droughts, increasingly erratic rainfalls and floods, violent sand storms, and destructive invasions of locusts. This led to alarming food shortages which further aggravated food insecurity and acute malnutrition and had significant health and socio-economic impacts on the population. But the most threat of climate variability in Niger is drought, whereby the country has experienced a deficit of production and reduction of livestock through four severe droughts in 1966-1967, 1973-1974, 1983-1984, and 2004-2005 throughout Niger. Floods as well as drought affect agriculture negatively. For the year 1998, for example, about 588 hectares of rice fields, 8608 hectares of millet fields, and 203 orchards were damaged in Niger. Floods contribute to the destruction and loss of production (CNEDD, 2006; UNDP et al., 2014).

Thus, the effects of climate change on Niger's natural and agro-sylvo-pastoral systems are significant: (1) a decrease in crop production (shorter agricultural season, reduction in yields, losses of harvests, loss of arable land); (2) a decline in livestock production (decrease in fodder and water availability, increased mortality in the event of drought or flooding, diseases) as experienced during the 2005 floods, with the loss of more than 8,000 head of livestock, and several thousand during the 2009 drought; (3) a reduction in forest resources (over-exploitation, fires, strong winds); and (4) a reduction in fisheries production (early drying-up of ponds, lower water quality)(FIDA, 2013).

In Niger, land degradation is caused by multiple forces, including extreme and erratic weather conditions, particularly drought and heat, and human activities (deforestation, overgrazing, continuous cropping and pollution) coupled with a lack of coherent environmental policies. Indeed, the desert is advancing by 200,000 ha each year and government reforestation programs to reclaim 215,000 ha each year face recurrent droughts and increasing demand for wood and farmland. Since 1990, forest land has decreased by one third and covers only 1% of the country's area.

Furthermore, Niger still suffers from climate hazards as in the 2009 drought which is reported to be among the most severe experienced by the Nigerien population. Although the main cultivated crops are well adapted to the tough climate conditions of the country, insufficient rains caused national crop production to drop by 31%compared to 2008 (IRIN, 2010). But as climate hazard floods also affect the Nigerien population recently many households are negatively impacted by floods in 2020.

Though, the direct impact of drought in Niger is the cereal deficit which, at the national level, is linked to dry years. The country's cereal balance analysis over the past thirty years (Figure 4) confirms the trend. The droughts of 1982, 1983, 1984, 2004, 2009, and 2013 affected the whole country, and were also years of agricultural production deficits and food crises (Moussa et al., 2022).

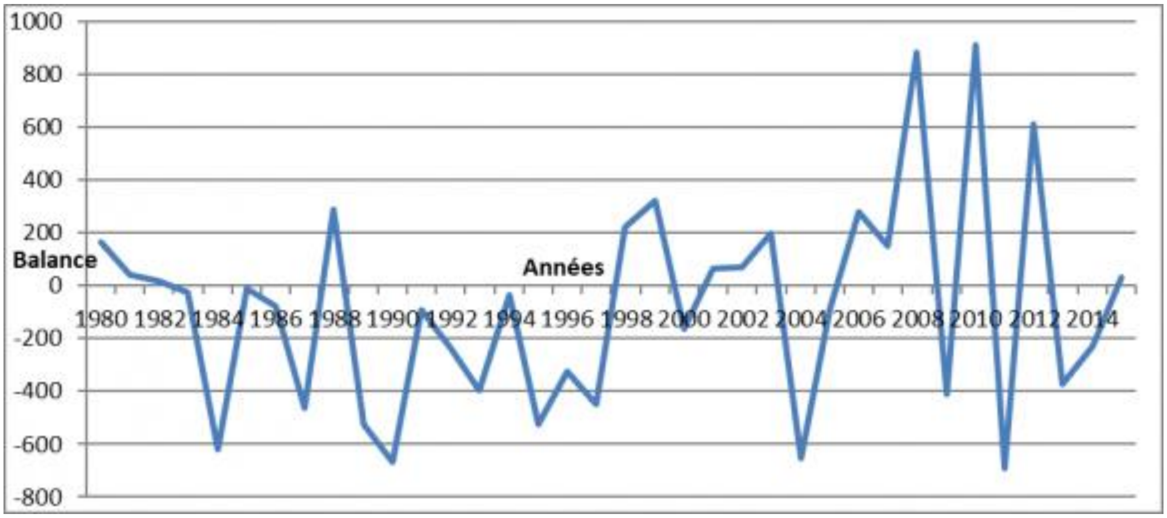

Figure 8:the evolution of the national cereal production balance between 1980 and 2014

Source: Moussa et al, (2022)

Highlighted in the study farmers' perception and adaptation strategies to climate change in Niger, the authors argued that the most climate variability felling by farmers is increasing in temperature, irregular rainfall patterns, aridity of the climate, reduction in water and fodder availability(Tidjani et al.,2016, Assoumana et al.,2016).

In the Dakoro department of Niger, it is highly recognized that domestic tasks, such as childcare, maintenance of the house, and food preparation, are the domain of women and cannot be undertaken by men, therefore women are not engaged in economic activity. Whereas concerning men will have the responsibility to provide all the household income. Men are typically in charge of livestock or crop production and the cash from sales; women are typically responsible for domestic tasks such as food preparation and fetching water for household use(FAO & CARE, 2019).

1.6 Adaptation practices in Niger

Adamou et al., (2021) indicate some strategies which are developed to reduce the negative effects of climate risks in Niger in order to improve food production during the dry season. The different practices of adaptation are:

- Irrigation, in Niger irrigated crops are mainly rice for home consumption and for the local market, along with a range of horticultural products for local and export markets. Niger's population has been practicing subsistence or economic irrigation for many years and with potential irrigable land estimated at 270,000 ha or about 2% of the cultivable area, only 76600ha have yet been exploited. Thus, the use of this practice by farmers is very low.
- Techniques of water conservation and soil restoration, these allow populations to manage their ecosystems and improve their agricultural production. These techniques help to better prepare the population for environmental changes (changes in climate and land degradation) and shocks, including drought. The techniques are well developed in regions where the annual rainfall amount is lower than 600 mm, which includes more than 90% of the country's total landmass. These techniques have helped to recover important land and they can also help to increase crop yields up to 200%. the main techniques are: trays arrangement (half-moons, Nardi Trenches, benches), slope arrangement (manual trenches, filtering dykes), landscaping of glacis (stony cords, filtering dykes, Zaï), and development of the lowlands (thresholds for water spreading, micro-dams).
- Crop diversification consists of farming systems that combine cash crops and food crops. In Niger, this practice varies across agro-ecological zones and ethnic groups. Most farmers opt for crop production systems based on the associated cultivation of millet, sorghum and cowpea. Intercropping also makes it possible to mitigate production risks by combining crops with different seasonal growth characteristic.
- The development of new varieties of crops which are more drought tolerant. In Niger it concerns millet variety because it the most cultivated crop in Niger. In terms of area, it occupies 63% of the land planted with cereal crops. Its production varies with the agro-climatic conditions of the growing areas.

- Conservation agriculture plays a crucial role in the cropping systems of dryland regions such as Niger. It aims to produce high crop yields while reducing production costs, maintaining soil fertility and conserving water. These include: maintaining soil cover, mixing and rotating crops; zero tillage, minimum tillage and animal traction; mulching (crop residues, pruning, and other plant materials); intercropping, relay cropping, sequential cropping, and the use of animal droppings.
- Agroforestry, which consists of land-use systems that combine the use of trees, animals and crops in cropping systems, is practiced in Niger. Agroforestry improves livelihoods in smallholder cropping systems. Agroforestry parklands constitute one of the most dominant vegetation types in Niger while also playing a great role in fighting land degradation such as desertification.

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Chapter Two: Literature Review

2.1 Introduction

This chapter provides different literature related to how gender dimensions are considered in the different strategies of adaptation to climate change among farming households in general. Therefore, the conceptual analytical framework illustrates the relationship between gender climate change, adaptation, and vulnerability. It is also important to review the different studies on climate change impacts in Niger, the literature on climate change impact on gender dimensions, strategies of adaptation, and constraints of adaptation to climate change. Finally, this study shows the theoretical and empirical studies on gender analysis with climate change and gender empowerment index in agriculture.

2.2 Conceptual analytical framework

It is recognized that climate hazards have differentiated impacts on the member of the community. Certain social groups become more affected and have less capacity to cope with climate shocks, then particular attention is according to examining if adaptation to climate change is gender-differentiated in the community. Though, this literature starts by giving the definition of gender afterward the different concepts related to climate change and its impact in Niger.

Thus, gender refers to the economic, social, political, and cultural attributes and opportunities associated with being women and men. The social definitions of what it means to be a woman or a man vary among cultures and change over time. Gender is a sociocultural expression of particular characteristics and roles that are associated with certain groups of people with reference to their sex and sexuality(Jhpiego, 2016).

Gender is one of a number of categories, including ethnicity, class, age, and geographical location, which affect the ability of women and men to benefit from climate change adaptation technologies(Huyer, 2016). Thereby, Gender-responsive climate policy aims to ensure that women benefit from climate policy implementation as much as men. It addresses women’s aspirations and priorities specifically. It is created through processes that listen to women’s voices and incorporate women’s contributions along with men’s(Huyer et al., 2015).

According to Intergovernmental Panel on Climate Change (IPCC), Climate change is defined as a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. While United Nations Framework Convention on Climate Change (UNFCCC), climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods(IPCC, 2007).

Though, to cope with the negative effects of climate change, peoples have to adopt certain strategies and practices to reduce the risks.

Thus, UNFCCC defines adaptation as actions taken to help communities and ecosystems to cope with changing climate conditions. The IPCC describes it as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Thus, it refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. However, the impact of climate change differs between and within the community because of their vulnerability certain have difficulty to adapt with climate hazards such as drought, floods, etc. Vulnerability in the context of climate change refers to 'the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity, and the adaptive capacity of that system (IPCC, 2007).

The conceptual framework of this research bases on understanding gender dimensions to cope with climate change. Thus, the study uses the framework provided by the International Food Policy Research Institute (IFPRI, 2011) to examine the differential impact and response of women and men to cope with climate change and for understanding the importance of information, livelihood resilience, institutions, and asset accumulation in terms of vulnerability to climate change and adaptation responses (Goh, 2012). The framework in this study is to understand the relationship of factors such as user characteristics, biophysical characteristics, information, technology, land tenure, institutional arrangements and social capital through farmer group organization with an appropriate response of adaptation enhance the gender empowerment in agriculture thereby, improving the well-being outcomes.

However, the first component user characteristics cover the fact that some individuals or groups may be more vulnerable to climate change impacts given their livelihood activities, disposal assets, gender, sociocultural norms, or cognitive ability. The second component biophysical characteristics describe the sensitivity of physical or ecological systems, for example, agricultural systems that individuals, households, or communities rely on for livelihoods; the third component information and technology refer to the access of actors to information about climate risks and appropriate responses. The accessibility of actors to land reduces the vulnerability and enhances actors' decision making in adaptation practices. The fourth component of vulnerability are institutional arrangements these represent the markets, laws, policies, and sociocultural norms that influence how different actors are affected by and respond to climate change; also the social capital through farmer group organization could help individuals, households and communities to share knowledge, accumulate assets and build resilience to climate change. Across these factors, a climate signal such as long-term changes in average climate conditions, changes in climate variability patterns, or extreme weather events (such as droughts, floods) may affect actors differently in terms of their assets, strategies of adaptation and decision-making power in the four domain such political, social, economic and agriculture in the adaptation arena, with different well-being outcomes at different spatial and temporal scales.

Hence, the adaptation arena captures actors, their resources, and their behavior, which can be studied at the gender of individual within the household and community levels. The interaction of climate shock, the vulnerability context, and the adaptation arena eventually improve positively the gender empowerment index, and well-being consequently. So, if actors are empowered that can have important feedback in term of reduces the vulnerability context.

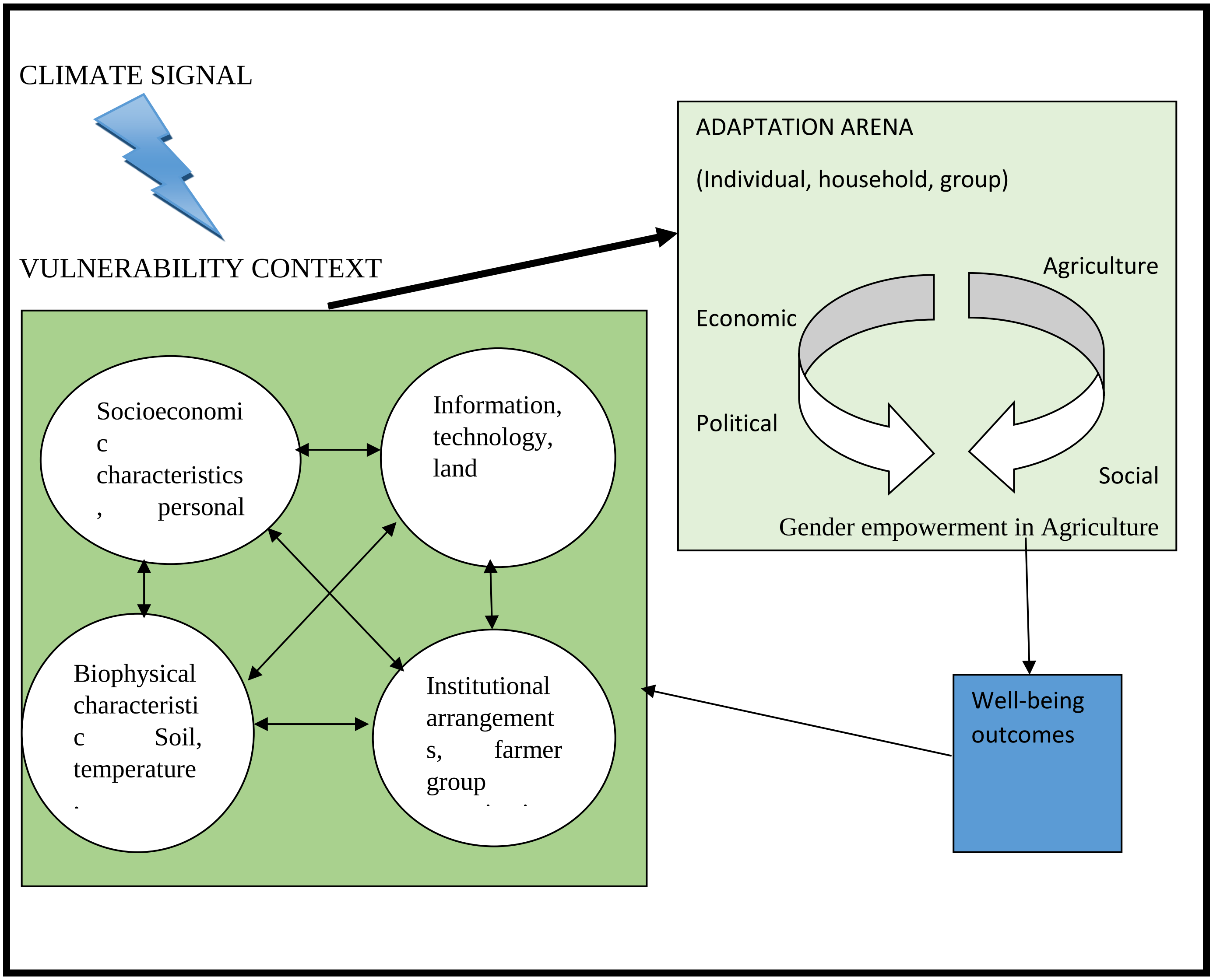

Figure 9:Conceptual Framework for assessing the interaction between gender, adaptation and empowerment under Climate risk:

Source: adopted from Goh, (2012).

2.2.1 Climate Change and Gender

Climate change impacts men and women differently, given their different roles and responsibilities at the household and community levels. Women are more exposed and vulnerable to climate change because they are often poorer, receive less education, and are not involved in political and household decision-making processes that affect their lives. Cultural norms related to gender sometimes limit the ability of women to make quick decisions on whether to move to safer grounds in disaster situations until it is too late(UNDP, 2013). According to Okali & Naess, (2013), the introduction of a separate program for women was a major policy choice from the outset. Plans were laid early in the 1970s for the collection of sex-disaggregated data to demonstrate the value of women to the functioning of the economy and household. In terms of agricultural production, women were invariably shown to work longer hours than men; to be more likely to grow food crops for home consumption than men; to have more limited access to physical assets than men for their independent farming; to spend more time caring for children and the sick; and to undertake more household chores including the collection of firewood and water. Their rewards, in terms of cash or other benefits, were consistently recorded to be minimal compared with those of men.

In the context of climate change, gender disparities in vulnerability are likely to magnify inequalities in intra-household bargaining power, with implications for gender equality and women's rights at both the micro and macro levels. Rising familial burdens due to male out-migration and declining food and water security, coupled with a relative inability to employ productive assets to cope with climatic shocks, should decrease female income generation capabilities, mobility, opportunities to build human capital, and access to formal credit markets. That can reinforce gender disparities in the household division of labor and heighten female reliance on male income, which increases the opportunity costs of divorce and reduces women's independence. These effects can also increase the likelihood that gender discrimination and stereotypes will persist across generational divides. Because parents have the incentive to prepare children for what they expect their adult responsibilities to be, and because children learn via socialization, the greater the level of female subordination in the household, the more likely these norms will be passed along(Eastin, 2018).

As highlighted by Nagasha, the different roles of men and women were affected by the stressors to which they have exposed hence their copying behavior. Socialization may influence one's potential to respond to climate change effects regardless of sex. It may alter the gender roles, as men or women will have to take appropriate responses to the impact of climate change irrespective of gender (Nagasha et al., 2019). Therefore, FAO and CARE demonstrate a gender-transformative approaches, which create opportunities for individuals to actively challenge existing gender norms, promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders, are key to addressing the threats posed by climate change, especially threats to women and girls in developing countries(FAO & CARE, 2019).

According to Roehr, (2007), women in the South suffer the most and have the least capacities (economic, information, education, etc.) to adapt to climate change and to prepare for the effects. Whereas both women and men in the global North need to adapt their consumption behavior and daily life routines in order to mitigate climate change, they are differently affected by natural disasters and changing weather conditions too. In developing countries, women are more vulnerable to the effects of climate change than men, because of their dependent on livelihood in natural resources that are threatened by climate change, due to the higher rate of poor women in the world (UN Women, 2009).

However, rural women and men increasingly face the challenge of having to adapt their production systems within the context of climate change and natural resource depletion. Women farmers are more exposed to climate change risks compared with men. They tend to be more dependent on natural resources for their livelihood, have fewer endowments and entitlements to help them absorb shocks, and may not equally benefit from agricultural technologies and practices. Climate change can exacerbate existing gender inequalities in agriculture, but also create new opportunities to tap into women's potential as agents of change and resilience building(FAO & CARE, 2019).

Quisumbing et al. (2011) founded that in Uganda, floods have a positive effect on husbands' land accumulation. While in Bangladesh, flood shocks negatively affect only husbands' land accumulation. However, drought shocks have a negative impact on husbands' nonland assets (mostly agricultural and consumer durables) in Bangladesh.

In some cases, the climate hazard can make women less vulnerable, like the repeated droughts in Niger which strengthened women's control over livestock because they were able to invoke a cultural norm that made men responsible for household food security, with the result that men had to sell their livestock before women's(Kristjanson. P et al., 2014). However, in another study, the same authors found that many women in the Sahel felt that they would lose traditional access to resources if competition for rangeland and other livestock resources increased due to increasing climatic vagaries.

In Uruguay, gender dialogues were organized as one of six adaptation dialogues to find out more about the realities of different sectors to inform the National Adaptation Plan (NAP). The dialogue revealed that some women do not know how to respond to climate change; others do not realize that some of the practices they are currently undertaking are actually in line with national adaptation recommendations; and, for others, the climate change language acts as a barrier. Women were given space to outline how their roles as producers could be incorporated into plans to adapt to climate change. Suggestions from rural producers were documented and fed back to government circles. Results from this work will inform the high-profile Gender Equality Plan and the NAP Roadmap for agriculture (FAO & UNDP, 2018).

However, the gender gap in agriculture refers to the fact that women typically have less access to and control over productive assets, inputs, productive resources, and services needed to make the most productive use of their time. Moreover, women often have less decision-making authority in the household and community. These social and institutional barriers lead to a gender gap that hinders women's productivity and reduces their contributions to agriculture and achievement of broader economic and social development goals. In many developing countries the agricultural sector is underperforming for a variety of reasons. One of the main underlying causes is that women lack resources, services, and employment opportunities, although they play a major role in agriculture as farmers, workers, and entrepreneurs. Closing the gender gap in agriculture produces significant gains not only for women but for society as a whole, by increasing agricultural productivity, reducing poverty and hunger, and promoting economic growth (FAO & World Bank, 2017).

Ume et al., (2021) used off-farm income as an indicator of adaptive capacity, female-headed households were found to have a higher vulnerability score. This means that more female-headed households rely only on farming for income. The high agriculture dependency index of female-headed households suggests that female-headed households might be very sensitive to climate change impacts, as agriculture, being a very volatile and unpredictable enterprise, is subject to total loss once there is a climate event such as flooding, heat-wave, or even disease outbreak.

Nevertheless, the study on the experiences of smallholder crop farmers in the transition zone of Ghana concludes that there are some differences between female and male farmers' adaptation strategies. Whilst men are more into on-farm agronomic practices, women are interested and utilize more off-farm adaptation strategies especially petty trading, in addition to the on-farm agronomic practices. Petty trading which is linked to the traditional roles of women, therefore, provides some form of resilience to climate change as well as empowering women (Wrigley-Asante et al., 2017). Further, Twyman et al., (2014) argued that there are gender differences in setting up food storage facilities because of social norms in Kaffrine (Senegal) men are more engaged in on-farm agriculture production while women are in off-farm activities. Fadina & Barjolle, (2018) have also found a similar where female household heads are more implicated in the diversification of income-generating activities like trade as an adaptation to climate change in the Zou Department of Benin.

Though, female–headed households are more vulnerable to livelihood strategies, socio-demographic profile, social networks, water, and food, whereas male-headed households are more vulnerable to health. Furthermore, female-headed households have the least adaptive capacities. In all, female-headed farming households are more vulnerable to climate change and variability than male-headed farming households(Alhassan & Kuwornu, 2019).

Tall et al., (2014), found wide differences in women's local capacities and adaptation needs in information services, anchored in differing degrees of access to opportunities and social constraints limiting empowerment. To counter with negative effects of climate hazards in Ghana female heads of farm households mainly relied on borrowed money from village savings and loans groups, and do small business of fruits, vegetables, and firewood. Whereas male heads of farm households mainly sold livestock and temporary migration to look for jobs(Assan et al., 2018).

2.2.2 Climate change adaptation

Given that the agriculture sector is the most vulnerable to climate risks, the International United Nation for Agriculture has developed Climate-smart agriculture (CSA) as an adaptation strategy to overcome challenges due to climate change.

The CSA aims to increase sustainable agricultural production by adapting to and building resilience to climate change. It focuses on food security and national development goals and, where possible, it also aims to reduce or remove GHG emissions. Thus, the Climate Smart Village (CSV) approach is implemented to address climate challenges and food security. It is part of the agriculture research-for-development approach to test, through participatory methods, technological and institutional options for dealing with climate change in agriculture. It aims to generate evidence at local scales of what climate-smart agricultural options work best, where, why, and how, and use this evidence to draw out lessons for policymakers, agricultural development practitioners, and investors from local to global levels(Aggarwal et al., 2018).

Though, smallholder farmers need information and knowledge on appropriate climate-smart agriculture (CSA) practices, technologies, and institutional innovations in order to effectively adapt to changing climatic conditions and cope with climate variability. Mary et al.,(2017) assessed farmer adoption of climate-smart agricultural practices and innovation in Lushoto (Tanzania). They mentioned the following CSA practices: soil and water conservation practices, forestry innovations and environmental conservation strategies, cropping innovations and livelihood diversification, and improving access to finance through collective action, and weather information services. They also found that the most important CSA technologies and practices used in Lushoto by women were intercropping, strip cropping, and the use of inorganic fertilizers. Whereas for men, the practices were minimal tillage, cut and carry feeding for livestock, and improved crop varieties.

Ndamani & Watanabe, (2016) found that the most farmers who perceived climate change in Ghana have used adaptation practices crop diversification, changing the planting date, improved crop varieties, farm diversification measures, income-generating activities, agroforestry, and irrigation to mitigate the effects of climate change on their farming activities. According to Diiro et al (2016), more the farmer’s system is diversified, more the climate resilient is it. The most important adaptation methods influencing positively farmers' crop yield are mixed farming, irrigation, fertilizers, and improved seed varieties.

The farmers in Ekiti State (Nigeria) gave a list of many climate change adaptation strategies they had been using over the years. The changing of planting and harvest time was the most wide adaptation strategy used by farmers while the use of acclimated crop varieties was least adopted as a climate change method of adaptation. They used also mulching and soil conservation, planting of cover crops and trees and irrigation systems (Ajayi, 2011).

Farmers in Uganda used both men and women reported adopting new crop management practices equally to cope with climate hazards. The most used was intercropping, followed by dry planting before the rains started, earlier planting, adopting drought-resistant varieties, and making adjustments in the timing of weeding and harvesting. Less frequently, farmers said they had begun rotating crops and integrating crops, livestock, and trees. Only a few farmers reported using improved seeds. Whereas in Ghana men reported using new crop varieties, new tree crops (mango, cashew, citrus, and papaya), new livestock species, inorganic fertilizers, and other agrochemicals. While women reported having introduced new vegetable crops such as moringa, spinach, and cabbage, starting to make compost, and planting in rows across slopes to better capture and retain rainwater(Jost et al., 2015).

According to FAO & UNDP (2020), coping strategies in response to climate risks in Zambia are gendered in the households involved in the cashew sector. In general, farmers are engaged in livelihood diversification and income-generating activities to cope with prolonged dry spells and droughts, flash floods, increased temperatures, and the late onset of rains. In times of stress, women depend on piece work, laboring in the fields of resource-rich people rather than their own. While this appears to meet their immediate needs, it locks their households in a hand-to-mouth cycle. Men commonly tend to pursue coping strategies that are natural resources based, in some cases contributing to environmental degradation, such as unsustainable fishing or wild fruit gathering as well as making non-timber forestry products and charcoal burning. Compared to male-headed households, it appears that female-headed households have fewer financial resources and information to cope with the plant diseases and pests resulting from unfavorable weather conditions.

Most of the adaptation strategies doing by women farmers in response to erratic rainfall and increasing temperature are: changing sowing and harvesting times, dry season gardening, soil conservation, and growing new crops Furthermore, mixed farming is an important source of additional income for families. Two main socio-economic strategies adopted to generate additional income included petty trading and out-migration. Migration was occasionally adopted by relatively younger women (less than 30 years), whereas the agro-biodiversity strategies were adopted by married women aged 20–50 years. The use of agrochemical inputs and irrigation schemes is low among all the socially differentiated groups of women farmers. Marital status influenced the choice of an adaptation strategy (Lawson et al., 2020).

According to Fadina & Barjolle, (2018), farmers in Benin have developed an adaptation strategy in order to reduce the negative impact of climate change. These include Crop–livestock diversification (mixed cropping, intercropping, and crop rotation) and other good practices (mulching, organic fertilizer); Use of improved varieties, chemical fertilizers, and pesticides; Agroforestry and perennial plantation (oil palm, orchard, tree species) and Diversification of income-generating activities. These various strategies adopted by farmers are seeking to strengthen their farming systems through agro-biodiversity.

Whatever the choice, the farmers aim to ensure a minimum harvest for their own food security. In an attempt to reduce the adverse impacts of climate change and variability, farmers in rice production employ several strategies to cope with climate change and variability. The most adaptation practices are the use of climate tolerant varieties, early planting of rice, diversification into non-farm activities, mulching of paddy fields, use of zero tillage, and use of early maturing rice variety. Farmers also suggest other adaptation strategies include, increased/reduced farm sizes cultivated, application of organic fertilizers, transplanting of rice seed, access to rural services of credit, and other necessary inputs in an attempt to reduce the negative impacts of climate variability on their livelihoods(Kim et al., 2017).

The socio-economic team of Advancing Capacity to Support Climate Change Adaptations (ACCCA) indicated that the most common adaptation strategies include: the use of different crop varieties, soil and water conservation, changing planting dates, use of external fertilizer, borrowing lost local crops from the community, and using short-duration crops. cited in (Juana et al., 2013).

The Study on Rural Farmers' Approach to Drought Adaptation: Lessons from Crop Farmers in Ghana, found that farmers' adaptation to drought differs across various agroecological locations in Ghana. The study reveals that drought adaption measures differ significantly among farmers in the Forest, Transitional, and Savannah zones of Ghana. Therefore, the most commonly adopted drought adaptation measures comprise the application of agro-chemicals, changing of planting date, cultivating different crops, integration of crop and livestock production, changing the location of the crop on yearly basis, diversifying from farm to non-farm income generation activities, cultivation of early maturing crops, and drought monitoring (Dumba et al., 2021).

Olanike (2021), highlighted that indigenous adaptation strategies are the traditional conservative knowledge, experience, and practices that are products of repeated activities, communicated from parents and elders to younger ones through the socialization process, adopted as coping strategies to reduce the vulnerability and impacts of climate change. Indigenous adaptation strategies for alleviating the climate change impacts on agriculture and Agriculture Value Chain (AVC). The most indigenous adaptation strategies were: Preproduction phase (Bulk purchase of inputs at the group level, bush following, zero tillage, fragmented planting, late and early planting, and land intensification); Preproduction phase, Production phase (Mulching, thinning, supplanting, manual irrigation, nursery and transplanting, organic fertilizer, etc); Harvesting phase (Early/late harvesting, fragmented/installment/selected harvesting, on-farm sales of fresh crops, harvesting fresh); Storage (Air drying, sun drying, heat drying, application of pepper, storage under the roof, etc); Processing (Value addition, repackaging to enhance economic value, group purchase of materials); Marketing (Online marketing, e.g., mobile phone, group-marketing of produce, value-addition, selling on the farm and at the farm gate, direct sales to bigger companies and consumers) and Consumption (Avoiding bulk purchase, cooking what can is consumed at once, storage of used water for other purposes).

Egbule et al (2011), found the indigenous adaptive measures used by farmers to cushion the harmful effects of climate change were: changes in planting dates, changes in harvesting dates, Changes in the timing of land preparation activities, Increased weeding, multiple cropping, intensive manure application, intercropping main crops planted with subsidiaries at low densities, expansion of the cultivated land area, movement to a different site, mixed farming and use of wetland/river valley (e.g. fadama).

Ann & Anayochukwu (2016) found that adaptation measures used by farmers in coping with climate change effects in Ebonyi State of Nigeria included: cover cropping, increased fertilizer application, use of improved varieties of crops, adopting following and practice of mixed cropping. They practice other indigenous adaptation measures such as organic manure (use of humus), use

of fresh leaves (banana, plantain) for mulching, application of wood ash for liming, invoking of rain during a delay in the onset of rain through sacrifices to their gods known as “Chi”.
Balama et al (2016) founded farmers in Tanzania use as adaptation strategies crop diversification, changing the cropping calendar, adopting modern farming technologies, and increasing reliance on non-timber forest products.

Ojo & Baiyegunhi (2019) found that farmers affected by prolonged drought and incidences of the flood were more likely to adopt adaptation strategies on their farmlands. Therefore, smallholder rice farmers adopted at least one climate change adaptation strategy in response to changes in climatic conditions. The common adaptation strategies used by smallholder rice farmers in Nigeria were: the use of improved varieties, the use of agrochemicals, varying planting date, rearing of livestock, use of mulching, mixed cropping, mono-cropping, soil and water method, and varying farm size.

Smallholder farmers who observed the existence of climate variability in Namutumba District, Uganda had suitably chosen and implement one or more adaptation strategies as a means to reduce the adverse effects of the climate variability stresses. Thereby, adaptation strategies used by the majority of the household’s respondents included soil and water conservation, mixed farming, engaging in off-farm activities, use of mulching, use of manure, growing of food security crops and changing planting date. Other common adaptation strategies included crop water harvesting techniques, early planting, inter-cropping, crop rotation, cultivating in wetlands and rearing livestock. Adaptation strategies like changing the crop calendars with respect to the stress and use of drought-tolerant crops have low adoption rates in the area. However, in some cases, the farmers opt for such strategies owing to the fact that they have limited access to resources and choices because of socioeconomic factors (Ajak et al., 2018).

The study on Comparative Assessment of Local Farmers’ Perceptions of Meteorological Events and Adaptations Strategies in Niger Republic (Diffa and Aguie) showed that adaptation strategies used by farmers to cope with climate variability farmers adopted included crop diversification, different planting dates, planting trees, organic fertilizers and other strategies including resistant varieties to heat, increasing frequency of irrigation, changing fields in the study area (Toukal Assoumana et al., 2016).

Asfaw et al (2014) argued that the most common strategies households used to adapt to the effects of climate change in Niger included: diversification of income sources especially in pastoral areas and where climate change manifests through a change in rainfall patterns; migration is also a common strategy used mostly in the agricultural zones of the country; change in seeds varieties; use of anti-erosion methods and switches from livestock raising to crop production are also quite common strategies used, particularly in agricultural and agro-pastoral areas. Households in pastoral zones tend to engage more in dry-season agriculture and raise fewer sheep and switch to goats when facing changes in temperatures and in rainfall patterns.

2.2.3 Climate change adaptation barriers

Farmers perceived barriers to the use of adaptation practices are the unpredictability of weather, high farm input cost, lack of access to timely weather information, and lack of access to water resources, these form the most important barriers to farmers. Lack of credit facilities and agricultural subsidies and poor soil fertility were considered moderate constraints while limited numbers of agricultural extension officers, agricultural markets, and limited farm size and farm labor were generally considered to be less important barriers. The unpredictability of weather coupled with limited information from weather forecasts makes it difficult for farmers to plan ahead (Ndamani & Watanabe,2016).

The smallholder farmers' adaptation constraints to Climate Change in Chengdu were unpredictable weather, limited farm size, lack of access to timely weather information, inadequate farm labor, lack of access to water resources, poor soil fertility, high-cost farm inputs, limited access to agricultural markets, lack of credit facilities, limited access to agricultural extension services, as well as a lack of farming subsidies(Pickson & He, 2021)**.**

Diiro et al (2016), argued the most commonly cited constraints to climate resilient practices adoption are low agricultural productivity, declining soil fertility, and poor seed quality. However, female-headed households have to withstand specific barriers including lack of finances, labor shortages, and lack of access to land. In the same line Lawson et al.,(2020) argued that the lack of labor and finance, lack of access to land, and to adapted livestock breeds is also important barrier to climate resilient strategies, in particular for female farmers. Barriers to the adoption of adaptation strategies by women farmers were exposed based on age and the type of capital or assets accessible to them. Because of cultural norms most of the women farmers could not own land which affected their willingness to adopt innovative adaptation practices and strategies.

Several studies carried out in Africa pointed out many barriers, which challenged the ability of farmers to adapt to climate change. The main barriers identified are institutional factors, access to credit, lack of information, and irregularity of extension services (Fadina & Barjolle, 2018). This is similar to the findings of Assoumana et al., (2016), where farmers are attempting to adapt to on-going rainfall variability, but there were some constraints that hindered them to adopt appropriate measures. This includes lack of information, irregularity of extension agents, no subsidies, lack of access to improved crop varieties, poor government attention to climate problems, and low awareness level.

Some authors as Kim et al., (2017) found that inadequate capital, shortage of land, poor irrigation system and poor technical know-how of the farmers, scarcity of improved varieties, insufficient credit facilities, poor economic status of farmers, inadequate extension services and poor information on climate change, low subsidies on necessary inputs poor knowledge of mitigation and Adaptation and late supply of fertilizers and other agro-chemical constitute the major hindrances for farmers to adapt with climate risk hazard.

Leal Filho et al (2021) argued that in Seychelles fragile institutions and inadequate governance related to climate change as barriers to adaptation to climate change. The second barrier was limited scientific knowledge and understanding of how climate change impacts the country. Another barrier was the lack of appropriate knowledge and quality data further widening the adaptation deficit margin in Seychelles. Social and cultural barriers also can emerge in response to pre-existing perceptions of risk, beliefs, values, and preferences that underpin the ways individuals and societies experience, understand, and respond to climate change. Finally, legacy barriers are another set of adaptation barriers that are common in Seychelles and other developing countries. One of the legacy barriers in Seychelles that put to test the nation's capacity to adapt to climate change relates to land use planning in the past that affects the drainage of rainwater.

Egbule et al (2011), found in their study the major constraints farmers face in adapting to climate change in northern Nigeria were: the lack of financial resources, non-availability of credit facilities, high cost of irrigation facilities, absence of government policy on adaptation, lack of access to weather forecasts, poor access to information source relevant to adaptation, poor/low extension services, limited access to improved crop varieties, lack of access to improved livestock breeds, non-availability of storage facilities, limited presence of adaptation measures, poor response to crises related to climate change by the government and interest groups, risk of adaptation, high cost of fertilizers and other inputs, non-availability of farm inputs, non-availability of processing facilities, inadequate knowledge of how to cope, high cost of farm labor, and non-availability of storage facilities.

Ndamani & Watanabe (2016) classified farmers' perceived constraints on the use of adaptation practices as major, moderate, and low. Therefore, the unpredictability of weather, high farm input cost, lack of access to timely weather information, and lack of access to water resources are the most important barriers to farmers. Lack of credit facilities and agricultural subsidies and poor soil fertility were considered moderate constraints while limited numbers of agricultural extension officers, agricultural markets, and limited farm size and farm labor were generally considered to be less important barriers.

However, the study on male poultry egg farmers in Rivers State Nigeria used principal component analysis (PCA) and founded five constraining factors. These are factor 1 named access to climate information, interest rate, and land tenure constraints; Under factor 2 the constraining variables were awareness of climate finance and poultry facilities; The constraints that weighed under factor 3 were poultry production and adaptation strategies constraints; the factor 4 regrouped farmland, farmer association and extension service constraints and the loaded constraints under factor 5 included collateral and government responsiveness (Aroyehun & Henri-Ukoha, 2021).

Otitoju & Enete (2016) argued that the principal constraints that the food crop farmers in South-west, Nigeria faced in climate change adaptation strategies using principal component analysis (PCA) were: under factor 1: public, institutional, and labor constraint; Under factor 2: land, neighborhood norms, and religious beliefs; Factor 3: the high cost of inputs, traditional beliefs/ practices (e.g. commencement of the farming season, crop festival), illiteracy of the food crop farmers, technological and information constraints. The variables under factor 4: are farm distance, access to climate information, off-farm job and credit constraints, and factor 5: is poor agricultural program and service delivery constraints. Ann & Anayochukwu (2016) identified three (3) factors that might constitute a great barrier to climate change adaptation in the Ebonyi State of Nigeria. The results from the principal component analysis given, factor 1 named cultural/environmental constraints; factor 2 named social /institutional constraints, and factor 3 named financial/ economic constraints

2.2.4 Gender Empowerment in the agriculture sector

The Women's Empowerment in Agriculture Index (WEAI) measures the empowerment, agency, and inclusion of women in the agriculture sector in an effort to identify ways to overcome those obstacles and constraints. The Index is a significant innovation in its field and aims to increase understanding of the connections between women's empowerment, food security, and agricultural growth. It measures the roles and extent of women's engagement in the agriculture sector in five domains: (1) decisions about agricultural production, (2) access to and decision-making power over productive resources, (3) control over the use of income, (4) leadership in the community, and (5) time use. It also measures women's empowerment relative to men within their households.

Therefore, the WEIA is composed of two sub-indexes: the first measures the five domains of empowerment which assesses whether women are empowered across these five domains. For the women who are disempowered, it also shows the percentage of domains in which they meet the required threshold and thus experience sufficiency. The second measures the gender parity index (GPI) in empowerment within the household. It is an aggregate index reported at the country or regional level that is based on individual-level data on men and women within the same households. The GPI reflects the percentage of women who are as empowered as the men in their households. But for those households that have not achieved gender parity, the GPI sub-index shows the gap that needs to be closed for women to reach the same level of empowerment as men. Based on both Thus, WEAI shows the degree of empowered women in their households and communities and the degree of inequality between women and men within the household(USAID et al., 2012).

According to Alkire et al (2013), in Uganda, women have the highest 5DE score (0.79) whereas in Guatemala it is men. While in Guatemala women have the lowest 5DE score, in Bangladesh men have the lowest 5DE score (0.77). Therefore, in Guatemala's pilot region, nearly 37% of households have a disempowered woman and an empowered man, and only 7% have the reverse. In contrast, in Bangladesh, 17% of households have a woman who is disempowered and a man who is empowered, whereas almost 21% have it. However, gender parity is highest in the Bangladesh pilot and lowest in Guatemala. In Bangladesh, though, although the share of women enjoying parity with the primary males in their households is highest (59.8%), in the households that lack parity, the gap is 25.2%. In contrast, in Uganda, a lower percentage of women enjoy parity (54.4%), but in households lacking parity, the gap is lower (22.4%). In Guatemala, both indicators are worse, with only 35.8% of women enjoying parity and the remainder having the highest gap, at 29.1%.

Women's empowerment in agriculture in India based on the WEAI, the 5DE scores indicated that women in all four districts are disempowered (5DE < 0.80). Across districts, at least 80% of women are disempowered, with the highest proportion being in Maharajganj (95% women). The average inadequacy scores are lowest in Munger, and similar for the other three districts. While women on average have inadequacy in 40% of the domains in Munger, for UP and Bihar this proportion rises to slightly more than half. When the threshold changes from 20% to 40% and 60% showed that the magnitude of the decline in the disempowered headcount is greater than the magnitude of the increase in the average inadequacy scores across districts. However, the main driver of women's disempowerment is the absence of group membership, followed by women's lack of ownership of agricultural land and women's control over agricultural income and input in agricultural production (Gupta et al., 2019).

Hariharan et al (2020) found that, women in 52% of the households in the CSVs of Haryana have better levels of empowerment when compared to a level of non-empowerment in the households of non-CSVs. But in the case of Bihar, the women in both CSVs and non-CSVs are not adequately empowered. However, gender equality in each household was measured by subtracting the GEI-CSV of women from the GEI-CSV of men. In the CSVs of Haryana, 36.1% of women in the households who were less empowered were at par in gender equality with the men in the household whereas in the households where women were more empowered gender equality to is on the higher side. There are 76.9% of households where women have equal status with men. Women in a small share of households enjoyed higher status than men in their households in the CSVs of Haryana. In the less empowered households in the non-CSVs of Haryana, the majority of women have fewer benefits when compared to their counterparts.

Eastin (2018) argued that income and asset inequality coupled with rising familial burdens due to male out-migration, declining subsistence resource access, and increasing vulnerability to natural disasters diminish women's ability to achieve economic independence and enhance their human and social capital relative to men. The consequences of this on gender equality included reductions in intra-household bargaining power, as women become less capable of generating independent revenue. These constraints the advancement of laws and norms that can promote gender equality.

The report on women's empowerment in Kenya found that 29 percent of women aged 15-49 years in Kenya are empowered in 80 percent of the total weighted indicators set as a threshold. Women in urban areas are nearly twice (40%) as likely to be empowered compared to those in rural areas (22%). Some socio-economic characteristics found to be relevant to women's empowerment thereby, the incidence of women's empowerment is higher among households headed by men (30%) compared to those headed by women. Further, the incidence of women's empowerment was low (10%) among households where the head has completed no education compared to household heads who completed high education (62%). The marital status also showed that single and married women are more likely to be empowered, while the opposite is true for widowed women with only 12 percent of them empowered. Women in monogamous marriages are also more likely to be empowered compared to those in polygamous marriages. Empowerment is positively associated with household wealth. While only 6 percent of women belonging to the poorest wealth quintile are empowered, in the richest wealth quintile the rate reaches 53 percent. Other socio-economic characteristics are also relevant (Kenya National Bureau of Statistics et al., 2020).

Crookston et al (2021) analyzed whether Building the Resilience of Vulnerable Communities in Burkina Faso project, an agricultural development program, improved women's empowerment, as measured by the project-level Women's Empowerment in Agriculture Index (pro-WEAI). They found that the pro-WEAI of women in the comparison group experienced greater improvement in empowerment over time. Whereas men in the treatment, group experienced an improvement in empowerment and a decline in empowerment for men in the comparison group. Further, the drivers of disempowerment for both the treatment and comparison groups (for both men and women) over time were, membership in influential groups, access, and decisions on credit and finance, input in productive decisions, autonomy in income, and attitudes about domestic violence. Finding from Differences-in-differences (DID) estimation showed an increase in empowerment indicators for participants from the treatment group while the comparison group saw a decrease in average adequacy over time.

The study of Mekonnen (2022) found that women are less empowered in getting access to productive resources, decision-making over production, control over the use of income, community leadership roles, and time allocation in a household. This disempowerment of women in important agricultural domains will hamper women's efforts in enhancing production and productivity in the farming system and make them vulnerable to the impacts of climate change. Thereby, the results found that the gender parity index (GPI) of a wife on access to productive resources was 0.64, the GPI of a wife on decision-making over production was 0.65, the GPI on control over the use of income in a coupled household was 0.69, the GPI on community leadership was 0.58 and GPI on time allocation in a household was 0.49. The overall agricultural gender parity index in the study was 0.62. This indicates that wives were not empowered in a household as compared to husbands.

Hasan et al (2021) argued that empowering women in agriculture, specifically improving primary female decision makers ability to make independent choices regarding agricultural production in Bangladesh, is positively and significantly associated with productivity change, efficiency change, and technical change. Furthermore, they found that closing the gender parity gap is associated with higher farm productivity.

Abdu et al (2022) used cross-sectional data to investigate a nutrition-sensitive agriculture intervention implemented through FBOs in rural Ghana. The authors used Generalized linear mixed models to test the relations of empowerment and household gender equality with FBO membership, nutritional status, and household food security. The results show that women's FBO membership was positively associated with the individual indicators of women's empowerment related to attitudes about domestic violence, access to and decisions on financial services, mobility, group membership, membership in influential groups, and household gender parity index. However, household food insecurity but not nutritional status was positively associated with women's FBO participation and individual empowerment indicators like financial services. But food insecurity was negatively associated with the women's empowerment indicator related to attitudes toward domestic violence.

Highlighted that there is a link between women and food insecurity, due to women's limited access to resources, assets, and decision-making. The study on gender, empowerment, and households' food security status in Nigeria using a tobit and ordered probit regression model, found a low level of empowerment among households in Nigeria, but it was more pronounced with female-headed households. However, the level of food insecurity was lower among female-headed households compared to the male-headed households. The finding revealed that a majority of households in Nigeria were food secure and disempowerment. The results from tobit regression showed that male-headed households were less food insecure, empowerment index had a negative and significant implies that empowerment is directly related to households' food security. These results also show that high income, large family, and high educated were significant and associated with food security. Furthermore, the level of food insecurity was high among households residing in the rural sector and North West zone of the country. Though, the ordered probit regression found that male-headed households were in a more food-secure and empowered group than their female counterparts (Ashagidigbi et al., 2022).

Lufuke et al (2023) argued that with their prominent role in the kitchen and household food preparation, women offer an important avenue for addressing several challenges in relation to the food subsector. Empowering them with the necessary capabilities can lead to changes in various aspects of households' dietary patterns. Studies of Africa indicate that empowering women through physical capital, economic agency, and sociocultural factors can have a positive influence on either food security, diet improvements, or the enrichment of diet-related health.

2.3 Theoretical review

This section provides the theory of rational choice, utility, welfare, and gender empowerment

2.3.1 Rational choice and utility theory

Rational choice theory, also called rational action theory or choice theory, school of thought based on the assumption that individuals choose a course of action that is most in line with their personal preferences. Rational choice theory is used to model human decision-making, especially in the context of microeconomics, where it helps economists better understand the behavior of a society in terms of individual actions as explained through rationality, in which choices are consistent because they are made according to personal preference.

Rationality in the context of climate change adaptation is the fact that farmers have a set of adaptation practices and they make preferences on the choice of some practices under climate risks and budget constraints to maximize their production.

The rational choice theory makes two assumptions about individuals' preferences, these include:

- Completeness means that if we face an agent with two choices, she will necessarily have an opinion on which she likes more all actions can be ranked in an order of preference. For example, farmers will prefer crop rotation to irrigation.
- Transitivity means that an agent’s weak preferences can cycle only among choices that are indifferent. For example if plant drought-resistant crop is preferred irrigation, irrigation is preferred to agroforestry(Allingham, 2002).

However, Herbert Simon defined psychological principles of individual behavior and first recognized the imperfect access to information and limited computational capacities of individuals, which he called “bounded rationality”. Simon argued that only when choices are very simple and transparent does an individual behaves like a utility maximizer. However, when decisions are more complex, choices generally deviate from perfect rationality. In practice, decision-making occurs under time constraints, cognitive limitations, and imperfect or costly information. According to Simon, people are then unable to maximize their utility and instead will “satisfice”, i.e. make a choice that is “good enough” (Gsottbauer, 2013).

Though, rational choice in decision-making is modeled as an optimization of the utility function. Utility theory is concerned with people's choices and decisions. It is concerned also with preferences and with the judgement of preferability worth, value, goodness, or any of a number of similar concepts. This theory provides a methodological framework for the evaluation of alternative choices made by individuals, firms, and organizations. Utility refers to the satisfaction that each choice provides to the decision-makers. Thus, this theory assumes that any decision is made on the basis of the utility maximization principles according to which the best choice is the one that provides the highest utility (satisfaction) to the decision-makers. Utility theory is often used to explain the behavior of individual consumers In all cases the utility that the decision makers that is, farmers get from selecting a specific choice of climate change adaptation strategy is measured by a utility function U, which is a mathematical representation of the decision makers (farmers) system of preferences such that: U (x1) > U (x2), where the choice of the climate change adaptation x1 is preferred over choice x2 or Ux1 = Ux2, where choice x1 is indifferent from choice x2, that is both choices are equally preferred. For example, if a farmer prefers the adaptive option of planting drought-resistant crops over-irrigation farming and irrigation farming over crop rotation, his preferences would have the relation: U (plant drought-resistant crop) > U (irrigation) > U (crop rotation) (Allingham, 2002).

2.3.2 Welfare theory

Welfare economics is a branch of economics that uses microeconomic techniques to evaluate well-being from the allocation of productive factors to the desirability and economic efficiency within economy, often relative to competitive general equilibrium. It analyzes social welfare, however, measured in terms of the economic activities of the individuals that compose the theoretical society considered. Accordingly, individuals, with associated economic activities, are the basic units for aggregating to social welfare, whether of a group, a community, or a society, and there is no "social welfare" apart from the "welfare" associated with its individual units. Welfare economics typically takes individual preferences as given and stipulates a welfare improvement in Pareto efficiency terms from social state *A* to social state *B* if at least one person prefers *B* and no one else opposes it (Wikipedia). Well-being or welfare is a general term for the condition of an individual or group, for example, their social, economic, psychological, spiritual, or medical state; high well-being means that, in some sense, the individual or group's experience is positive, while low well-being is associated with the negative.

2.3.3 Gender empowerment theory

Firstly, gender schema theory is a perceptive theory which attempts to explain the process involved in maintaining and transmitting gender-linked qualities from one generation to another. Introduced by Sandra Bem in 1981, the theory shows that sex-linked information is mainly transmitted from one generation to another through "schemata," which is a systematic way of allowing some gender-associated information to be more imbibed by individuals within a society. This information consequently shapes the perception the society has about a particular gender in relation to the other gender, which eventually leads to gender stereotyping. The theory argues that the degree to which individuals become gender-stereotyped is influenced heavily by institutional factors and cultural transmissions such as norms, media, school, home training, etc. By institutional factors, the theory refers to configurations in society that steer people's behavior (norms, routines, and rules). This means that changing any negative stereotype will involve a transformation of existing norms, rules, and routines (Ume et al., 2021).

According to World Bank Empowerment is the ability of an individual or group to make a choice and transform it into desired action and get the results from it. The theory of empowerment is identified in Brazil in, 1973; Pluto Freire has used humanity theory in the context of empowering education. Pluto Freire has put forward a plan or strategy to liberate the oppressed community through education empowerment. He believes education plays an important role in empowering the community and thus liberates them from continuing to be oppressed. He added that empowerment through education will enhance the individual's ability to identify the ability and the ability of individuals to identify their capabilities and abilities in terms of knowledge and skills. However, this empowerment theory is not only focused on education, it has also been widely applied in various fields such as psychology, management, political theory, social work, education, women's studies, economics, and sociology cited in (Hafizan et al., 2018).

Further, the theory of empowerment involves two components which are personal and collective aspects. Personal empowerment relates to the way people think about themselves, as well as the knowledge, capacities, skills, and mastery to influence the social and political systems. Collective empowerment refers to processes by which individuals join together to break their solitude and silence, help one another, learn together, and develop skills for collective action to influence the political and social environment (Hur, 2006).

The empowerment theory links the well-being of individuals with a larger social, economic, and political environment. Thus, empowerment is focused on interventions that improve wellness, resolve problems, provide opportunities for individuals to develop knowledge and skills, and involve professionals as partners (Perkins & Zimmerman, 1995).

However, there are four main dimensions of empowerment, namely economic, social, psychological, and political. Thus, economic empowerment refers to the local community's access to productive resources, social empowerment refers to a situation in which a community's sense of cohesion and integrity has been confirmed or strengthened. Psychologically empowerment refers to optimism about the future and faith in the abilities of the community. The community is politically empowered when their voices and their concerns should guide the development of any project from the feasibility stage through to its implementation(Scheyvens, 1999).

The theory of empowerment is defined as a multidimensional aspect in sociology, psychology, economics, politics, and other dimensions. Further, empowerment is the social-action process through which people gain greater control, efficacy, and social justice. Through empowerment, participation in individual, community, and group activities is improved(Peterson et al., 2005). World Bank (2002), defined the theory of empowerment as mechanisms to support poor people's access to information; inclusion, and participation; creating social accountability mechanisms, and investing in poor people's organizational capacity to solve problems.

Empowerment theory is a participatory process through which individuals take control over their lives and environment. Thereby, empowerment has been viewed as a process and an outcome; as a process, empowerment involves relationships and the transfer of the power base from one group to another, with the outcome of "liberation, emancipation, energy and sharing power. As a social process, empowerment is linked with external social forces that act on the individual and affect one's sense of control and feelings of power (Shearer & Reed, 2004).

According to Sharma women's empowerment is when women are involved in the process of decision-making to change their level of self-confidence, especially about women's status and how women make decisions in their homes (Hafizan et al., 2018).

Sultana & Mahbub (2021), defined women's empowerment as the process of raising the status of women through education, awareness, literacy, and training. Women's empowerment equips and allows women to take life-determining decisions. They may get the opportunity to redefine gender roles, which in turn provides them more freedom to pursue desired goals.

2.4 Empirical review

This section provides some empirical studies on gender and climate change.

Analyzing the factors affecting the choice of adaptation methods to climate change based on cross-sectional survey data in the Nile basin of Ethiopia, using the multinomial logit (MNL) model to investigate the factors guiding household choices of climate change adaptation methods. The authors found a significant impact of household characteristics and institutional factors such as access to information, and credit on adaptation to climate change. Further, they argued that male-headed households adapt more readily to climate change(Tadesse et al., 2009). Further, the analysis of farmers' intention and decision to adapt to climate change in the Yom and Nan basins, Phichit province of Thailand. Using the MNL model, the results showed that male-head households adopted crop rotation practice more openly, changing from an old production site to another site, and altering rice varieties(Arunrat et al., 2017).

However, Onyeneke et al, (2012) using the MNL method in their study of Bayelsa communities in Nigeria found a contrary result, where female-headed households adapt more readily to climate change than male-headed households in adaptation to climate change. They argued that women are more engaged in agriculture activities than they have more experiences and information to manage practices of agriculture to cope with climate stress.

Theriault et al., (2017) using a multivariate probit model to a nationally representative household panel. Authors concluded that the determinants of adoption strategy sets are gender-differentiated. Hence, female plot managers are less likely to adopt yield-enhancing and soil-restoring strategies stets than males. Furthermore, they argued that the availability of household labor strongly influences the adoption of soil-restoring strategies by female plot managers. By contrast, household resources such as the extent of livestock owned, the value of non-farm income, and area planted to cotton affect the adoption choices of male plot managers.

Combining both multivariate and ordered probit models to analyze adoption decisions of a large number of on-farm in Soil and Water Conservation(SWC) practices, using a case study of West African Sahel. Baba et al., (2017) found a positive effect of the gender of the household's head in the adoption of SWC practices because of their limited control on productive resources female-headed households are less likely to intensify the use of SWC practices than male-headed households. Nevertheless, Ngigi et al., (2017), study shows that there are gendered risk perceptions regarding climate change that in turn influence actors' adaptive behavior. Moreover, gender-specific roles, responsibilities, and social norms are linked to differences in risk perceptions, access to resources, and participation in social groups influence coping strategies and adaptive behavior, and ultimately the well-being outcome in a gender-differentiated way. Further, group-based approaches benefit husbands and wives differently. However, extension services and farmers' training programs are still largely gender-blind.

The empirical study in analyzing the determinants of farm-level adaptation strategies to climate change in Southern Africa, using a multivariate discrete choice model and a cross-section database of three countries (South Africa, Zambia, and Zimbabwe). Finding, female-headed households are more likely to take up adaptation options than males. The plausible explanation is that, in most rural smallholder farming communities in the region, much of the agricultural work is done by women. Thus, women have more farming experience and information on various management practices and how to change them based on available information on climatic conditions and other factors such as markets and food needs of the households(Nhemachena et al., 2014).

Gender-differentiated impacts of climate variability were manifested in the unequal distribution of roles and responsibilities of men and women in the communities. Thus, women seem to bear the most burdens resulting from climate variability impacts, they have to work hard than men in order to increase their yield and income faced with climatic stressors(Babugura et al., 2010). According to Bryan et al.,(2013), several factors influence farmers' decision to adjust their livestock practices in response to perceived climate change. Therefore male-headed are more likely to change livestock feeds than women. This is due to the fact that women have limited resources than men to purchase supplemental feed. While, Kurukulasuriya et al (2006) used the multinomial logit model to analyze crop and livestock choice as climate change adaptation options in Burkina Faso, Cameroon, Ghana, Niger, Senegal, Egypt, Ethiopia and Kenya, South Africa, Zambia, and Zimbabwe. They found that farmers adapt to changes in climate by switching crops. The results of the choice models from the livestock study showed that farmers in warmer temperatures tend to choose goats and sheep as opposed to beef cattle and chicken. Goats and sheep can do better in dry and harsher conditions than beef cattle.

Nhemachena & Hassan (2007) examined farmers' adaptation strategies in South Africa, Zambia, and Zimbabwe. The results from the multivariate discrete choice analysis show that gender, years of farming experience, access to extension services, and access to credit facilities and markets are the significant determinants of adaptations to climate change in the region. In Ethiopia, Tadesse et al (2009) analyzed the determinants of farmers' choice of adaptation methods in the Nile Basin. Using cross-sectional data from a survey of farmers to illicit information on adaptation methods. Therefore, the level of education, age, sex, and household size of farmers were found to be significant determinants of adaptation to climate change in the study area. Also, farmers in different agro-ecological settings employ different adaptation methods

Fosu-Mensah et al (2012) conducted a survey of 180 farmers in the Sekyedumase District in the Ashanti Region of Ghana to investigate how they perceive long-term changes in temperature and rainfall over the past twenty years. The survey also posed questions about adaptations and barriers to adaptations. Results of logit regression analysis indicated that access to extension services, credit, soil fertility, and land tenure are the four most important factors that influence farmers' perception and adaptation. The main barriers included a lack of information on adaptation strategies, poverty, and lack of information on weather.

In Osun State, Nigeria, (Sofoluwe & Tijani, 2011) surveyed 100 farmers to gather information on their perceptions about changes in temperature and precipitation. The study used the Multinomial Logit Model to analyze the factors that determine farmers' adoption of various climate change adaptation measures. The regression results showed that livestock ownership, access to loans, off-farm income generation, gender, and household size are the significant determinants of adapting to climate change impacts.

Temesgen et al (2014) investigated to answer how farmers perceive climate change, what adaptation measures are farmers practicing in South Eastern Ethiopia, and the factors influencing adaptation to climate change. The study used the multinomial logit model (MNL) to analyze factors that affect the choice of adaptation methods. From the MNL result education, access to credit, access to weather information, total farm income, and household size are positively and significantly affect the likelihood of adapting by implementing a combination of multiple adaptation measures.

Menike & Arachchi (2016) used cross-sectional household surveys and binary logistic models for farmers' decision to undertake any adaptation at all for the smallholder farmers in a rural community in Sri Lanka. The result showed that the probability of undertaking any adaptation increases with the size of the family, higher educated farmers, being a member in a farmers' group, access to formal loans, less distance to input market, access to information through electronic media and growing beans as the main crop. However, farmers located in the alluvial plains and hilly arrears seem to do the most adaptation. Farmers expressed short-season crops, crops that are resistant to drought, irrigation, changing planting dates, and planting trees as the means they have employed to cope with climate change.

Maddison (2007) investigated the ability of farmers to detect and adapt to climate change. The study collected data from Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, and Zambia on the natural trends in temperature and precipitation, perceived barriers to adaptation, and socio-economic factors influencing adaptation in each country. Therefore, adaptation strategies across these countries varied from planting varieties of the same crop, changing the planting dates, increased the use of irrigation, to water and soil conservation techniques. However, some of the country's farmers indicated that they have made no adjustments to their agricultural practices. What the farmers considered as barriers to adaptation also differed among the countries. These barriers included lack of credit, lack of access to water and appropriate seed as well as lack of information about the weather or long-term climate change.

Acquah (2011) found that planting different varieties of crops, changing planting dates, and soil and water conservation as the main adaptation measures taken by farmers in Ghana to cope with climate change. The finding also reported that insufficient access to inputs, lack of knowledge about other adaptation options, and no access to water were the main climate change adaptation constraints. Other barriers included lack of credit and lack of information about climate change, high cost of adaptation, and insecure property rights. Furthermore, results revealed a high level of willingness to pay for mitigation policies among the farmers. Years of farming experience, ownership of farm land, farm size, and other income are significant predictors of the probability to pay for climate change mitigation policy.

The Study on Farmers ' Intention and Decision to Adapt to climate change: A case study in the Yom and Nan Basins, Phichit province of Thailand, The MNL estimation showed that male-headed households adopted more adaptation practices than female-headed. Finding also that farmers with more farm experience tend to have more expertise in practicing adaptation strategies to climate change; high education level, farm income, farm size, land ownership, having a large household, and access to credit were found to positively increase the probability of farmer adaptation; the distance from the output and input markets increases, farmers' adaptation to climate change decreases; Training attendance and social capital were highlighted, and significantly increase the probability of adaptation(Arunrat et al., 2017).

A multivariate probit (MVP) model was used to analyze the determinants of adaptation strategies adopted by smallholder rice farmers in southwest Nigeria. The findings that years of farming experience and the age of the head of household had a negative influence on the decision of farmers choice of adaptation. Therefore, younger farmers are more likely to choose adaptation strategies than older farmers unlike, farmers with more years of farming experience were less likely to adapt to climate change. Household size had a significantly positive influence on the choice of adaptation strategies to climate change. Furthermore, households with access to off-farm income, large sized, belong to in the association of a group of persons, and accessibility to credit and extension services were more likely to invest in climate change adaptation strategies. Also, climate change variables have a positive significant influence on the decisions of smallholder farmers to adopt climate change adaptation strategies(T. O. Ojo & Baiyegunhi, 2019).

Ajak et al. (2018), used the MNL model in the study on the Choice of Adaptation Strategies to Climate Variability among Smallholder Farmers in the Maize Based Cropping System in Namutumba District, Uganda. They found that the gender of the household head, belonging to a group, farming experience, level of education, access to extension services, having radio, and area under crop had a positive and significant effects on the probability of adoption of climate change adaptation strategies during the dry spells.

Ndamani & Watanabe (2016) using the logistic regression model found that the probability of adaptation rises with increased access to information, large household sizes, access to credit facilities, household income, membership in a farmer-based organizations (FBOs), education and access to the market. On the other hand, the probability of adaptation decreases with farming experience, this implied that the likelihood of adaptation to climate change decreases with older farmers. Balama et al (2016) assessed forest adjacent households' voices on perceptions and adaptation strategies to climate change in Kilombero District, Tanzania. The MNL estimation showed that household size, residence period the respondent lived in the study area, land ownership and household income were the socio-economic variables that positively influenced significantly adaptation strategies. But the Age of the respondent has negatively influenced significantly adaptation strategies.

2.5 Conclusion

In sum, the greater studies reported that climate change affects men and women differently, making women the most vulnerable because of their limited access to productive resources. The majority of papers used the gender of household heads as the basis of their analyses related to climate change, and few have considered the gender role intra-household analysis among farming households. Most analysis used the MNL model to determine the drivers of adaptation practices to climate change, the authors concluded that socioeconomic characteristics have a significant effect on the strategy of adaptation to climate change and there are some barriers that inhibit an effective adoption of climate change adaptation strategies. Very fewer research has analyzed the determinant focused on the level of adaptation and constraints to climate change in their analysis.

However, the women empowerment index in agriculture showed at the farming household the empowerment or not of women in the community or wives within the household through the five domains and gender parity index. Some research found that women were not empowered in getting access to productive resources, decision-making over production, control over the use of income, community leadership roles, and time allocation in a household. While others found that the adoption of climate-smart agriculture increases women's empowerment in agriculture.

Chapter Three: Methodology

3.1 Introduction

This thesis covers the four main agriculture production areas in Niger, within these the most vulnerable communes in each region are selected, and finally villages and households are randomly selected to administer the questionnaire for the primary data collection. The technique of survey is done within the household in which two persons (woman and man) responded to the question related to the use of adaptation practices to climate change in the agriculture sector. The secondary data like temperature and precipitation are collected from the National Statistical Institute (INS). However, the study uses as a proxy of gender women, men, young and old doing agriculture as their main activity. The multinomial logit model is used to analyze the determinants of farmers' (women and men) level of adaptation practices to climate change. The study uses also the principal component analysis and ordered logit for the factors/constraints analysis, at the end Fractional logit regression is used for gender empowerment index analysis. The chapter is organized as follows: study area, sampling design, sample size, data collection, data analysis, and expected added value.

3.2 Study area

This study focuses on Niger, specifically on the principal agricultural production zones of the country, which include Maradi, Zinder Thaoua and Dosso.

Thus, Maradi region is located in central southern Niger and covers an area of 41,796 km², representing 3.3% of Niger's surface area. Whereas, Zinder region is located in East Central Niger. The region has a surface area of 155,778 km², equivalent to 12.3% of the country's surface area. However, the region of Tahoua covers an area of 113,317 km2. Agriculture employs more than 80% of the population, covering around 28% of the region's total area. While, Dosso region, located in the southern part of Niger, it covers an area of 121,844 km², which is 8.7% of Niger's territory.

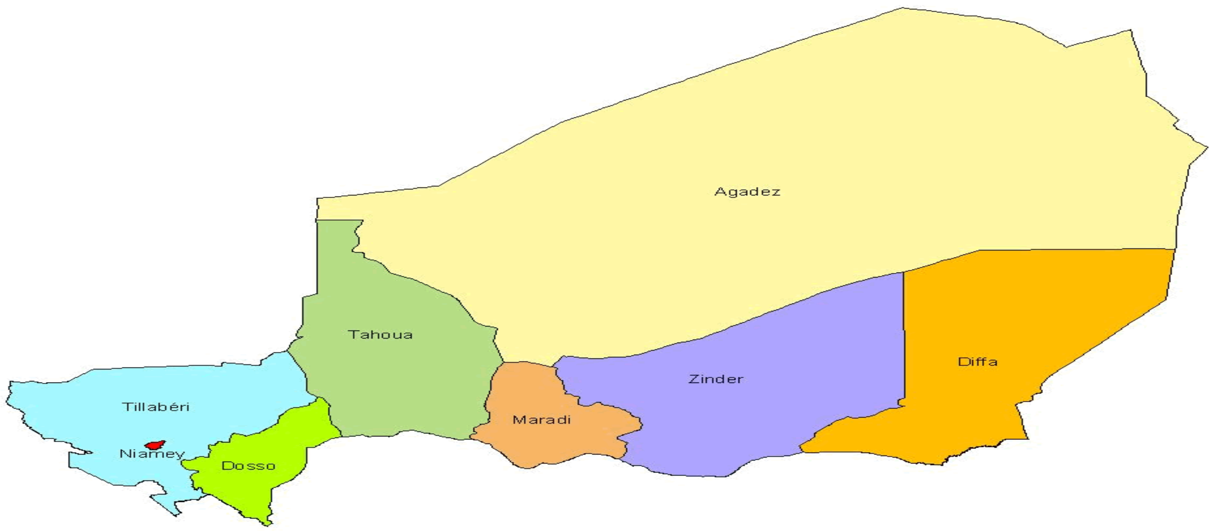

Figure 10:Map of Niger

3.3 Sampling design

The target population of this study will be agricultural households in Niger where sampling is farmers who cultivate the last year's growing season and the sample unit is a household in the community.

However, the multi-stage purposive sampling method is used in the selection of the respondents. The first stage aims to select regions where agriculture is the most practiced. After, the second stage consist to select two (2) communes that are in agricultural areas with the highest degree of vulnerability to climate change. The choice of communes is based on the report of the United Nations (2014), which identified thirty-five (35) communes with the highest degree of vulnerability in Niger. Among this, we take into account the spaciotemporal and financial accessibility of the village. The third stage is to select randomly four (4) villages by commune and from each village, agricultural households are randomly selected.

3.4 Sample size

According to the ministry of Agriculture female head in agriculture, activities was 7,43% and the male head was 92.6%, while the proportion of female farmers was 49% and 51% for males in 2018. Thus, in this study farmer is considered as a unit of the sample. In fact, that, the proportion of farmers by region is unknown, the study considers the same proportion to determine the sample size (**n_i**) for each region.

The sample size (n) of this study is given by the number of regions multiply by **n_i**.

the approach of the proportion method is as follows:

$$ni = \frac{z^2 \times p(1-p)}{\varepsilon^2}$$

Where p is the proportion of farmers in Niger; z is the z score and ε is the margin error.

According to the National Statistical Institute in Niger agricultural sector employed 87% of the population, hence p=87% with a 95% level of confidence which gives a z score of 1.96 and 5% of margin error.

$$ni = \frac{1.96^2 \times 0.87(1-0.87)}{0.05^2} = 174$$

Given that the selection of a minimum of 174 farmers by sex in each region for this study. Therefore, twenty-two (22) questionnaires should be administrated by sex from each village, this gives a total of eighty-eight (88) questionnaires by commune, and the sample size by region is **ni=176.**

The sample size of this study is $n = 176 \times 4 = 704$

Thus, the study area will cover the first four (4) regions of Niger namely, Maradi, Zinder, Tahoua, and Dosso. Eight (8) communes such as Falwe, Sokorbe, Djirataoua, Chadakori, Allakeye, Bangui, Goge, and Gafarti; thirty-two (32) villages and 704 farmers (male and female).

3.5 Data Type and data collection

This study used both primary and secondary data. however, to analyze the effect of climate variables on farmers and their agricultural production. the secondary data was collected like rainfall and temperature from the National Statistical Institute of Niger.

The primary data was collected using a questionnaire. This collection is important to have micro-level information on adaptation strategies of farmers by gender different from the study area across the southern part of Niger. the data was collected with the help of three research assistants for each region. The data collection was focused on information like socio-economic characteristics of the household, the awareness and the source of information of farmers on climate change, the strategies of adaptation done by male and female farmers, and constraints which these were faced.

3.6 Data Analysis

The data analysis of this study uses both statistics and econometry to achieve each objective.

3.6.1 The first objective is to analyze the different practices of adaptation to climate change used by women and men farmers in Niger.

Then, descriptive statistics such as mean, standard deviation, frequency, and charts to analyze household characteristics, and the test of proportion are used to examine the difference between men and women in each adaptation practice.

3.6.2 The second objective is to determine the factors behind climate change adaptation practices and their constraints for men and women farmers in Niger.

Therefore, approaches that are commonly used in the adoption of decisions are the multinomial logit (MNL) and multinomial probit (MNP) models. Both the MNL and MNP are important for analyzing farmer adaptation decisions. These approaches are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies.

According to Nhemachena & Hassan, (2008), the advantage of using an MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form. This model provides a convenient closed form for underlying choice probabilities, with no need for multivariate integration, making it simple to compute choice situations characterized by many alternatives. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave. The main limitation of the model is the independence of irrelevant alternatives (IIA) property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set. While for the multinomial Probit model (MNP) does not require the assumption of the IIA. The main drawback of using the MNP is the requirement that multivariate normal integrals must be evaluated to estimate the unknown parameters. This complexity makes the MNP model an inconvenient specification test for the MNL model.

Hence, this study used an MNL logit model to analyze the determinants of farmers' decisions of adaptation strategies, because it is easier to compute than its alternative, the MNP. Further, due of the simplicity in calculating choice probabilities, which can be expressed in analytical form.

The multinomial logit model of McFadden (1974) is a classic choice between three or more alternative responses in modeling the individual behavior of consumers in marketing research. This individual behavior is influenced by socioeconomic characteristics, marketing instruments, or latent variables. The connection between these influencing variables and the choice of a product is typically studied by using a statistical choice model for disaggregated data(Bartels et al., 2000). Though, households employ simultaneous different strategies of adaptation to climate change. Several studies on adaptation to climate change used widely the multinomial logit as provided by (Ngigi et al., 2017), (Arunrat et al., 2017)., (Alauddin & Rashid, 2014) and (Hisali et al., 2011) analyze the determinants of adaptation strategies used by farmers.

3.6.2.1 Multinominal Logit model

In random utility choice models, a subject j chooses between M distinct choice alternatives, and it is assumed that he will choose the alternative that gives maximal utility. The (Mx1) vector of (unobserved) utility that the jth individual derives from the M alternatives, Uj is equal to:

$$\mathrm{Uj} = Xj\beta + ej, \quad (1)$$

where Xj is an (MxS) matrix of variables representing characteristics of the M choice alternatives for the jth individual, β is an (Sx1) vector of unknown parameters, and ej is the (Mx1) error term that also may include effects from attributes not specified in the matrix X. In a more general specification, the parameter vector β can depend on j or can contain different elements for different alternatives m or both, and the matrix X need not depend on j or may have equal rows for all m.

Furthermore, it can contain, for example, quadratic main effects and interaction effects. When the X-matrix does not depend on m, the model in (1.1) is called an alternative specific model and β then has to depend on m. For each individual j, it is assumed that the alternative with the highest utility is chosen. The variable yjm describes the observed choices and is defined as:

$$yjm = \begin{cases} 1, & when\ Ujm > Ujn \quad \forall\, n \neq m \\ 0, & when\ \exists\, n \neq m :\ Ujn > Ujm \end{cases}, \qquad n = 1, .., M. \quad (2)$$

Let pjm be the probability that yjm equals one. Then, when there are J individuals, the likelihood function is equal to:

$$L = \prod_{j=1}^{J} pj1^{yj1}\ pj2^{yj2} \ldots .pjM^{yjM} \tag{3}$$

Maximum likelihood estimates of the parameters in (1.1) are obtained by maximizing (1.3). In most cases, not the likelihood itself is evaluated but the log-likelihood instead:

$$l = \sum_{j=1}^{J} \sum_{m=1}^{M} yjm \ln(pjm) . \tag{4}$$

The form of the probabilities in (1.3) or (1.4) depends on the distribution of the error term in (1.1).

Many empirical studies on climate change adaptation used both multinominal logit or probit, in this case, our choice will be multinominal logit.

The Multinomial Logit (MNL) model follows when the assumption is made that the error term in (1.1), ej, is independently and identically distributed with a Weibull density function. A Weibull density function for a random variable Y is defined as (see, e.g., McFadden 1976):

$$P(Y \leq y) = exp^{-exp\quad -y}. \tag{5}$$

This distribution belongs to the class of double negative exponential distributions as are, e.g., the Type I extreme value distribution and the Gumbell distribution, which are sometimes also used to specify the MNL model. In the MNL model, the choice probabilities were described as follows:

$$Pjm = \frac{\exp(Xjm\beta\mu)}{\sum_{n=1}^{M} \exp(Xjm\beta\mu)}, \tag{6}$$

where μ is the scale parameter of the MNL model. This parameter scales the variance of the MNL model, but since it cannot be identified, it is often set to one. However, MNL models are limited because of the Independence of Irrelevant Alternatives (IIA) property, which states that for a specific individual, the ratio of the choice probabilities of any two alternatives is completely unaffected by systematic utilities of other alternatives. This is closely related to the assumption that all disturbances are mutually independent. Ben-Akiva and Lerman state that the problem does not per se lie with the IIA property, but rather every model that has an underlying assumption that the disturbances are mutually independent states similar results. Dow and Endersby (2003) state that for most applications the IIA property is not particularly restrictive and for most applications not even relevant.

3.6.2.2 Model specification for the determinants of farmers level of adaptation practices to climate change

The adoption of new technology by farmers to reduce their risk of climate hazards is based on two choices: adapting or non-adapting. Therefore, the assumption will be farmers who adapt reduce the risk of climate hazards on their crop production. while non-adapting farmer has lost their crop production due to climate risk.

The decision to adapt in this study is represented by a binary variable (y):

$$y = \begin{cases} 1 \; if \; farmers \; adapt \\ 0 \; otherwise \end{cases} \qquad (7)$$

To describe the MNL model, let y denote a random variable taking on the values {1, 2, . . ., J} for J, a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation options or categories and x contains different household, institutional and environmental attributes. The question is how cetirus paribus changes in the elements of x affect the response probabilities (P(y = j/x), j = 1, 2, . . ., J. Since the probabilities must sum to unity, P (y = j/x) is determined once we know the probabilities for j = 2, . . ., J.

Let x be a 1x K vector with the first element unity.

Therefore, the multinomial logit model can be written as:

$$P\left(Y = \frac{j}{X}\right) = \frac{\exp(\beta jX)}{1 + \sum_{j=1}^{J} exp\,(\beta jX)} \qquad (8)$$

Where P=response of probability

Y= adaptation strategies used by farmers (Mixed crop, Use of Improved varieties, crop rotation, mulching, agroforestry, crop diversification, migration, income diversification, crop cover, application of fertilizers, use of organic manure …. etc), X= socioeconomic characteristic and β parameter.

However, according to the study on Climate Change, Agriculture and Food Security (CCAFS), the adaptability index categorizes farmer with as low level of adaptability if it has not made any change which means no adaptation, intermediate level when it has adopted 1–4 strategies and high level when the household uses more than 5 strategies (Diakité et al., 2011).

Therefore, this study has identified 14 practices of adaptation used by farmers so the classification of farmers' levels of adaptation to climate change is as follows:

– Low level when farmers are using no adaptation (0) to three (3) practices,

– Medium level from four (4) to six (6) practices, and

– High level from seven (7) to fourteen (14) practices.

Therefore, in the case of this study the dependent variable Y is the level of adaptation practices:

Y= (low level, medium level, high level).

While the independent variables X summarize in the table 1 below.

The choice of independents variables is based on the review of literature on adaptation to climate change. The hypothesis of the independent variables in this study represents the influence of factors that affect the use of adaptation practices across farming household in Niger.

Hence, from the literature the experience in farming increases the probability of uptake of adaptation measures to climate change cited in (Tadesse et al., 2009). This study hypothesizes that farmers with high farming experience minimize climate risks by using more adaptation practices to cope with climate change.

According to Yirga the influence of household size on use of adaptation methods can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks cited in (Tadesse et al., 2009). This study hypothesis that household with larger size adopt probably more adaptation practices.

As access to land and property rights are important determinants of farmer adaptation, an additional hectare of farmland increases the probability of using adaptation strategies. (Bryan et al., 2009). Land size also, influences farmers' decision-making on adaptation and productivity. Therefore, large farm sizes provide an opportunity for diversification of farmers crop and livestock enterprises, and it can help to distribute risks associated with unpredictable weather(Diarra et al., 2021 ; Belay et al., 2017) Therefore, farmers accessibility to land hypothesis to increase the probability of farmers decision of adaptation practices. But, the size of land is expected in this study to have a positive or negative influence in the adoption of adaptation practices depending of the situation.

Depending on the type of strategy, availability of labor can have a positive or negative effect on farmers' level of adoption. Labor-intensive technologies, in particular, may be difficult to adopt if the farmer does not have access to enough free labor because of the cost of hiring it. Lack of labor is a major factor in the inability of farmers to adopt most adaptation strategies. Thus, farm households with more labor will be better able to adapt to climate change see (Diarra et al., 2021). Therefore, the hypothesis in this case is as follow: the large labor-intensive farmer will be able to increase his level of adaptation practices to climate change.

The farm and non-farm income of farmer positively influence farmers' perception of climate change. As a result, increasing off-farm income is relevant for farmers to overcome the working capital constraint and allow them to apply farming practices that might otherwise compromise their subsistence income(Gebrehiwot & Veen, 2013). As result, the adoption of agricultural technologies requires sufficient financial wellbeing. Higher income farmers may be less risk averse and have more access to information, a lower discount rate, and a longer term planning horizon (Tadesse et al., 2009). This study hypothesizes that higher farm and non-farm incomes increase the probability of farmers adaptation practices to climate change.

Hadgu et al., (2015) reported that farmers with higher education are likely to have more information on climate change, which in turn might promote the probability of adopting climate change adaptation strategies. Thus, educational opportunities have the potential to improve the farmers' capacity to understand, interpret and apply the relevant information to make innovative decisions on their farming activities. In this study farming schooling indicate the level of education attained by farmer, based on the hypothesis that farmer's level of education increases the adoption of climate change adaptation practices.

Further, the accessibility to credit relaxes liquidity constraints thus increasing technology adoption like improved seeds, fertilizers etc. There is positive relationship between credit access and the probability of adopting climate change adaptation strategies (T. Ojo & Baiyegunhi, 2018). Thus, credit facility in this study is expected to increase the probability of the level of adaptation practices.

However, social capital represented by farmer-to-farmer extension from the same group or organization in the local area. According to Hogest, informal institutions and private social networks play three distinct roles in adoption of agricultural technologies: First, they act as conduits for financial transfers that may relax the farmer's credit constraints; Second, they act as conduits for information about new technology. Third, social networks can facilitate cooperation to overcome collective action dilemmas, where the adoption of technologies involves externalities cited in (Tadesse et al., 2009). It assumes also, that farmers who are members of a Farmer-Based Organization (FBO) are able to benefit assistance provided by other farmers through informal training in decision making in farming activities. Farmers who are members of the FBO are then expected to increase their probability of reducing storage losses (Ogoudedji et al., 2019). Thus, this study farmer belonging in farmer group or organization is expected to have positive influence on the use of adaptation practices to climate change.

The climatic conditions prevailing in a specific region define the number of adaptation measures that could be taken in response to climate change. The prevailing climate also determines if these adaptation responses are required (Gebrehiwot & Veen, 2013). Hence, annual average of precipitation and temperature in the study area used. It is expected to have positive or negative influence on the likelihood of the using of adaptation practices.

Table 4: List of independent variables used

Variables	Description
Farming experience,	Continuous

Access to land,	dummy takes the value 1 if yes, 0 otherwise
Farm size (ha),	Continuous
Farmers' household size,	Continuous
Family labor (adult and young/adolescent),	Continuous
Farm income,	Continuous
Off-farm income,	Continuous
Famer's schooling,	takes the value 1 primary, 2 secondary, 3 superior,4 koranic, and 5 no
Access to credit,	dummy takes the value of 1 if there is access and 0 otherwise1,
Farmers Group membership,	dummy takes the value 1 if membership of Farmers Group, 0 otherwise
Precipitation data,	continuous annual average on the period 2019-2020
Temperature data,	continuous annual average on the period 2019-2020

In the case of this study, gender is not used as an independent variable then analysis of the model is done separately for men and for women, so the model is estimated by sex.

Thus, the estimated model according to gender is as follows:

$$\text{level adaptation}(\text{low, medium, and high level}) = \beta 1 farmsiz + \beta 2 farmexp + \beta 3 accescredit + \beta 4 accesland + \beta 5 farmincom + \beta 6 offfarmincom + \beta 7 farmschooling + \beta 8 membership + \beta 9 familylabor + \beta 10\ housesize + \beta 11 precip + \beta 12 temp + \mu \quad (9)$$

3.6.2.3 Factors or constraints analysis

Though in the case of constraints analysis, the study uses first the principal component factors analysis (PCA) to identify constraints under each factor among men and women farmers in their decision to adapt to climate change in Niger.

The method of principal component analysis with iteration and varimax rotation is used in grouping the constraints of farmers decisions into major components. In this analysis, the factor loading under each constraint (beta weight) represents a correlation of the variables (constraint areas) to the identified constraint factor and has the same interpretation as any correlation coefficient.

Hence, the factor loadings, are chosen so that the constructed principal components satisfy two conditions: (1) the principal components are uncorrelated (orthogonal), and (2) the first principal component P1 absorbs and accounts for the maximum possible proportion of the total variation in the set of all X's, the second principal component absorbs the maximum of the remaining variation in the X's (after allowing for the variation accounted for by the first principal component and so on. A test based on the levels of significance (standard errors) of the Pearson correlation coefficients will be used to select the variable whose loading is significant. But, only variables with a factor loading of 0.40 and above will be used in naming the factor.

The high reliability of factor analysis models in barriers to climate change adaptation strategies studies has widely been explored by several authors. Aroyehun & Henri-Ukoha (2021), applied factor analysis to determine constraining factors encountered by Male poultry farmers in accessing climate change finance in rive state, Nigeria; the constraints to effective climate change adaptation among arable crop farmers in Ebonyi State of Nigeria using factor analysis by (Ann & Anayochukwu, 2016). Otitoju & Enete (2016) employed Factor analysis to study the constraints of food crop farmers to the use of adaptation strategies in South-west, Nigeria; The Study on gender and climate change adaptation decisions among farm households in Nigeria employed factor analysis to determine major factors constraining women from making an adequate contribution to climate change adaptation decisions among (Amusa, 2014);

Set of variables X's (X1, X2, ----------------------------Xn) are measured to derive Carleton coefficient or factor loading "a" between the n explanatory Variables.

Koutsoyiannis (1977) described that the correlation matrix is symmetrical as the elements of each row are identical to the elements of the corresponding columns thus rxixj =rxjxi.

The correlation coefficient or factor loading "a" for the principal component P1 is determined thus;

$$a1j = \sum_{j}^{k} rxixj \sqrt{\sum_{j}^{k}\sum_{j}^{k} rxixj} \qquad (10)$$

The sum of the square of the loadings of each principal component is called the latent root, characteristics root, or eigenvalue denoted l with the subscript of the principal component to which it refers and is given as;

$$\lambda = \textstyle\sum_{1}^{k} ai^{2} \qquad (11)$$

The eigenvalue measures the variance in the entire variable which is accounted for by that factor. Only components with an eigenvalue greater than 1.0 should be retained when interpreting the principal analysis result. The latent roots can be expressed as a percentage of the total variation in the set of X.

The PCA model is specified as follows:

$$P_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \cdots + a_{1n}X_n \qquad (12)$$

$$P_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \cdots + a_{2n}X_n \qquad (13)$$

$$P_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + \cdots + a_{3n}X_n \qquad (14)$$

* *

* *

$$P_n = a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 + \cdots + a_{nn}X_n \qquad (15)$$

Where:

P_1, $P_2 \ldots P_n$ =constraining variables observed by farmers to adapt to climate change;

a_1, a_2,…..a_n= factor loadings;

X_1, X_2,….X_n= unobserved underlying factors and constraints facing farmers in climate change adaptation.

3.6.2.4 Model specification of the determinants of constraints of climate change adaptation strategies among women and men farmers in Niger.

However, after rotation, the study uses the values of the loading under factor 1 to create an index of constraints and regroup it into three (3) groups. The equation is as follows:

$$indixconstraint = a_{11}constraint1 + a_{12}constraint2 + a_{13}constraint3 + \cdots + a_{1n}constraintn \quad (16)$$

The index is regrouped into three and classified: the first is the low level of constraint, the second is the medium level of constraint and the third represents the high level of constraint. Considering that the dependent variable (the level of constraint) has more than two categories and the values of each category have a meaningful sequential order where a value is indeed 'higher' than the previous one, for that the study will use the ordered logistic regression to determine the drivers among the level of constraint.

Therefore, in ordinal regression models assuming that a predictor X is linearly related to the log odds of some appropriate event, a simple way to check for ordinality is to plot the mean of X stratified by levels of Y. These means should be in a consistent order. If for many of the Xs, two adjacent categories of Y do not distinguish the means, that is evidence that those levels of Y should be pooled. One can also estimate the mean or expected value of X|Y = j (E(X|Y =j)) given that the ordinal model assumptions hold. This is a useful tool for checking those assumptions, at least in an unadjusted fashion (Harrell, 2015).

3.6.2.5 Ordered Logit Model

The ordered logit model is a regression model for an ordinal response variable. The model is based on the cumulative probabilities of the response variable: in particular, the logit of each cumulative probability is assumed to be a linear function of the covariates with regression coefficients constant across response categories.

Let Yi be an ordinal response variable with C categories for the i-th subject, alongside a vector of covariates xi. A regression model establishes a relationship between the covariates and the set of probabilities of the categories pci=Pr(Yi =yc| xi), c=1,…, C. Usually, regression models for ordinal responses are not expressed in terms of probabilities of the categories, but they refer to convenient one-to-one transformations, such as the cumulative probabilities gci=Pr(Yi ≤yc| xi), c=1,…, C. Note that the last cumulative probability is necessarily equal to 1, so the model specifies only C−1 cumulative probabilities.

Where the cumulative probabilities gci=Pr(Yi ≤yc| xi) (1) are related to a linear predictor:

$$\beta' xi = \beta 0 + \beta 1x1i + \beta 2x2i + \cdots , \tag{17}$$

through the logit function:

$$\text{logit}(gci) = \log\left(\frac{gci}{1- gci}\right) = \alpha c - \beta' xi ,, \tag{18}$$

c = 1,2,…,C−1.

The parameters αc, called thresholds or cut points, are in increasing order (α1 < α2 < … < αC-1). It is not possible to simultaneously estimate the overall intercept β0 and all the C−1 thresholds: in fact, adding an arbitrary constant to the overall intercept β0 can be counteracted by adding the same constant to each threshold αc. This identification problem is usually solved by either omitting the overall constant from the linear predictor (i.e. β0 = 0) or fixing the first threshold to zero (i.e. α1= 0).

The ordinal logistic model was described by Walker and Duncan and later called the proportional odds (PO) model by Mc- Cullagh. The PO model is best stated as follows, for a response variable having levels 0, 1, 2,..., C:

$$Pr[Y \geq \text{ j}|\text{X}] = \frac{1}{1+\exp[-(\alpha j + X\beta)]}, \tag{19}$$

where j =1, 2,... , C. This formulation makes the model coefficients consistent with the binary logistic model, there are k intercepts (αj). For fixed j, the model is an ordinary logistic model for the event Y ≥ j. The model can write as Y ≤ j. By using a common vector of regression coefficients β connecting probabilities for varying j, the PO model allows for parsimonious modeling of the distribution of Y.

There is an implicit assumption in the PO model that the regression coefficients (β) are independent of j, the cutoff level for Y. For a specific Y-cutoff j, it assumes that the log odds Y ≥ j is linearly related to each X and that there is no interaction between the Xs (Harrell, (2015); Grilli & Rampichini, (2021)).

According to Wan et al (2014), the ordered logit model is described as a cumulative probability that an individual i chooses a response category lower or equal to j, it is written:

$$Fij = \sum_{l=1}^{j} pil \qquad (20)$$

The log odds are determined by

$$\log\,[\mathrm{Fij}/\,(1-\mathrm{Fij})] = \alpha\mathrm{j} + \mathrm{X'i}\beta, \qquad (21)$$

Then, the model equation is written as follows:

$$P(Yi \le j|Xi) = \frac{\exp(\alpha\mathrm{j}+\mathrm{X'i}\beta)}{1+\exp(\alpha\mathrm{j}+\mathrm{X'i}\beta)} \qquad (22)$$

For j=1,…..J-1,

P((Yi≤j┤|Xi) =1

where the intercept coefficient αj varies across the different equations, but the slope coefficients of the regressor variables are common for all equations and β parameters.

In the case of this study, Yi represents the level of constraint “low, medium, high”, X socioeconomic characteristics “gender, farm experience, field size, age of farmers, farm income, off-farm income, access to credit, access to the climate information…etc”.

Hence, the estimation model is:

$$\text{level of constraint(low, medium, and high)} = \beta 1 gender + \beta 2 farmexp + \beta 3 accesland + \beta 4 farmincom + \beta 5 offarmincom + \beta 6 farmschooling + \beta 7 accescredit + \beta 8 membership + \beta 9 farmsiz + \beta 10\ housesize + \beta 11 precip + \beta 12 temp + \mu \quad (23)$$

,

3.6.3 The third objective is to analyze the determinants of the gender empowerment index for women and men farmers in Niger

Developed by the United Nations in the research for feed the future, the women empowerment in agriculture index (WEAI) is composed of two sub-groups index these are the five domains that assess whether women are empowered across these five domains and the gender parity index (GPI) in empowerment within the household. The WEAI is an aggregate index reported at the country or regional level that is based on individual-level data on men and women within the same households. The choice of method, in this case, is justified by the fact that the analysis is specifically focused on the use of different adaptation strategies to climate change in Niger since the women empowerment in agriculture index is a general model. Hence, this study uses the methodology of Hariharan et al (2020) who selected randomly climate-smart villages (CSV) and non-climate-smart villages in Haryana and Bihar to analyze if the CSV approach can lead to the better empowerment of both women and men. The authors calculated the Gender Empowerment Index across four domains which were political, social, economic, and agricultural domains as illustrated in the table below. The limit of this method is just the determination of the index thus, this study will not only determine the index but also make further analysis to see how some variables can affect the score of the gender empowerment index in Niger.

3.6.3.1 Fractional Response Model

The fractional response model (FRM) represents a viable solution to address many of the econometric limitations that are found in the nonlinear solutions currently utilized to model bounded dependent variables. The FRM is an extension of the general linear model (GLM) to a class of functional forms that circumvent most of the known issues of the traditional econometric models for bounded variables. The FRM accounts for the boundedness of the dependent variable from both above and below, predicts response values within the interval limits of the dependent variable, and captures the nonlinearity of the data, thereby yielding a higher fit compared to linear estimation models. When the outcome of interest is measured as a fraction or proportion bounded between zero and one. The bounded nature of variables and the possibility of observing values at the boundaries raise interesting functional form and inference issues. Therefore, Papke & Wooldridge (1996) developed the Fractional response model to study the participation rates of employees in firms.

The authors illustrated the methodological issues that arise with fractional dependent variables, suppose that a variable y, $0 \leq y \leq 1$, is to be explained by a 1 x K vector of explanatory variables $x = (x_1, x_2, \ldots, x_K)$, with the convention that $x_1 = 1$. The population model is:

$$E(y \mid x) = \beta 1 + \beta 2\, x2 + \beta 3\, x3 + \ldots . + \beta K\, xK = x\beta \qquad (24)$$

where β is a K x 1 vector, rarely provides the best description of E(y| x). The primary reason is that y is bounded between 0 and 1, and so the effect of any particular x_j cannot be constant throughout the range of x (unless the range of x_j is very limited). To some extent, this problem can be overcome by augmenting a linear model with non-linear functions of x, but the predicted values from an OLS regression can never be guaranteed to lie in the unit interval. Thus, the drawbacks of linear models for fractional data are analogous to the drawbacks of the linear probability model for binary data. The most common alternative to equation (1) has been to model the log-odds ratio as a linear function. If y is strictly between zero and one then a linear model for the log-odds ratio is :

$$E(\log\left[\frac{y}{1-y}\right] \mid x) = x\beta \qquad (25)$$

Thus, given a set of data, if any observation y_i equals 0 or 1 then an adjustment must be made before computing the log-odds ratio. The expected value under this equation:

$$E(y \mid x) = \int_{-\infty}^{+\infty} \left(\frac{\exp(x\beta + v)}{1+\exp(x\beta + v)}\right) f(v|x)\, dv \quad (26)$$

where f(.| x) denotes the conditional density of u = log[y/(l - y)] - xβ given x and v is a dummy argument of integration. Even if u and x are assumed to be independent, E(y | x) # exp(xβ)]/[l + exp(xβ)].

Therefore, the functional form is based on the assumption that (xi, y) for i=1,2,…N of an independent (though not necessarily identically distributed) sequence of observations with N =sample size and 0 ≤ yi ≤ 1. Thus, for all i :

$$E(\, yi \mid xi) = G(xi\, \beta) \quad (27)$$

where G(.) is a known function satisfying O< G(z)< 1 for all z € R. This ensures that the predicted values of y lie in the interval (0, 1). The equation is well defined even if yi can take on 0 or 1 with positive probability. Typically, G(.) is chosen to be a cumulative distribution function (cdf), with the two most popular examples being G(z) =A(z) =exp(z)/ [l + exp(z)] the logistic function and G(z) =Φ(z), where Φ(.) is the standard normal cdf.

The estimation procedure proposed by the authors is a particular quasi-likelihood method, as in Gourieroux, Monfort, and Trognon (1984) (hereafter GMT) and McCullagh and Nelder (1989) (hereafter MN). The Bernoulli log-likelihood function, given by

$$li(b) = yilog[G(xi\, b)] + (1 - yi)log[1 - G(xi\, b)] \quad (28)$$

is well defined for 0<G(.)<l and is attractive for several reasons. First, maximizing the Bernoulli log-likelihood is easy. Second, because equation (5) is a member of the linear exponential family (LEF), the quasi-maximum likelihood estimator (QMLE) of /3, obtained from the maximization

$$\max b = \sum_{1=1}^{N} li\ (b) \quad (29)$$

the Bernoulli, QMLE β^ is consistent and $\sqrt{N}$ asymptotically normal regardless of the distribution of yi conditional on xi; yi, could be a continuous variable, a discrete variable, or have both continuous and discrete characteristics. As we will see below, in some cases for fractional data the Bernoulli QMLE is efficient in a class of estimators containing all QMLEs in the LEF and weighted NLS. Papke and Wooldridge (1996) provide valid (robust) estimators of the asymptotic variance of β with the application of extended Ramsey RESET tests for H0: $y1 = 0$, $y2=0$ in the augmented model $G\,(xi\,\beta + y1(xi\beta)^2 + y2(xi\beta)^3)$.

3.6.3.2 Model specification of the influencing factors on gender empowerment index among women and men farmers in Niger

a) Gender empowerment index determination

However, the study used the same indicators for the analysis as illustrated in the table 2 below. But to compute the index this study uses the principal component analysis to attribute a weight for each domain like political, social, economic, and agriculture considering their contribution.

Table 5: the four domains of the Gender Empowerment Index

domains	codes	indicators	wight
Political	p1	Independent right to vote	1/2
	p2	More participation in village level decision making	1/2
Social	s1	Increase access to credit/KCC/bank and its facilities	1/8
	s2	Improved participation in the decision on spending money on agriculture	1/8
	s3	Improved participation in the decision on spending money on home expenses	1/8
	s4	Improved participation in the decision on spending money on child education	1/8
	s5	Better control of money for education for children	1/8
	s6	Better control of money for health for family	1/8
	s7	Better access to a mobile phone	1/8
	s8	Better access to insurance	1/8
Economic	e1	Improved earning opportunity	1/2
	e2	Improved skill set and capability to work	1/2
Agricultural	a1	Better awareness that climate variability can be a risk to agriculture	1/17
	a2	Better access to information to manage agricultural risk	1/17
	a3	Better information on nutrient application	1/17
	a4	Better access to nutrient application practices	1/17
	a5	Improved soil/land quality	1/17
	a6	Improved water use efficiency	1/17
	a7	Better access to improved seeds	1/17
	a8	Better access to quality inputs	1/17
	a9	Increased use of weather-based insurance/crop insurance	1/17
	a10	Better access to machines	1/17
	a11	Better access to markets (input and output)	1/17
	a12	Better participation in the sale of livestock products	1/17
	a13	Better participation in training/workshops/seminars	1/17
	a14	Better crop diversification/ any change in cropping pattern	1/17
	a15	Improved role in decision-related to change in cropping pattern	1/17
	a16	Better access to information through mobile-based agro-advisories	1/17
	a17	Improved income through selling output	1/17

Source: from Hariharan et al, (2020)

Therefore, the Gender Empowerment Index (GEI) was calculated as the summation of the weighted domains:

$$GEI = (\alpha * \sum P) + (\beta * \sum S) + (\lambda * \sum E) + (\mu \sum A) \quad (30)$$

where:

$\sum P = \sum_{i=1}^{2} pi$, $\sum S = \sum_{i=1}^{8} si$, $\sum E = \sum_{i=1}^{2} ei$, $\sum A = \sum_{i=1}^{17} ai$

With $\alpha + \beta + \lambda + \mu = 1$, these are calculated from PCA

b) Econometric model of GEI

Though the gender empowerment index is range from zero to one (0-1) thereby, the GEI is called bounded because the index may not be lower than zero and higher than one. According to Obayelu (2020), a proportion that is bounded between 0 and 1, means that the effect of explanatory variables tends to be non-linear, and the variance tends to decrease when the mean gets closer to one of the boundaries. Therefore, the fractional response model (FRM) is the adequate model to use especially in the case of continuous bounded dependent variables where econometric limitations are found to be nonlinear. Linear regression (OLS) could be used for a model, but it will not keep predictions within bounds and OLS assumptions will be violated making statistical tests untrustworthy such as the non-normality of residues.

According to Gallani et al (2015), the advantages of using the FRM are: it does not require any special correction of the values observed at the bounds, it accounts for the non- linearity in the data, it is fully robust under generalized linear model assumptions, and it allows for direct recovery of the regression function for the dependent variable given the set of predictors.

The fractional regression is similar to ologit regression in the sense that it can be used to model a variable that takes values within a bounded range. A key difference is that the dependent variable can be measured as continuous and does not need to be converted to categories. Then this study uses the fractional logit regression to analyze the influencing factors on the GEI, with GEI as the dependent variable.

Thus, in this study the dependent variable of the model is the GEI bounded in [0,1] interval then, the use of the Ordinary Least Squares (OLS), the Tobit regression, or the transformed logistic normal model (the log-odds ratio of the dependent variable) in such cases are inefficient, as their error distributions will be heteroskedastic. Face in the case of this situation Papke and Wooldridge (1996) have proposed a Fractional Response Model (FRM) which is extended of the generalized linear model (GLM). Thus, the Fractional Response Model is a non-linear model estimated using the Quasi- Maximum Likelihood Estimation (QMLE) method. The QMLE is asymptotically efficient and consistent compared to either OLS or Tobit (Oberhofer et al (2012); Ogoudedji et al., 2019).

Therefore, this thesis uses the Fractional Logit Model to analyze the influencing factors on the gender empowerment index (GEI), as Papke and Wooldridge (1996) the model is:

$$E(yi|Xi) = G(Xi\,\beta), \qquad i = 1, \dots, N, \tag{31}$$

where

$0 \le Yi \le 1$ denotes the dependent variable, in this case, it represents the GEI and (the $1\times$ k vectors) Xi represent the explanatory variables of observation i, β a vector of unknown parameters and G (.) is a distribution function that follows a logistic distribution function so

$$G = \frac{\exp(\mathrm{Xi}\beta)}{1+\exp(\mathrm{Xi}\beta)} \tag{32}$$

The Quasi- Maximum Likelihood Estimation (QMLE) method is used to estimate unknown parameters based on the Bernoulli log-likelihood function which is defined as:

$$Li(\beta) = Yi\log[\,G(Xi\beta)] + (1 - Yi)\log[\,1 - G(Xi\beta)] \tag{33}$$

The irregularity of rainfall patterns still continues to affect negatively the Nigerien population with a deficit of production, making the country in a situation of food insecurity. For this reason, the government with the support of its development partners has implemented some strategies such as the sale of cereals at moderate prices, free distribution of cereals and seeds, cash for work, etc., in order to reduce the vulnerability of the population. Since these strategies aim to reinforce the resilience of the population thus, improving their empowerment. The regression model of this study uses as independent variables the types of support that the population received, as well as the education level, farm income, and off-farm income. The added of these three socioeconomic characteristics as independent variables is based on the assumption that the high empowerment of women and men is correlated with a high level of education and also a high income (farm income and off-farm income).

$$\begin{aligned} GEI = {} & \beta 1 \text{gender} + \beta 2 \text{ education level} + \beta 3 \text{farm income} \\ & + \beta 4 \text{ offarm income} + \beta 5 \text{ moderate price sale} \\ & + \beta 6 \text{free cereals distribution} \\ & + \beta \text{capacity bulding} + \cdots \text{etc} \end{aligned} \tag{34}$$

3.7 Expected added-value

The contributions of this thesis are that it will firstly increase the literature on gender-climate change adaptation practices specifically in Niger because, to the best of our knowledge, most of the studies are aggregate as the case study on Sub-Saharan Africa. Second the determination of different factors/constraints and the Gender Empowerment Index, in adaptation decisions, may be helpful in the effective mainstreaming of gender in the implementation of adaptation and resilience of climate change adaptation program in Niger. Third the contribution of this thesis will be on the methodological approach used; the analysis will focus on the gender role in farm decisions within the household across farming households in Niger. The econometric analysis is the most innovative on gender dimensions to the adaptation of climate change in Niger.

Chapter Four: Results and Discussions

4.1 Introduction

This chapter provides the results and discussions of the findings as follow: data description which includes the socioeconomic characteristic of respondents, perception of climate change, risks climatic, impact of climate change, and access to climate information; then, practices of adaptation to climate change, the determinant of the level of adaptation practices to climate change, loading factors of constraints, the determinant of the level of constraints and the Gender Empowerment Index in Niger.

4.2 Data description

4.2.1 Socioeconomic characteristics

The table 3 below shows that 51% of farmers interviewed are male while 49% are female, but the majority of respondents have male as the sex of household head (45%) and only 5% have female as the sex of household head. The marital status of the household head gives 90% married, 8% widowed, and 2% divorced, 89% of males were married and only 1% were widowed; while 7% of females were widowed and 1% of females were married and divorced. The finding confirms that in Niger female head of household was fewer than the male because of social norms. The women become heads when they were widowed or absent of their husbands or divorced.

The average age of household heads is 53 years old and 54% have ages between 19-40 and the average years of farmers' experience is 29 years. The household size an average gives 11 persons within the household. Koranic is the most level of education attended by respondents (53%) while farmers who have attended formal education that means primary and secondary school 26%.

Furthermore, 99.44% of households used wood collected/purchased as a main source of energy for cooking,47.46% traditional latrines as a toilet, 46.05% tap water (46.05) as a source of drinking water, and 65% used battery lamps for light. The finding shows the persistence of poverty among farming households hence increase household vulnerability. The used of wood as the main source of energy contributes to increasing deforestation, therefore, contribute to climate change in Niger

Table 6: Results from socioeconomics characteristics

	freq	perc	mean
Gender			
Male	363	51.34	
Female	344	48.66	
Sex of household head			
Male	320	45	
Female	34	5	
Marital status			
Married	318	90.	
Divorce	5	2	
Widowed	30	8	
Age of household head			
19-40	87	25	
41-65	191	54	53
66-95	76	21	
Education level of farmers			
primary	67	19	
secondary	24	7	
coranic	187	53	
No	72	21	
household size			
<6 persons	77	22%	
6-10 persons	120	34%	11
11-15 persons	82	23%	
> 15 persons	75	21%	
farmers experience			
0-10	105	15	
10--20	154	22	29
20-30	170	24	
>30	278	39	
source of drinking water			
Covered well/drilling	74	21%	
Open well	112	32%	
Surface water	4	1%	
Tap water	163	46%	

	freq	perc	mean
Type of toilet			
Modern toilet	65	18%	
Traditional toilet	168	47%	
No latrine. Bush	121	34%	
source of energy			
wood collected/purchased	352	99%	
biomass	2	1%	
light of household			
battery lamp	230	65%	
solar	49	14%	
electricity	71	20%	
Farmer's income			
less 25 000fcfa	323	45.69	
25 000-50 000fcfa	227	32.11	
> 50 000 fcfa	157	22.21	

Source: Author's own field survey 2021

4.2.2 Perception of climate change in Niger

It results that farmer in the southeast of Niger perceiving climate change through the perturbation in raining season and land degradation. Therefore, early stop rain and scarcity of precipitation is the most change perceived by men while for women it is temperature rise and violent wind. The majority of respondents (64%) perceive the change by the early stop raining out of which 70% are Men and 58% women. Whereas 63% of respondents perceived climate change as a scarcity of precipitation, among this 66% are men and 60% women. Famers (23%) also recognize temperature rise as climate change of which 24% are women and 22% are men. Finally, 13% of farmers responded to violent wind among which 15% are women and 10% are men as indicate figure 3 below. This study is in line with the literature on farmers' perceptions of climate change such as the variability of temperature and precipitation. It is reported that over 70% of farmers in Niger perceive a shorter rainy season and an increase in temperature (Sarr et al., 2015; DanDano Na Inna & Larwanou, 2022). Moreover, changes in precipitation are observed through the decrease in precipitation, change in the frequency and distribution of precipitation, delay of rain, early rains, and early cessation of rains. Whereas the temperature is the increase in temperature (Asfaw et al., 2016; Akponikpè et al., 2010; Yegbemey et al., 2020).

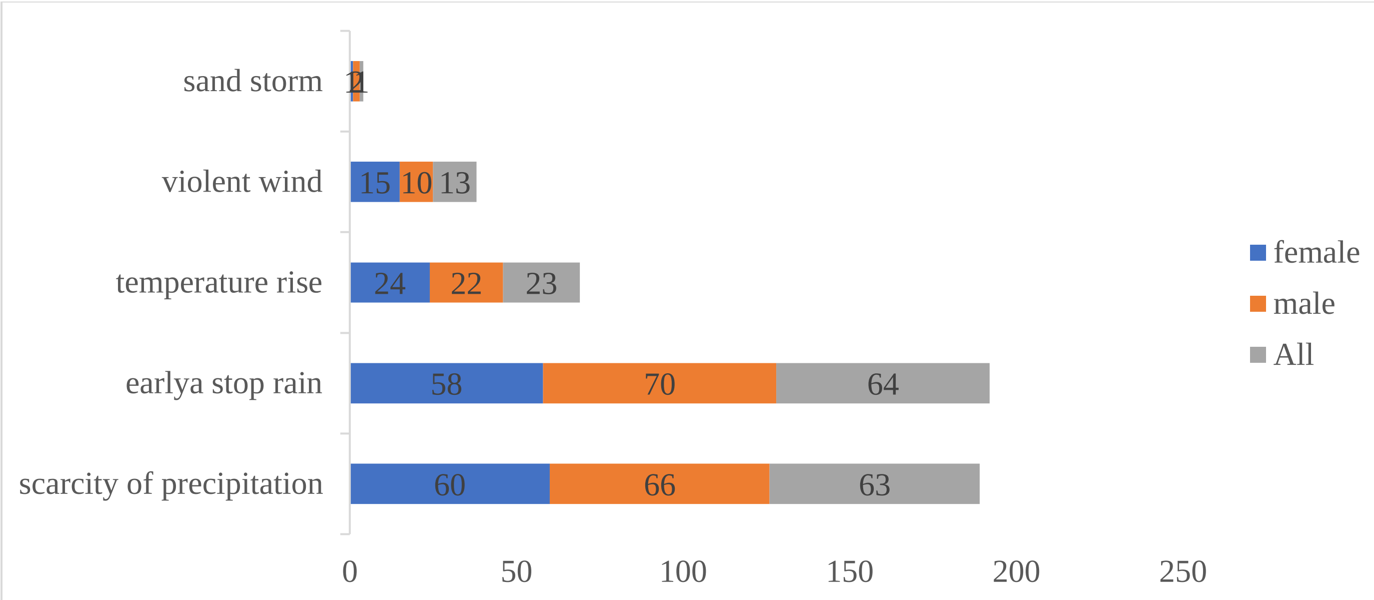

Figure 11:perception of climate change by women and men farmers in Niger

Source: Author's own field survey 2021

4.2.3 Risk of climate change in Niger

The figure 4 below shows the repartition of the climate risk hazard in Niger, the most risk is drought with 66% of respondents where 68% for men and 64% for women. The second risk is insect attacks with 29% of respondents, men, and women 28% and 31% respectively. The high temperature was given by 19 % of respondents while 22% are men and 16% are women. Finally flooding with 16% of respondents of which 14% are men and 18% are women.

Similar result to the study of DanDano Na Inna & Larwanou (2022), who argued that drought and floods are the major extreme weather events to which households are more exposed and these are the most risk that weighs on agricultural production in Niger.

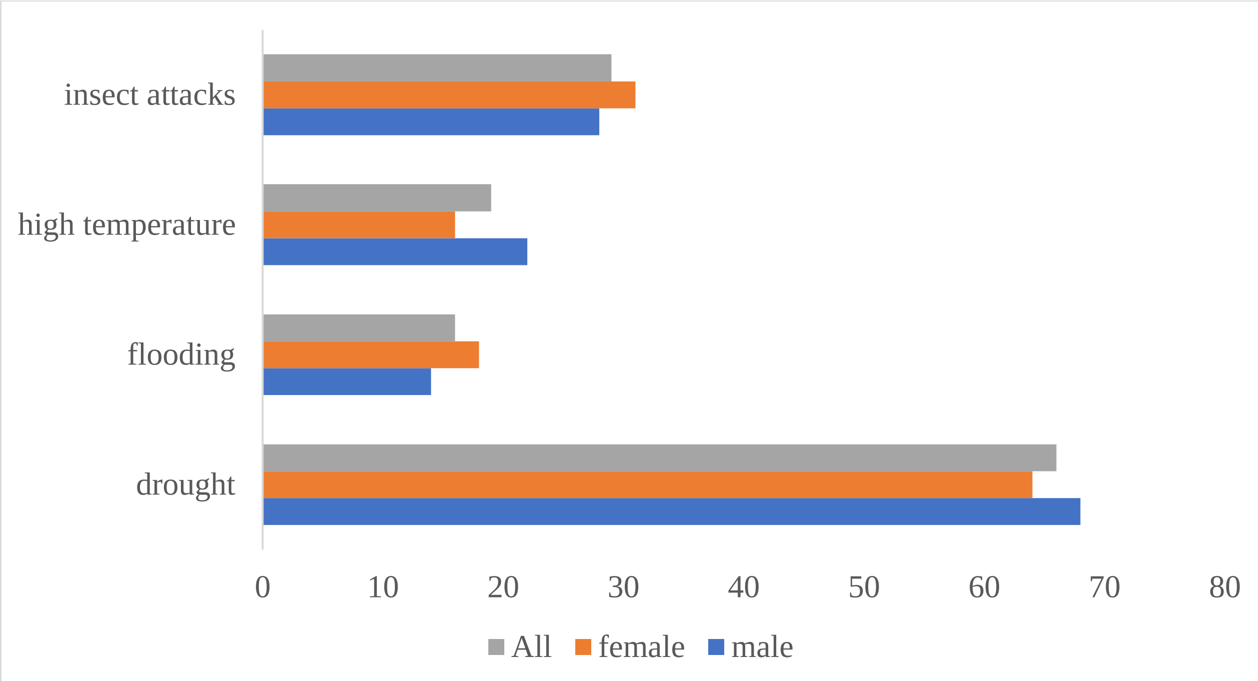

Figure 12:climatic risks in Niger

Source: Author’s own field survey 2021

4.2.4 Impact of climate change

However, figure 5 below illustrates that risks of climate change impact negatively farmers' well-being through the decrease in their agriculture production and their income. Results show that women are the most exposed thereby, 65% responded high decrease in agriculture production, for 56% of women the risk of climate affected negatively their income by forte decrease and for 46% of women, it caused a forte diminution of livestock production. While 61% of men responded high decrease in the climate risk in agriculture production, for 56% of men climate risk caused a forte diminution of their income and for 44% of men it impacted a forte diminution of livestock production.

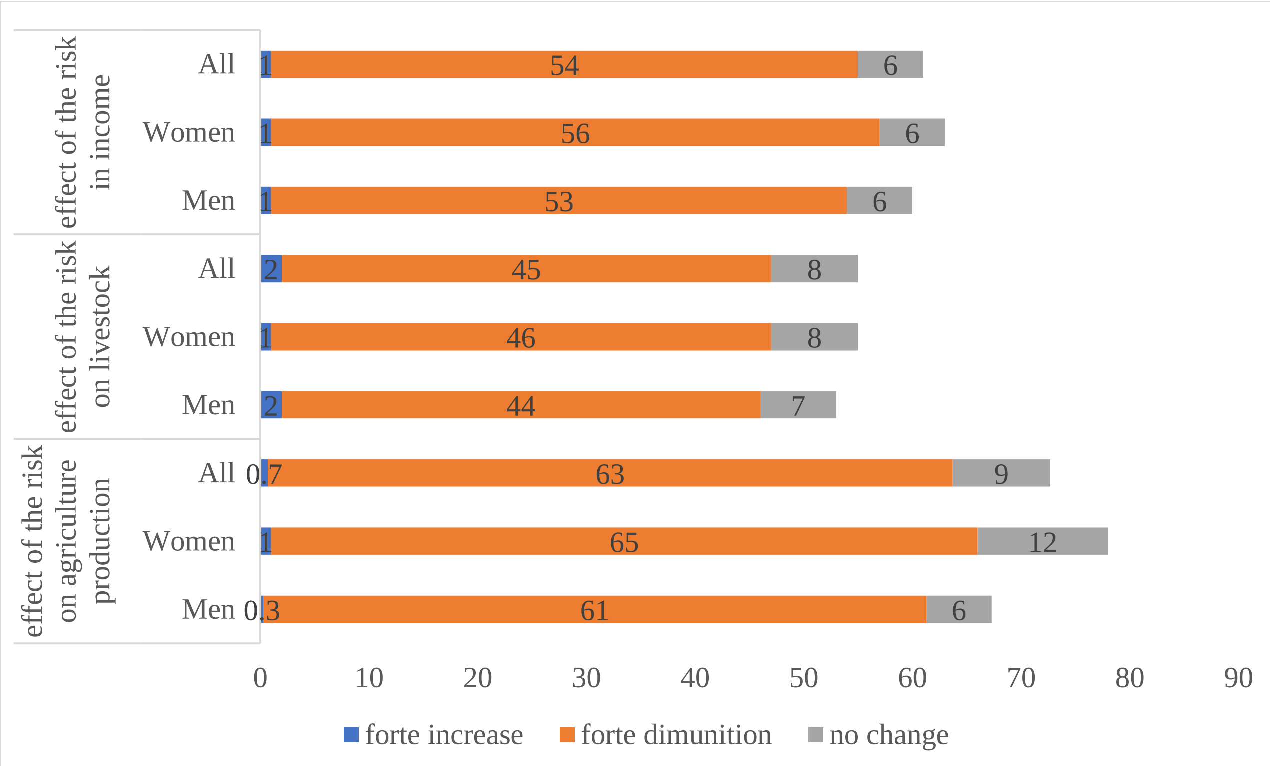

Figure 13:climate change impact among women and man farmers in Niger

Source: Author's own field survey 2021

4.2.5 Access to climate information

The result from figure 6 reveals that 92% of respondents have radio as their main source of access to climate change information in the study area, 25% receive it by phone and 7% receive it through organization peasant and TV. This is an accordance with the study on Farmers' awareness and perception of climate change impacts: a case study of Aguie district in Niger, which found that 81.4% of farmers received their information on climate change through radio. It's argued that farmers preferred the radio because the information is broadcast in the local language(Matsalabi et al., 2018).

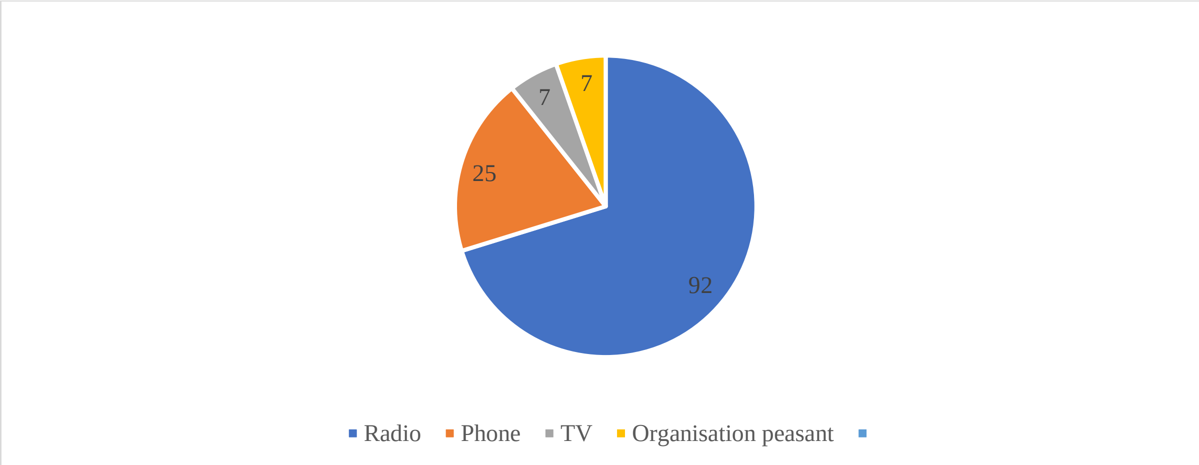

Figure 14:accessibility of farmers to climate information among farming households in Niger

Source: Author's own field survey 2021

4.2.6 The various assistance provided to farmers faced with climatic hazards in Niger

The findings as indicated in figure 7 show that a greater of farmers respond to have the benefit of moderate price sales following cash for work, free cereals, and seeds distribution all these are aids from the government and NGOs.

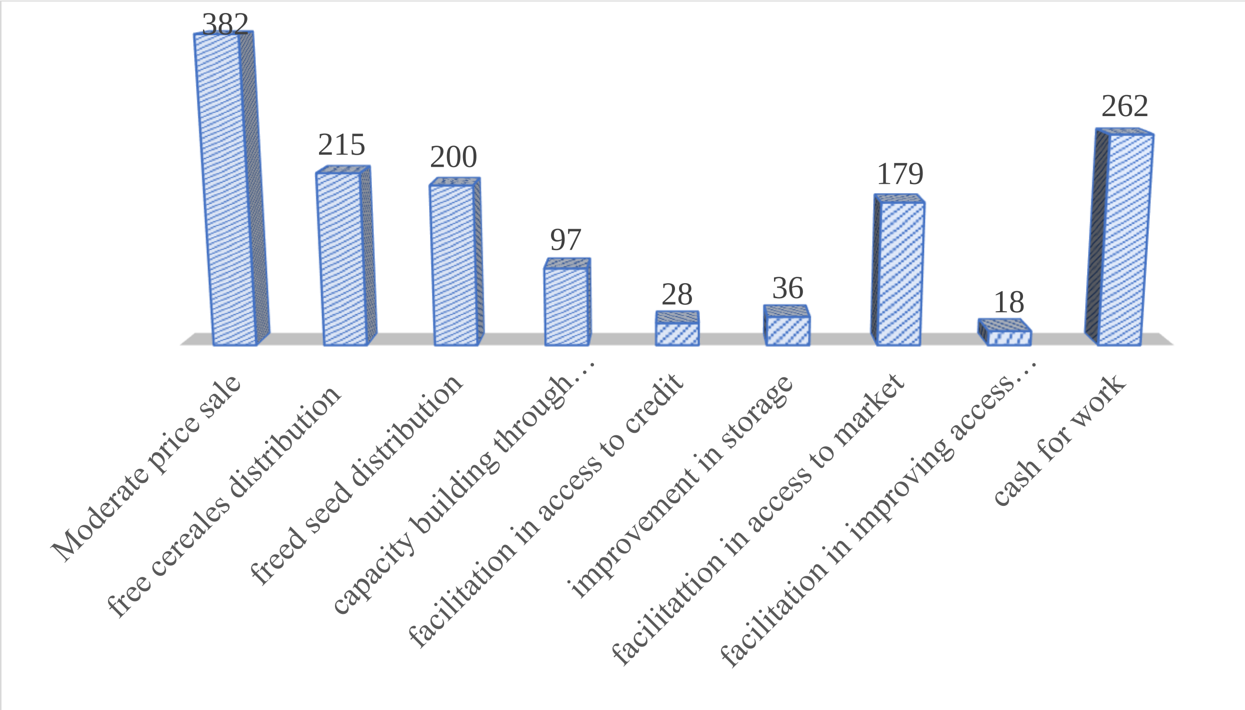

Figure 15: various assistance provided to farmers faced with climatic hazards in Niger

Source: Author's own field survey 2021

4.3 Practices of adaptation used by men and women to cope with climate change in Niger

It results that both men and women use different practices of adaptation to face with climate change. These practices include mixed crop, crop rotation, use of the improved seed, application of fertilizers, crop diversification, agroforestry, use of tassa demi lune, cover crop, use of organic manure, use of pesticides, livestock diversification, income diversification, migration, zero tillage, and mulching. However, the test of proportion is used to analysis the difference between men and women in the utilization of each adaptation practice.

Mixed crop and crop diversification are used by both Men and Women, their differences of 9.97% and 9.36% respectively are positive and statistically significant at 1%. That means men farmers used mixed crop and crop diversification more than women. This finding is similar to Asfaw et al.,(2014) who found that Crop productivity from plots managed by women was significantly lower comparatively than from plots managed by a male in Niger.

Crop rotation is the only adaptation practice used more by women farmers than men, with a difference equal to 4.43% is negative and significant at 10%. The finding is in contrast with Diarra et al.(2021) who found that men used the adaptation strategy crop rotation more than women in Mali because women have limited access to land.

The use of improved seed gives a difference of proportion equal to 6.97%, meaning that men used this practice of adaptation more than women, the difference is statistically significant at 5%. At 1% the difference (5.44%) from application of fertilizers as adaptation practice is positively significant, therefore this practice of adaptation is more used by men than women. Technic of soil and water conservation which regroup adaptation practices: agroforestry, cover crop, use of tassa/demi lune, and use of organic manure. The difference in proportion between men and women farmers in the utilization of these practices 8.4%, 5.72%, 9.8%, and 10.84% are positive and statistically significant at 5%, 10%, and 1% respectively. The finding is similar to Ndamani & Watanabe (2016) revealed that male farmers are more likely to use adaptation measures against climate change than female farmers. This finding is confirmed by the results of previous studies which showed that in Sub-Saharan Africa, female household heads have lower levels of education, less access to markets and credit, and other inputs (Blackden and Wodon, 2006).

Therefore, women farmers undertake fewer the adoption of improved seeds, application of fertilizers, and technic of soil and water conservation practices than men farmers in Niger. Hence, empowering rural women particularly, by improving their access to agricultural inputs and new technologies, as well as their access to finance, appears crucial to better mainstreaming the gender issue in decisions on climate change adaptation for agriculture in Niger.

Table 7:Results from descriptive statistics of adaptation practices to climate change in Niger

Practices of adaptation	Proportion of Men	Proportion of Women	Diff
Mixed crop	77.41	67.44	9.97*** (0.03)
Crop rotation	11.85	16.28	-4.43* (0.03)
Use of improved seed	31.68	24.71	6.97** (0.03)

Practices of adaptation	Proportion of Men	Proportion of Women	Diff
Applicant fertilizers	17.35	11.91	5.44*** (0.03)
Use of pesticides	27	22.38	4.62 (0.03)
Crop diversification	35.81	26.45	9.36*** (0.04)
Livestockdiversification	22.03	22.67	-0.64 (0.03)
Agroforestry	42.7	34.3	8.4** (0.04)
Income diversification	20.11	20.93	-0.82 (0.03)
Migration	2.5	1.7	0.8 (0.01)
Use of Tassa demilune	38.57	28.77	9.8*** (0.04)
cover crop	22.58	16.86	5.72* (0.03)
Zero tillage	5.7	5.2	0.5 (0.02)
Mulching	25	21.22	3.78 (0.03)
use of organic fertilizer	66.94	56.1	10.84*** (0.04)

Note: ***= $P \leq 0.01$, ** = $P \leq 0.05$, * = $P \leq 0.10$, ()=standard error
Source: Author’s own field survey 2021

4.4 The determinant of the level of adaptation practices to climate change from MNL regression

The multinomial logit (MNL) model is used to estimate separately according to gender, and socio-economic factors that influenced farmers' level of adaptation (low, medium, and high) to climate change among farming households in Niger it is estimated by normalizing one category, which is referred to as the “reference base category. In this study, the base category is a low level of adaptation practices against which comparisons are made in each case. The result of the multinomial logit (MNL) model indicated that socio-economic factors which determine farmers' level of adaptation to climate change are: access to land, education, farming experience, field size, household size, access to credit, farmer group membership, farm income, off-farm income, family labor, precipitation, and temperature.

The likelihood ratio statistics as indicated by $\chi 2$ statistics are highly significant ($p<0.0000$). The explanatory variable reflected by Pseudo R^2 is (0.5286), which means the hypothesized variables explained about 53% of the variations in the extent of farmers' level of adaptation practices in their farming activity. The parameter estimates of the MNL model only provided the direction of the effect of the explanatory variables on the dependent variable and did not present the actual magnitude of change or probabilities in the coefficients. Thus, the marginal effects from the MNL, measure the expected change in the probability of a particular level of contribution to decision-making with respect to a unit change in an independent variable.

Table 5 below shows that farm income, credit access, farmer group membership, temperature, precipitation, household size, adult family labor over 18 years old, and young family labor aged from 10 to 17 years old, have a significant effect to be part at medium and high level compared to low level of adaptation practices. While for women land access, farm experience, farm income, and off-farm income belong to 25000 fcfa-50 000 fcfa, and access to credit have a significant effect to be part of medium and high level compared to low level of adaptation.

Therefore, the farm incomes belong to (25000-50 000 fcfa), and (> 50000fcfa) are positive and statistically significant at 5%. Hence increases farm income by 18.6% and 22.4% respectively, mean to increase the probability of men to be part of medium-level of adaptation practices. This finding is consistent with a study by Belay et al. (2017), which found that household income has a positive impact on the adoption of adaptation strategies. A similar result to the study of Tadesse et al (2009), found that the farm income of the households has a positive and significant impact on the adoption of adaptation practices.

The variable off-farm income belongs to (25000-50 000 fcfa) is positively significant at 10%. Then increases off-farm income (25000-50000 fcfa) by 16.3%, the probability for men being part of the high level. This reduces by 26% the probability of being part of a low level. However, household off-farm income is earnings from other businesses without agriculture activity done by farmers. Therefore, a rise in off-farm income can positively increase the decisions of farmers to invest in the adoption of climate change adaptation strategies. Similar results to studies of Adeagbo et al.(2021) and Kassie et al.(2015) who found that non-farm income provided farmers with the additional financial power to adapt to climate change strategies.

Access to credit is positively significant at 5%. Therefore, accessibility of credit increases the probability by 13.1 % and 30% for men to be part of the medium and high level of adaptation practices respectively. It reduces by 36% the probability of being part of a low level. Similar result to Zakari et al (2022) finding, they argued that farmers with access to credit are more likely to adopt improved crop varieties than their counterparts. Because of their poverty in a rural area, many farmers cannot afford to buy these highly resilient crop varieties; therefore, access to credit may facilitate the adoption of improved crop varieties. Further, the availability of credit eases the cash constraints and allows farmers to purchase improved agricultural inputs such as fertilizer, improved crop varieties, and irrigation facilities which in turn can result in increased farm-level productivity and as such improve net revenue generated from their farm activities (Tadesse et al.,2009 ; Adeagbo et al., 2021).

The variable farmer group membership is positively significant at 5% and 10%. Being group membership for farmer increases by 14.5% and 10% the probability for men being part of the medium and high level of adaptation practices respectively. However, social capital is represented by the interaction between farmer-to-farmer relations, this contributes on facilitation of sharing information about innovative farming practices, improve the accessibility on weather information and the adoption of new technologies in agriculture. According to Adeagbo et al., (2021), membership in a farmers' group or association is a form of social capital to farmers not only in terms of accessing credit and other farm inputs but also in terms of marketing and provision of opportunities to share vital information. Thereby, membership in associations increases the likelihood of adopting climate change adaptation strategies. This is because some strategies of adaptation require new knowledge and significant investment, which may be facilitated by group membership (Bryan et al., 2013).

The household size is positively significant at 1%. Having a large family increase by 4% the probability for men to be part of a medium level. This reduces by 4.6% the probability of being part of a low level. Therefore, the larger household size represents an intensive labor unit which increases agricultural production and thus, influences the probability of adopting climate change adaptation strategies. This result is similar to the study of Adeagbo et al (2021), which found that an additional household member may increase the likelihood of adopting climate change adaptation strategies. In the same way, Belay et al., (2017) found that the larger the size of the family, the higher the probability of maize farmers adopting climate change adaptation in the study area.

Family labor out of which adult family labor (0ver 18 years old) and family labor young/adolescent are positively significant at 1%, at 5% respectively. then the availability of adult family labor increases by 6.3% and 4% the probability for men of being part of the medium and high level of adaptation respectively. It reduces by 1.1% the probability to be part of the low level. While for young adolescents' family labor increases by 3.3%, the probability for men of being part of medium level. thus, a family that has more labor has a better chance of adapting to climate change, so the larger this labor force, the greater the adoption of climate change adaptation strategies. Therefore, the number of adult household members reflects the availability of family labor that could potentially be used on farm activities that can increase household adoption of climate change adaptation practices(Wollni et al., 2010).

The result is similar to the finding of Zamasiya et al (2021) who argued that the family offers technical and manual skills that are crucial for executing agronomic practices on time. Smallholder farming households that have large pools of labor can spread labor resources across different adaptation practices. So, a large family means a greater labor force that would support a household to adopt labor-intensive agricultural technology (Tadesse et al., 2009; Bryan et al., 2009). Nhemachena & Hassan (2008), argued that the opportunity cost of labor might be low in rural areas of most developing countries, and farm households with more labor are more likely to take up adaptations.

Climatic variables (temperature and precipitation) are statistically significant at 1%. Therefore, the decrease of precipitations reduces by 4% and 5%, the probability of men being part of medium and high levels respectively, and increases by 9% the probability of men being part of low level.

Also, the increase in temperature, reduces by 90% and 84%, the probability of men being part of the medium and high level of adaptation respectively. It increases by 17.3% the probability of being part of the low level of adaptation. Unlike, to increase farmers' adoption of adaptation practices to climate change in Niger, when temperature increased and precipitations decreased. The poverty of farmers and education can explain this because farmers need money to access some new technology such as irrigation and how to manage some new inputs like application of fertilizers.

This result is in contrast to literature findings that increased temperature lead farmers to increase the adoption of adaptation strategies of farmers to climate change. The findings indicate that to cope with increased temperatures, farmers will tend to use drought-tolerant crop varieties, as well as conserve soil to preserve moisture content. Moreover, farmers employed irrigation measures to supplement rainfall deficits due to increased temperature. Like rising temperatures, a decrease in rainfall was likely to increase the probability of adapting to climate change(Gebrehiwot & Veen, 2013). Tadesse et al (2009) finding, where households with higher annual mean temperatures were more likely to adapt to climate change through the adoption of different practices. In the same way, they argued that farmers will vary planting dates so that critical crop growth stages do not coincide with peak temperature periods, and they will irrigate to supplement rainwater and compensate for the loss of water associated with increased evapotranspiration due to increased temperature. But, similar findings with precipitation, when higher precipitation can lead farmers to adopt climate change adaptation strategies less.

Table 8:determinants of the level of adaptation practices for Men from the MLN model

variables	Low level		Medium level		High level	
	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Land access	-	-0.03	0.01	-0.01	0.34	0.04
		(0.3)	(1.28)	(0.21)	(1.69)	(0.16)
FarmExpe	-	0.00	0.00	0.00	-0.012	-0.00
		(0.00)	(0.01)	(0.00)	(0.014)	(0.02)
field size	-	0.21	-0.94	-0.13	-0.93	-0.08
		(0.15)	(0.81)	(0.11)	(0.89)	(0.08)
Farmincon(25000-50000fcfa)	-	0.17	-1.11**	-0.19**	-0.22	0.011
		(0.13)	(0.61)	(0.08)	(0.68)	(0.08)
Farmincon(> 50000fcfa)	-	-0.20	1.11*	0.22*	0.22	-0.02
		(0.14)	(0.61)	(0.12)	(0,68)	(0.07)
OffarmInc(25000-50000fcfa)	-	-0.26*	0.22	0.012	1.63*	0.03*
		(0.15)	(0.57)	(0.09)	(0.77)	(0.11)
OffarmInc(>50000fcfa)	-	0.09	-0.22	-0.02	0.69	-0.07
		(0.13)	(0.57)	(0.09)	(0.65)	(0.06)
education	-	-0.04	0.2	0.03	0.08	0.00
		(0.06)	(0.27)	(0.04)	(0.29)	(0.03)
CreditAcces	-	-0.36**	1.25**	0.13**	1.86**	0.23**
		(0.15)	(0.75)	(0.12)	(0.79)	(0.12)
Famergroupmemb	-	-0.24	-1.1**	0.15**	-1.11*	0.01*
		(0.10)	(0.54)	(0.07)	(0.59)	(0.06)
Temperature	-	1.73***	-6.52***	-0.90***	-8.21***	-0.84***
		(0.23)	(1.03)	(0.17)	(1.27)	(0.14)
Precipitation	-	0.09***	-0.04***	-0.04***	-0.05***	-0.05***
		(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Household size	-	-0.05***	0.24***	0.04***	0.11	0.01
		(0.02)	0.01	(0.01)	(0.07)	(0.01)
adultfamilylaborover18yearsold	-	-0.01***	0.38***	0.06***	0.04**	0.01**
		(0.02)	(0.08)	(0.01)	(0.08)	(0.08)
familylaboryoungadolescent10-17	-	0.03	0.18**	0.03**	-0.02	0.01
	-	(0.02)	(0.10)	(0.02)	(0.09)	(0.01)
_cons			206.73***		261.48***	
			(32.41)		(40.20)	

LR chi2(32) = 350.07
Prob > chi2 =0.0000

variables	Low level		Medium level		High level	
	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Pseudo R2 = 0.4544						

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.10, () =standard error
Source: Author's own evaluation using field survey 2021

Although, the table 6 below show that access to land has a significant (P<0.05) effect on the probability for women to be part of a medium level compared to a low level of adaptation. Accessibility to land increases by 17%, the probability for women to be part of the medium level of adaptation. It reduces by 23%, the probability of being part of a low level. Therefore, access to land provides an important source of resilience for women who may lack other options to adapt to the effects of climate change (Global Gender and Climate Alliance, 2016). Along the same line, Ume et al (2021) found that female farmers with both structural and relational access to land have better control and decision on how to put the land to best use. Otherwise, improving women's right to land and property is crucial for women's economic empowerment. Because land is a base for food production and income generation; the land as collateral for credit and a means of holding savings for the future. In additionally, women's ownership of property extends their capabilities, expands their negotiating power, and enhances their ability to address the vulnerability. It is also serving as a critical factor in social protection against gender-based violence(Sida, 2015).

Further, the farm income belongs to (25000-50 000 fcfa) is positively and statistically significant at 10%. Hence increases farm income by 22%, the probability for women to be part of medium level. The variable off-farm income (25000-50 000 fcfa) is statistically significant at 1% and 10%. Then increases off-farm income by 81% and 1%, the probability for women being part of the medium and high level of adaptation respectively. This reduces by 81% the probability of being part of a low level. Having the opportunity of off-farm income high than 50 000fcfa, increases by 33% the probability for women of being part of a medium level of adaptation.

The finding is in contrast with Adeagbo et al (2021) and Issahaku (2018) findings that Famers with other sources of income are less likely to adopt climate change adaptation methods as they could easily switch completely to off-farm employment, particularly when the cost of climate change adaptation becomes costly and unaffordable. Asrat & Simane (2018) argued that non- farm income decreases the likelihood of adaptation. Thus, households engaged more in non-farm activities, become less dependent on crop farming, and are less motivated to invest in adaptation in the crop sector. Though, Amoah et al (2021) found gender differentiated effect in the engagement of off-farm activities. Female farmers are more engaged in off-farm activities like petty trading as compared to male farmers. The possible reason that could be attributed to this is that female farmers undertake off-farm practices to counterbalance their comparable lower on-farm earnings. Along the same line, Wrigley-Asante et al. (2017) argued that for female farmers petty trading in agricultural and consumable goods, is an off-farm strategy to face climate risks. The income and often crop market information gained has in turn increased the resilience of women in adapting to climatic hazards and empowered them in the sense that it has subsequently improved their decision-making role at the household level.

Access to credit is positively significant at 10%. Therefore, accessibility of credit increases the probability of women by 13% being part of the medium level of adaptation practices.

Farm experience has a positive significant effect at 5%. Having experience increases by 1%, the probability for women to be part of a high level. The result is an accordance with the study of Abid et al (2015), which found a positive relationship between farming experience and adaptation to climate change. The study concluded that farmers with greater farming experience are likely to be more aware of past climate events and better judge how to adapt their farming to extreme. Then, highly experienced farmers have more knowledge on climate change adaptation and know more about risk management (Montle, & Teweldemedhin, 2014).

Level of education is positively significant at 10%, improving the level of education of women increases by 6% the probability of being part of a medium level of adaptation The finding of this study is supported by the study of Abid et al (2015), who argued that farmers with more years of schooling are more likely to adapt to changes in climate compared to the farmers with little or no education. Therefore, a significant positive relationship was found between the education of household heads and adaptation to climate change (Bryan et al., 2009; Tadesse et al., 2009). Farmers with higher education are likely to have more information on climate change, which in turn might promote the probability of adopting climate change adaptation strategies (Hadgu et al., 2015). Moreover, educated farmers tend to better recognize the risks associated with climate change, also education can improve the skill and awareness of farmers about new technologies and hence induces them to adopt (them (Ali & Erenstein, 2017; Asrat & Simane, 2018).

Temperature and precipitation are negatively significant effects at 1%. Thus, precipitation and temperature respectively reduce by 3% and 48% the probability of women being part of a medium level of adaptation. This is in contrast with previous studies, found that greater variability in rainfall and maximum temperature increases the use of risk-reducing practices through adopting changes in agricultural management (Solomon & Leslie 2015; Ojo & Baiyegunhi, 2018).

Table 9:determinants of the level of adaptation practices for Women from the MLN model

Variables	Low level		Medium level		High level	
	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Land access	-	-0.23***	2.04**	0.17**	19.33	0.06
		(0.09)	(1.13)	(0.08)	(12.05)	(0.04)
FarmExpe	-	0.003	-0.02	-0.00	-0.06**	-0.01**
		(0.01)	(-0.02)	(0.00)	(0.02)	(0.02)
Field size	-	-0.31	1.83	0.31	1.34	0.00
		(0.26)	(1.23)	(0.3)	(1.29)	(0.29)
Farmincon(25000-50000fcfa)	-	-0.22	2.25*	0.22*	1.95	-0.00
		(0.26)	(1.26)	(0.14)	(1.4)	(0.32)
Farmincon(>50000fcfa)	-	-0.42	2.25	0.42	1.95	0.00
		(0.31)	(1.26)	(0.44)	(1.4)	(0.52)
OffarmInc(25000-50000fcfa)	-	-0.81***	4.9***	0.81***	2.72*	0.01*
		(0.17)	(1.63)	(0.30)	(1.61)	(0.18)
OffarmInc(>50000fcfa)	-	-0.33	4.9***	0.33**	2.72	0.00
		(0.23)	(1.63)	(0.14)	(1.61)	(0.33)
Education	-	-0.07	0.51*	0.06*	0.94	0.00
		(0.18)	(0.27)	(0.06)	(0.32)	(0.23)
CreditAcces	-	-0.12	1.12*	0.13*	0.68	0.00
		(0.29)	(0.75)	(0.07)	(0.89)	(0.27)
Famergroupmemb	-	-0.03	0.27	0.04	-0.57	-0.00
		(0.16)	(0.56)	(0.08)	(0.7)	(0.15)
Temperature	-	0.49	-3.61***	-0.48***	-8.11	-0.01
		(1.59)	(0.88)	(0.48)	(2)	(2.05)
Precipitation	-	0.00	-0.02***	-0.03***	-0.05	-0.00
		(0.01)	(0)	(0.00)	(0.01)	(0.01)
Household size	-	-0.01	0.07	0.01	0.00	0.00
		(0.01)	(0.07)	(0.10)	(0.08)	(0.00)
adultfamilylaborover18yearsold	-	0.01	-0.08	-0.01	0.00	0.00
		(0.01)	(0.08)	(0.01)	(0.09)	(0.01)
familylaboryoungadolescent10-17	-	0.01	-0.06	-0.01	0.06	0.00
		(0.02)	(0.11)	(0.02)	(0.12)	(0.02)
_cons	-		109***		238.52	
			(27.73)		(1206)	
LR chi2(32) = 353.82						
Prob > chi2 = 0.0000						
Pseudo R2 = 0.5286						

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.10, ()=standard error
Source: Author's own field survey 2021

4.5 Loading factors of constraints from PCA

The table below gives results from a principal component analysis of major factors constraining women and men farmers in the decision to adapt to climate change in Niger. Until the sample size is greater than 50 (n > 50), a loading is significant at the 1% level if its value is greater than±0.346. In the case of this study, the number of factors is extracted by leaving out components with corresponding Eigen values (a measure of explained variance) of less than one. Only variables with factor loadings of ±0.40 factor loading and above are extracted and used in named factors, while variables that have factor loading of less than ±0.40 were not used (Otituju & Enete, 2016). Therefore, three factor are extracted and based on the highest loaded constraints in each factor, factor 1 is named institutional, public, high cost of inputs, and field distance constraints; the factor is named land, education, and religious beliefs/customs constraints and factor 3 is named labor and financial constraints.

Thus, under factor 1(institutional, public, attacks of pest/ diseases, high cost of inputs and field distance constraints), for women and men the constraining variables in farming households include: the high cost of input/fertilizers (0.76), (0.73); insufficient technical knowledge (0.75), (0.74); low skill (0.75), (0.71); lack/poor access to climate information (0.75), (0.68); lack/weak support from agricultural extension services (0.84), (0.72); poor storage and processing facilities (0.64), (0.55); lack/ weak of government support (0.58), (0.68); problem related of availability in the supply of agricultural inputs(0.78), (0.79); poor access to information on climate adaptation strategies (0.78), (0.74); attack of pests/diseases (0.85), (0.86) and field distance (0.74), (0.67) respectively.

Hence, the major constraints for farmers to an effective adaptation practice to climate change are the problem of information and weak support from the public and institutional. Because the information is capital for farmers to follow the new weather forecast and adaption strategies to better manage climate risks like the attack of pests/diseases. The weak or absence of agricultural extension services and availability and affordable price of inputs also increase farmers' low adoption of new technologies. This finding is supported by literature where similar finding with Amusa (2014), who argued that weak infrastructural supports to farm households such as lack of weather forecast technologies, storage facilities and far distances to farms may reduce the capacity to adapt to climate change. Otitoju & Enete (2016), found that public and institutional problems are serious challenges to farmers' coping or adaptation strategies because they may not be aware of recent developments regarding climate change adaptations and necessary readjustments needed. Whereas, the variables loaded women and men under factor 2 (land, education, and religious beliefs/customs constraints) include the problem of land access (0.58), (0.62); illiteracy of farmers (0.58), (0.57.) and religious beliefs and customs (0.46), (0.56) respectively. This is similar with Otitoju & Enete (2016), who found that high cost of farmland, poor access to and control of land, the inherited system of land ownership religious belief and customs norms were the major barrier in effective adaptation to climate.

Meanwhile, under factor 3 (labor and financial constraints) the constraining variables for women and men include lack of inadequacy of labor (0.61), (0.60); low income (0.43), (0.42) and insufficient or poor access to credit (0.42), (0.45) respectively. It is in conformity with the study by Ige et al. (2021), who found that major constraints in the adoption of climate change strategies are the high cost of labor and inadequate finance and credit. Because adaptation to climate change is costly, lack of money hinders farmers from getting the necessary resources and technologies in order to adapt to climate risk (Ann & Anayochukwu 2016; Fagariba & Song, 2018).

Thus, the results of PCA show that in each factor women are to be the most constraining than man. This is particularly due to women's low financial capacity; very poor accessibility of women to information on climate and new adaptation strategies; weakness or lack of interaction between women and extension agents; and low level of education. Similar to Amoah et al. (2021) who found that gender had a significant influence on barriers including lack of access to credit facilities and the high cost of improved crop varieties. Majority of the female farmers reported these barriers as more critical than the male farmers implying their low access to household financial resources as opposed to the males.

Nevertheless, the most constraints of adaptation practices in Niger are attacks of pests/diseases coupled with the high cost of farm input low income of farmers, land tenure issues, poor government support, problems related to labor and level of education, and weak information restrain farmers from effective adaptation practices. In conformity of Fagariba et al (2018) argued that poor government support for the agriculture sector, high cost of inputs including tractors services, improved seeds, and farm labor, land ownership issues, and poor diffusion of climate information led to farmers' inability to make provisions for uncertainty thereby, increasing their vulnerability to climate change impact. These hinder farmers' efforts to mitigate challenges associated with climate change.

Table 10:Results of constraints from principal component analysis (PCA) among women & men farmers

	factor 1		factor 2		factor 3	
	Women	men	women	men	women	men
problem of land access	0.19	0.06	**0.58**	**0.62**	0.27	-0.25
lack of inadequacy labor	**0.47**	**0.43**	0.07	0.00	**0.61**	**0.60**
low income	0.23	**0.41**	**-0.44**	0.05	**0.43**	**0.42**
high cost of input/fertilizers	**0.76**	**0.73**	0.01	0.17	-0.02	0.07
Insufficient/poor access to credit	0.39	0.04	0.26	0.31	**0.42**	**0.45**
Insufficient technical knowledge	**0.75**	**0.74**	-0.02	0.08	0.15	-0.24
low skill	**0.75**	**0.71**	**-0.40**	**-0.45**	-0.12	0.14
Illiteracy of farmers	0.26	0.20	**0.58**	**0.57**	0.10	0.28
lack/poor access to climate information	**0.75**	**0.68**	-0.13	-0.12	0.02	-0.06
lack / weak support from agricultural extension services	**0.84**	**0.72**	0.05	0.16	-0.02	0.11
poor storage and processing facilities	**0.64**	**0.55**	0.07	-0.12	-0.00	-0.14
lack weak government	**0.58**	**0.68**	0.05	0.03	-0.36	0.33
problem related availability in the supply of agricultural inputs	**0.78**	**0.79**	-0.22	-0.18	-0.06	-0.05
poor access to information on climate adaptation strategies	**0.78**	**0.74**	-0.25	-0.22	-0.04	0.19
attack of pests/diseases	**0.85**	**0.86**	0.12	0.27	0.03	-0.02
religious beliefs and customs	0.23	0.17	**0.46**	**0.56**	-0.01	0.11
field distance	**0.74**	**0.67**	0.05	0.00	-0.04	-0.11

Factor loading => **0.40**
Source: Author's own field survey 2021

4.6 The determinant of the level of constraints from ordered logit regression

The result of the parameter estimates from ordered logit regression is significant as indicated by $\chi 2$ statistics and significant (p=0.0000). The explanatory power of the factors as reflected by Pseudo R2 is (39%), which means the explanatory variables explain 39% of the dependent variable of the model. The determinants of the level of constraints among farmers in Niger include: gender, farming experience, size of the field, farm income, off-farm income, education, access to climate information, membership in a group or organization of farmers, temperature, precipitation and age of farmers have a significant effect on the level of constraints.

Thus, the coefficient related to gender is negatively significant effect on the probability of constraining in making the decision of adaptation practices to climate change in Niger. This implies that women are likely the most constraining in making the decision of adaptation practices to climate change in Niger. The result of the marginal effect is significant at 1% and positive for the low level of constraint and negative for the high level of constraint. Therefore, a unit increase in the number of male farmers will result in a decrease of 18.68% in the probability of being constrained at the low level of constraint and an increase of 24.55% in the probability of being constrained at the high level of constraint for male farmers in their decision of adaptation practices to cope with climate change. Hence, women farmers are the most constrained and the least in the adoption of adaptation practices to climate change. Similar to Thinda et al (2020) finding that a lack of knowledge of Climate Change in female-headed households increased their likelihood of being constrained comparatively to male-headed households.

The coefficient farming experience is negative and significant effect (p-value=1%) related to the probability of the level of constraint among women and men farmers in their decision to adapt to climate change in Niger. However, the marginal effect is significant and positive for the low level of constraint and a negative effect on the high level of constraints of adaptation practices to climate change. That means a unit increase in an average of years of farming will increase by 1% the probability of farmers being constrained at a low level, but a unit increase of years of farming means a decrease by 0.66% in the probability of farmers being constrained at a high level.

The age of farmers is a statistically positive effect on the probability of farmers being constrained in their farm decision to adapt to climate change in Niger. From the result of a marginal effect, a unit increase in the age of farmers will lead to increasing their farming experience, this reduces by 1% probability of being constrained at a low level. This implies that, as the age of the farmer increases, his experience with certain shocks and climatic risks increases, and then his level of adaptation will also increase. The finding is in line with Thinda et al (2020), who argued that the farming experience of older farmers might possibly increase their propensity to easily perceive the impact of climate change compared with their less experienced counterparts.

The field size is a statistically negative influence on the level of constraint (p=10%) in the farming decision to adapt to climate change. The results of the marginal effect show that a unit increase in the size of a farm leads to an increase of 8% in the probability of farmers being constrained at a low level and decreases by 6% the likelihood of field size being constrained at the high level of constraint in the decision of adaptation practices with climate risk in Niger. That means farmers with a large area of the field are less constrained, due to their ability to adopt more adaptation strategies for climate change. This finding supports by Ojo & Baiyegunhi (2018), who argued that Farmers with large landholdings are likely to have more capacity to try out and invest in climate risk adaptation strategies.

The farm income has a positive effect on the level of constraint among women and men farmers in their decision to cope with climate hazards. When the farm income increases an average by one unit, the probability of being part of a low level of constraint decreases by 12%, but it increases by 9% the probability to be constrained at a high level of constraint. This implies that farmers with income are more comfortable having access to and using the adaptation strategies like the purchase of inorganic fertilizers, new tolerant varieties of inputs, and soil/water conservation methods to cope with climate risk in Niger. According to Gbetibuou, wealthier farmers are more likely to use adaptation practices in response to climate change than poor farmers cited (Ndamani & Watanabe, 2016).

The coefficient of off-farm income is negative and statistically significant at 1% on the level of constraint for women and men farmers in their decision to cope with climate hazards. The marginal effect shows that a unit increase in off-farm income means increasing by 11% the probability of farmers being constrained at the low level of constraint but decreasing by 8% the probability of being constrained at the high level of constraint. Therefore, farmers with alternative secondary sources of income are in a better position to invest in innovative farm technologies; they can purchase chemical inputs, invest in the conservation of soil, and also improved varieties as their financial constraints may be overcome by being involved in off-farm income activities (Ojo & Baiyegunhi, 2018).

The coefficient of the variable education is a positive and statistically significant effect (1%) on the level of constraint for women and men farmers in the decision of adaptation strategies to cope with climate risk in Niger. Then the result of the marginal effect shows that an increase in farmers' level of education by one unit will decrease by 14% the probability of being part of the low level of constraint, but it increases by 11% the probability to be constrained at high level of constraint. The negative relation shows that more the level of education of farmers is improved, more they are susceptible to being less constrained in the adoption of climate change adaptation strategies in Niger. Ndamani & Watanabe (2016) found that farmers with higher levels of education are more likely to use improved technologies in order to adapt to climate change. This could attribute to the fact that educated farmers are more knowledgeable due to their ability to access information pertaining to climate change and adaptation options.

The coefficient of access to climate information is positive and significant impact (5%) on the level of constraint in the decision of adaptation to climate change in Niger. The marginal result shows that a unit increase in access to climate information will decrease by 52% the probability of farmers being part at the low level of constraint and increase by 16% the probability of being constrained at the high level of constraint in the decision of adaptation to climate change among men and women in Niger.

However, the negative relationship implies that access to climate information is capital for farmers to increase their adaptation strategies to climate change. Because, through shared information, farmers know the new technology and how to manage it for better use like improved varieties, and soil and water technic conservation…the shared information improved farmers' skills and how to manage risk. Whereas, the positive relationship means that farmers are constraining by the lack of or poor access to climate information. This is in concordance with Thinda et al (2020) who reported due to the lack of information about climate change smallholder farmers are more likely constrained in the adoption of climate change adaptation strategies. This has an implication to increase their vulnerability face the impact of climate risks like drought.

The coefficient of farmer membership in an organization/group of peasants is negatively significant (5%) on the level of constraint. The marginal effect indicates that an increase of one unit of farmer participation in an organization/group of peasants leads to an increase in the probability of being constrained at the low level of constraint by 13% and a reduction by 9% in the probability to be part at the high level of constraint in the adaptation strategies to cope with climate change. Similar finding with the study on the Determinants of Relevant Constraints Inhibiting Farmers' Adoption of Climate Change Adaptation Strategies in South Africa, the authors found that the participation of farmers in farmer-based organizations (FBOs) reduces their probability of being constrained by a lack of climate change knowledge. Through this involvement in FBOs, farmers share information on farming practices, markets, and other production-related issues, that will enhance their skills and knowledge of farming (Thinda et al.., 2020; Ahmed & Melesse, 2018).

Table 11:Result of determinants of constraints from ordered logistic regression

Variables	coef	Pvalue
Gender	**-1.26*** **	0.01 (0.47)
Landaccess	-0.42	0.56 (0.71)
FarmExpe	**-0.04*** **	0.00 (0.01)
fieldsize	**-0.41* **	0.08 (0.24)
Farmincon	**0.61*** **	0.00 (0.21)
OffarmIncome	**-0.57*** **	0.01 (0.21)
education	**0.71*** **	0 (0.17)
CreditAcces	-0.12	0.77 (0.41)
AwarenessCC	0.74	0.34 (0.77)
Accessclimateinfo	2.33	0.13 (1.53)
Household size	-0.05	0.19 (0.04)
Famergroupmemb	**-0.63** **	0.05 (0.32)
Farm labor	0.00	0.93 (0.04)
Temperature	**-5.24*** **	0 (0.62)
Precipitation	**-0.03*** **	0 (0.00)
AgeofHH	**0.05*** **	0.00 (0.02)

LR chi2(15) =303.03
Prob > chi2 =0.00
Pseudo R2 = 0.39

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.10, () standard error
Source: Author's own field survey 2021

Table 12: Marginal values from ORL estimation

variables	Low level		Medium level		High level	
	Margff	Pvalue	Margff	Pvalue	Margff	Pvalue
Gender	**0.19*** **	0	0.06	0.39	**-0.25** **	0.03
		(0.05)		(0.07)		(0.11)
Landaccess	0.07	0.51	-0.00	0.87	-0.07	0.60
		(0.11)		(0.02)		(0.13)
FarmExpe	**0.01*** **	0.00	-0.00	0.13	**-0.01*** **	0.00
		(0.00)		(0.00)		(0.00)
fieldsize	**0.08***	0.09	-0.02	0.23	**-0.06***	0.09
		(0.05)		(0.02)		(0.04)
Farmincon	**-0.12*** **	0.00	0.03	0.16	**0.09*** **	0.00
		(0.04)		(0.02)		(0.03)
OffarmIncome	**0.11*** **	0.01	-0.03	0.14	**-0.08*** **	0.01
		(0.04)		(0.02)		(0.03)
education	**-0.14*** **	0	0.03	0.12	**0.11*** **	0
		(0.04)		(0.02)		(0.03)
CreditAcces	0.02	0.77	-0.01	0.79	-0.02	0.76
		(0.08)		(0.02)		(0.59)
AwarenessCC	-0.16	0.38	0.08	0.52	0.09	0.21
		(0.19)		(0.12)		(0.07)
Accessclimateinfo	**-0.52** **	0.04	0.36	0.11	**0.16** **	0
		(0.26)		(0.23)		(0.04)
Household size	0.01	0.20	-0.00	0.29	-0.01	0.20
		(0.00)		(0.00)		(0.01)
Famergroupmemb	**0.13***	0.07	-0.04	0.20	**-0.09** **	0.04
		(0.07)		(0.03)		(0.04)
Farm labor	-0.00	0.93	0.00	0.93	0.00	0.93
		(0.01)		(0.00)		(0.01)
Temperature	**1.03*** **	0	**-0.24*** **	0.10	**-0.80*** **	0
		(0.14)		(0.15)		(0.10)
Precipitation	**0.01*** **	0	**-0.00*** **	0.09	**-0.00*** **	0
		(0.00)		(0.00)		(0.00)
AgeofHH	**-0.01*** **	0.00	0.00	0.12	**0.01*** **	0.00
		(0.00)		(0.00)		(0.00)

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.10, () standard error
Source: Author’s own field survey 2021

4.7 The Gender Empowerment Index

Table 13:results of the gender empowerment index

variables	observations	mean	Std deviation	min	max
GEI for women	344	0.26	0.21	0.06	0.81
GEI for men	362	0.29	0.21	0.06	0.84

Source: Author's own field survey 2021

The average of Gender Empowerment Index (GEI) in this study is 0.29 for farmers who are men and 0.26 for women farmers, with a range between [0.06,0.84] and [0.06, 0.81] for men and women respectively. The results found that very fewer of farmers (1%) have attended the adequacy level of empowerment GEI > 0.8.

However, the results from fractional logit regression give factors that influence positively and negatively the GEI among women and men farmers in Niger. As reported in the table below, the level of education, farm income, off-farm income, moderate price sale, free cereals and seeds distribution, capacity building, facilitation in access to credit, facilitation in access to market and cash for work are statistically significant effect on the GEI across farming households in Niger. The coefficient associated with gender and facilitation in improving access to credit have a negative effect on the GEI, which means the GEI decreases when the sex of farmers is female and when the facilitation in credit reduces, but these are statistically non-significant.

The results show that formal and koranic education are positively significant thereby, the margin effect shows that an improving farmers' level of education as well as formal and koranic will increase the GEI by 3% and 7% respectively. Meanwhile, a small change in the farm income increases GEI by 4% for farm income between 25 000-50 000fcfa and by 6% for farm income belonging from 50 000fcfa to high. But, when the opportunity to have off-farm income (25 000-50 000fcfa) reduces, decreases GEI by 3%. Though, enhancing farmers' support from the government such as moderate price sales, free cereals distribution, free seed distribution, capacity building, facilitation in access to credit, facilitation in access to market, and cash for work contribute to improving gender empowerment by 5%, 2%,3%, 5%, 6%,14%, and 15% respectively.

Nevertheless, the estimation of the model according to the gender of farmers shows that for women farmers education level, farm income, moderate price sale, free cereals distribution, capacity building, facilitation in access to market, and cash for work are positively significant. In contrast, off-farm income is a negative and statistically significant effect on the GEI. While for men farmers the level of education (formal and koranic), the farm income, moderate price sale, free seed distribution, facilitation in access to credit, facilitation in access to market, facilitation in improving access to credit and cash for work. Therefore, improving women farmers' koranic education increases GEI by 8%. Whereas raising men farmers formal education as well as koranic one increases GEI by 6% and 7% respectively. So, the increase of farm income belongs 25 000fcfa to 50 000fcfa may increase the GEI of women and men by 5% among farming households in Niger. In addition, changing the farm income for men farmers who have 50 000fcfa and more increases GEI by 7%. Also, a decrease in the opportunity for women farmers to have access to off-farm activity reduces the GEI by 3%. Furthermore, increasing women farmers in moderate price sales, free cereal distribution, capacity building, facilitation in access to market, and cash for work will improve the GEI by 3%, 4%, 8%, 13%, and 12% respectively. Whereas for men farmers the augmentation in receiving moderate price sales, free seed distribution, facilitation in access to credit, facilitation in access to market and cash for work, increases the GEI by 6%, 4%, 9% and14% respectively. But the decrease of facilitation in improving access to credit reduces by 15% the GEI of men farmers in Niger.

In summary, the results of this analysis show that Koranic education also provides moral values to women and men for improved community living. It is also, an ideal platform for exchange and sharing of information. Therefore, it is important for us to consolidate knowledge from Koranic teachings for better decision-making. The findings also demonstrate that the government and its partners in development should focus on activities such as capacity building, infrastructure to facilitate access to markets, and improved facilitation of access to credit which will greatly increase the sustainable resilience of the population rather than the free distribution of cereals. This finding is supported by Bago et al (2021) who argued that electrified areas under PRONER have significatively increased women’s time allocation to non-agricultural activities. Thus, increasing infrastructure leads to increase economic opportunities thereby, the bargaining power of women will improve through the augmentation of income.

Table 14:Fractional logit regression

Variables	coef	Pvalue	Margin valu	P value
Gender	-0.03	0.65 (0.06)	-0.00	0.65 (0.01)
formal education	**0.18****	0.03 (0.08)	**0.03****	0.03 (0.01)
Koranic education	**0.41*****	0.00 (0.08)	**0.06*****	0.00 (0.01)
Farm income (25 000 - 50 000)	**0.30*****	0.00 (0.07)	**0.04*****	0.00 (0.01)
Farm income (50 000 FCFA to high)	**0.35*****	0.00 (0.10)	**0.06*****	0.00 (0.02)
Off-farm income (25 000 - 50 000)	**-0.14****	0.04 (0.07)	**-0.02****	0.04 (0.01)
Off-farm income (50 000 FCFA to high)	-0.113	0.27 (0.10)	-0.02	0.26 (0.02)
Moderate price sale	**0.30*****	0.00 (0.07)	**0.05*****	0.00 (0.01)
Free cereals distribution	**0.10***	0.10 (0.06)	**0.02***	0.10 (0.01)
Freed seed distribution	**0.18*****	0.01 (0.06)	**0.03*****	0.01 (0.01)
Capacity building	**0.26*****	0.00 (0.09)	**0.05*****	0.01 (0.02)
Facilitation in access to credit	**0.40****	0.02 (0.16)	**0.06****	**0.04** (0.03)
Improvement in storage	0.16	0.27 (0.15)	0.02	0.29 (0.02)
Facilitation in access to market	**0.81*****	0.00 (0.07)	**0.14*****	0.00 (0.01)
Facilitation in improving access to credit	-0.31	0.23 (0.26)	-0.05	0.19 (0.05)
Cash for work	**0.78*****	0.00 (0.07)	**0.14*****	0.00 (0.01)
_cons	**-2.17***** (0.08)	0.00		
Wald chi2 (19) =1093.21 Prob > chi2 =0.00 Pseudo R2 = 0.11				

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.10

Source: Author's own field survey 2021

Table 15:Fractional logit regression results by gender

	Women				Men			
GeWin	Coef.	Pvalu	margin	Pvalu	Coef.	Pvalu	margin	P
Formal education	0.04	0.77	0.01	0.77	0.34***	0.01	0.07***	0.01
		(0.12)		(0.02)		(0.12)		(0.02)
Koranic education	0.44***	0.00	0.08***	0	0.42***	0.00	0.08***	0
		(0.12)		(0.02)		(0.12)		(0.02)
Farmincon(25 000 - 50 000)	0.27***	0.01	0.05***	0.01	0.28***	0.01	0.06***	0.01
		(0.10)		(0.02)		(0.11)		(0.02)
Farmincon(50 000 to high)	0.28	0.11	0.05	0.12	0.39***	0.00	0.08***	0.01
		(0.17)		(0.03)		(0.13)		(0.03)
OffarmIncom(25 000 - 50 000)	-0.17*	0.07	-0.03*	0.07	-0.12	0.26	-0.02	0.26
		(0.10)		(0.02)		(0.11)		(0.02)
OffarmIncom(50 000 to high)	-0.09	0.61	-0.02	0.61	-0.14	0.30	-0.03	0.29
		(0.18)		(0.03)		(0.14)		(0.03)
Moderate price sale	0.17*	0.07	0.03*	0.07	0.32***	0.00	0.06***	0
		(0.09)		(0.02)		(0.09)		(0.02)
Free cereals distribution	0.22**	0.02	0.04**	0.02	-0.03	0.71	-0.01	0.71
		(0.09)		(0.02)		(0.08)		(0.02)
Freed seed distribution	0.09	0.31	0.02	0.32	0.24***	0.01	0.05***	0.01
		(0.09)		(0.02)		(0.09)		(0.02)
Capacity building	0.47***	0.00	0.09***	0	0.17	0.21	0.03	0.22
		(0.11)		(0.02)		(0.13)		(0.03)
Facilitation in access to credit	0.21	0.35	0.04	0.37	0.48**	0.03	0.10**	0.04
		(0.23)		(0.05)		(0.22)		(0.05)
Improvement in storage	-0.04	0.89	-0.01	0.89	0.16	0.36	0.03	0.37
		(0.30)		(0.05)		(0.18)		(0.04)
Facilitation in access to market	0.80***	0.00	0.16***	0	0.84***	0.00	0.18***	0
		(0.10)		(0.02)		(0.10)		(0.02)
Facilitation imprving accesscredit	0.10	0.72	0.02	0.73	-0.84**	0.03	-0.13***	0
		(0.29)		(0.05)		(0.37)		(0.04)
Cash for work	0.74***	0.00	0.14***	0	0.76***	0.00	0.15***	0
		(0.12)		(0.02)		(0.09)		(0.02)
_cons	-2.10***	0.00			-2.27	0.00		
		(0.11)				(0.12)		
Wald chi2(15) = 604.38						Wald chi2(15) = 633.56		
Prob > chi2 = 0.0000						Prob > chi2 = 0.0000		
Pseudo R2 = 0.1131						Pseudo R2 = 0.1070		

Note: ***= P ≤ 0.01, ** = P≤0.05, * = P≤0.1

Source: Author’s own field survey 2021

Conclusion & Policy Implications

This dissertation investigated the gender dimension in the decision of adaptation strategies to climate change among farming households in Niger. The analysis of this study is based on three specific objectives and used purposive multi-stage and random sampling method, where 707 farmers (women and men) were randomly selected to respond to the structured questionnaires, these constitute the primary data and secondary data were obtained from national institute of statistic (INS). Descriptive statistics such as frequency, percentage, bar charts, mean, and test of proportion are used for data analysis. The study used also, multinomial logit (MNL), principal component analysis (PCA), and ordered logit regression (OLR), to analyze factors, determinants of the level of adaptation, and level of constraints.

The results from socio-economic characteristics show that 51% of farmers interviewed were male while 49% were female, but the majority of respondents had sex of household male (45%) against 5% are females. The dominant marital status of the household head is married with 90% of respondents The average age of household head and farming experience are 53 and 29 years old respectively. The majority of farmers (54%) have ages between 19-40. The average size of a household is about 11 persons. The study found that Koranic is the most level of education attended by respondents (53%) while farmers who have attended formal education which means primary and secondary school is 26%. Furthermore, 99.44% of households used wood collected/purchased as the main source of energy for cooking,47.46% traditional latrines as a toilet, 46.05% tap water (46.05) as the source of drinking water, and 65% used battery lamps for light. The finding shows the persistence of poverty among farming households hence increasing household vulnerability. The use of wood as the main source of energy contributes to an increase the deforestation, therefore, contribute to climate change in Niger.

The study found that the perception of climate change is gender-differentiated in the southeast of Niger. The majority of respondents (64%) perceive the change by the early stop raining out of which 70% are Men and 58% women. Whereas 63% of respondents perceived climate change as the scarcity of precipitation, among this 66% are men and 60% women. Meanwhile, 66% of respondents where 68% of men and 64% of women recognize drought as the climate hazard in

Niger. However, women appear to be highly exposed to the risks climatic which have a negative effect on women's income, and agricultural and livestock production compared to men. The greatest of respondents (92%) have radio as the main source of access to climate information.

The results show that both men and women used different adaptation strategies to face climate change. These strategies include mixed crop, crop rotation, use of the improved seed, application of fertilizers, crop diversification, agroforestry, use of tassa demi lune, cover crop, use of organic manure, use of pesticides, livestock diversification, income diversification, migration, zero tillage, and mulching. However, the test of proportion reveals the difference between men and women in the utilization of each adaptation practice. Despite Niger's irrigation potential, this study shows that this adaptation practice in response to climate change is not adopted by farmers in the study area. However, regardless of the adaptation strategies, men farmers are more likely to adopt these than women farmers. This indicates that women farmers are less and less involved in the use of climate change adaptation practices in Niger. Thus, women farmers are likely low in the adoption of adaptation strategies to cope with climate risks in Niger.

The results of the multinomial logit (MNL) model indicate that the estimated parameters are highly significant (p=0.000), and the explanatory variables affect 53% of the probability of farmers' level of adaptation decision to climate change. Socio-economic factors which determine farmers' level of adaptation to climate change are access to land, education, farming experience, field size, household size, access to credit, farmer group membership, farm income, off-farm income, family labor, precipitation, and temperature. The study compares the medium and high levels of adaptation to the low level of adaptation strategies, these findings that women have fewer determinants than men to be part of the medium and high level of adaptation comparatively to the low level. Thereby, the determinants for women to be part of medium and high level compared to low level of adaptation practices include land access, farm experience, farm income, off-farm income, and access to credit. Whereas the determinants for men to be part at medium and high level compared to low level of adaptation practices are farm income, credit access, farmer group membership, temperature, precipitation, household size, and family labor.

The analysis of factors constraining farmers' decision of adaptation used principal component analysis (PCA) and ordered logit regression to determine the major factors and determinants of constraints among farming households in Niger. PCA results with a factor loading of ±0.40 show that the major factors constraining women and men in making adequate decisions of adaptation strategies to climate change in Niger include: factor 1 institutional, public, and high-cost constraints; factor 2 land, education, and religious beliefs/customs and factor 3 labor and financial constraints. The results from ordered logit regression indicate that the parameters estimated are significant (p=0.0000). The explanatory power of variables reflects 39% of the variation of the dependent variable. The variables which determine the level of constraints in farmers' decisions of adaptation strategies in Niger include gender, farming experience, size of the field, farm income, off-farm income, education, access to climate information, membership in group or organization of farmers, temperature, precipitation and age of farmers these have a significant effect on the level of constraints.

Thus, the most constraints of adaptation practices in Niger are attacks of pests/diseases coupled with the high cost of farm input low income of farmers, land tenure issues, poor government support, problems related to labor and level of education, and weak information restrain farmers from effective adaptation practices. Nevertheless ,the results indicate that women are the most constraining than man in decision of adaptation practices. This is particularly due to women's low financial capacity; very poor accessibility of women to information on climate and new adaptation strategies; weakness or lack of interaction between women and extension agents; and low level of education.

The Gender Empowerment Index (GEI) shows that men and women are disempowered, women seem to be low empowered than men across farming households in Niger. Furthermore, the results from fractional logit regression show the influencing factors on the GEI among women and men farmers in Niger. The findings show also a gender-differentiated determinant of GEI therefore, for women farmers Koranic education, farm income, moderate price sale, free cereals distribution, capacity building, facilitation in access to market, and cash for work positively significantly affect the GEI. In contrast, off-farm income is a negative and statistically significant effect on the GEI of women farmers. While for men farmers' formal and koranic education, farm income, moderate price sale, free seed distribution, facilitation in access to credit, facilitation in access to market, facilitation in improving access to credit and cash for work have significant and positive effects on the GEI.

Considering gender, men farmers perceive more climate change through early stop rain and the risk related to this is drought rather than women farmers in Niger. But women are the most negatively affected by climate change by a forte decrease in agricultural production and income than men among farming households in Niger. The findings show that women farmers adopt fewer strategies of adaptation to climate change therefore, women have low level of adaptation practices than men to cope with climate hazard in Niger. Also, socioeconomic characteristics attribute to farmers influence significantly their decision level of adaptation strategies to climate change. The factors that constrain farmers to make an adequate decision to adapt to climate change are institutional, public, land, labor, education, religious belief/customs, field distance, and finances. Hence, women farmers appear the most vulnerable to climate change and they have a low level of adaptation strategies to climate change but highly constraining than men among farm decisions in the southeast part of Niger. Further, women and men farmers do not achieve the adequacy level of empowerment which means the disempowerment of women and men in the farming household with women more disempowered. The supports from the government and its partners influence more men's gender empowerment index than women farmers in Niger. The opportunity for women to have off-farm activities, improvement of farm income, and improved education level have a positive influence on the enhancement of women's empowerment. Therefore, improved socio-economic characteristics according to gender will enhance farm-level adaptation to climate change for increased especially women's resilience and empowerment in the rural area of Niger.

Nonetheless, this study identifies certain limitations as follow: firstly, the gender analysis is focused on adaptation decision in crop production among farming household in Nigeria therefore, the other production in the agriculture sector such as livestock and others are not taken into account. Secondly in this study, the income of households is estimated in an interval instead of the calculation. Finally, the gender empowerment index is based on the computation of the four domains economic, social, political, and agriculture, therefore, gender empowerment as regards from time allocation of women is not been considered in this study.

Therefore, based on the findings, this study proposes the following policy implications:

1. The result of this study shows a low interaction between farmers and agricultural extension services therefore, the government should ensure the facility of extension services to farmers because the interaction between these services and farmers will improve their level of adaptation to climate change;
2. The results showed that women have a low level of adaptation, hence particular attention is required in terms of policy towards women specifically the improvement of women's education level, access to land, access to credit, and also the development of activities such as the transformation of agricultural and forestry products, the promotion of income generating activities, all of these contribute to improving the income of women as well as their resiliency in rural areas of Niger;
3. Irrespective of gender, the government should ensure capacity building of the farmers through training and farmer field schools in the quality adaptive response to climate change in order to increase their agricultural production and livelihoods, therefore, improving farmers' vulnerability indices.
4. Findings showed that low off-farm income is related to low empowerment of women thus, government and partners of development should develop for women more opportunities in off-farm activities in the rural area
5. Founded that improved women's level of education in the Koranic lead to improve women's empowerment, therefore policies around women teacher in Koranic education are required such as the development of a program in term of capacity building through training in the transformation of agriculture products, agribusiness, literacy classes, in order to improve women empowerment and their resilience around farming household in Niger.

However, the findings of this dissertation highlighted some limitations due to the lack of financial and temporal resources, which explains the following perspectives for future research:

- The data collected for this thesis are from four of the eight regions of Niger, so for future research, it would be interesting to extend the analysis to include the other four;

- Furthermore, the method used to determine the gender empowerment index is limited by the working time of the household. it would be interesting to investigate how much time women spend on domestic chores, leisure, etc;
- The findings of this research indicate that there is no problem with women's access to land since the majority of women responded that they have access to land through their husbands or family member. For this reason, future research should focus on women's ownership of land.

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Appendice B: Survey questionnaire

Questionnaire menage

Date de l'enquete ☐ Identification de l'enqueteur ☐

Identification questionnaire ☐ Identification du region ☐

Identification departement ☐ Identification du commune ☐

Identification du village ☐ Numero du Menage ☐

I. Caracteristiques du Menage

Sexe Du Chef Du Ménage ○ Homme ◉ Femme

Age Du Chef Ménage ☐

Ethenie du chef de menage ☐

Taille du menage Nombre d'homme ☐ Nombre de femme ☐

Statut matrimonial du chef de menage (choix unique)

○ Marie ○ veuf/veuve ○ divorce ○ celibataire ○ separe

Niveau d'instruction du chef de menage (choix unique)

○ primaire ○ secondaire ○ Superieur ○ Ecole Coranique ○ Aucun

Nombre de garcons scolarise ☐ Nombre de filles scolarise ☐

Quelle est Votre Activité Principale (choix unique)

○ Agriculture ○ Elevage ○ Artisanat ○ Transformation des produits ○ Commerce ◉ Autre

quelles sont les cultures de productions (choix multiple)

☐ mil ☐ sorgho ☐ mais ☐ niebe ☐ arachide ☐ oseille ☐ riz ☐ autre

quelle est votre nombre d'annee d'experience ☐

votre menage dispose t il du betail ○ oui ○ non

Quelle Est La Main D'œuvre Totale d'homme adulte (plus de 18ans) ☐

Quelle Est La Main D'œuvre Totale femmes adulte (plus de 18ans) ☐

Quelle Est La Main D'œuvre Totale jeune garcons adolescent(10 a 17ans) ☐

Quelle Est La Main D'œuvre Totale jeunes fille adolescent (10 a 17ans) ☐

Quelle Est La Main D'œuvre Totale du menage ☐

QUEL EST LE STATUT D'OCCUPATION DU LOGEMENT DE VOTRE MÉNAGE?

Propriétaire Locataire autre a preciser

QUELLE EST LA PRINCIPALE SOURCE D'EAU DE BOISSON DU MENAGE ?

Eau de robinet Puits ouvert Puits couvert/forage Eau de surface Autres sources (à préciser)

QUEL EST LE PRINCIPAL TYPE DE TOILETTE QU'UTILISE VOTRE MENAGE ?

W.C moderne/toilette avec chasse d'eau Latrine améliorée Latrine traditionnelle Pas de latrine/Brousse (dans la nature) Autres à préciser

QUELLE EST LA PRINCIPALE SOURCE D'ENERGIE POUR LA CUISSON DANS LE MENAGE ?

1. Bois ramassé/acheté Biomasse Charbon de bois Gaz Autres à préciser

QUELLE EST LA PRINCIPALE SOURCE D'ECLAIRAGE POUR VOTRE MENAGE ?

Électricité Énergie solaire Pétrole Lampe à pile Autres à précise

quel est le nombre d'exploitation(champs, jardin...) du menage

nombre de champs nombre de jardins nombre de parcelle ou terres irriguees

II. Questionnaire individuel

sexe du l'individu

Homme Femme

lien avec le chef de menage

Epouse Enfant Neuve/Niece beau fils/belle fille Autres à préciser

quelle est votre niveau d'instruction

Primaire Secondaire Superieur Ecole Coranique Aucun

Quelle est votre activite principale

Agriculture Elevage Artisanat Transformation des produits Commerce Autres à préciser

Quelle est votre nombre d'annee d'experience dans cette activite

En dehors de l'activite principale quelle autre(s) activite(s) vous menez

Agriculture Elevage Artisanat Transformation des produits Commerce Autres à préciser

Pourquoi diversifiez vous vos activites

Avez vous acces a des terres/champs de culture

Oui Non

quelles sont vos modes d'acces a cette terre/champs

☐ Héritage ☐ Don ☐ Achat ☐ Location ☐ Emprunt (sans contre partie) ☐ Métayage ☐ Gage ☐ Bail ☐ Autre a preciser

Quelle est la superficie de votre champs

○ Moins de 1 ha ○ De 1 à 5 ha ○ De 6 à 10 ha ○ Plus de 10 ha

avez vous acces au credit

○ oui ○ non

Pensez-vous que les terres que vous cultivez sont fertiles ou dégradées ?

○ Fertiles ○ Dégradées

Etes vous membre d'une organisation/cooperative paysanne

○ Oui ○ Non

vous etes adherez a cette organisation/cooperative pour

☐ promouvoir vos activités économiques et accroitre votre revenu ☐ accéder au crédit ☐ accéder aux intrants ☐ Autre a preciser

combien est estime annuellement votre revenu agricole

○ moins de 25 000 fcfa ○ de 25 000 a 50 000 fcfa ○ de 50 000 fcfa a 100 000 fcfa ○ plus de 100 000 fcfa

combien est estime annuellement votre revenu non agricole

○ moins de 25 000 fcfa ○ de 25 000 a 50 000 fcfa ○ de 50 000 a 100 000 fcfa ○ plus de 100 000 fcfa

pensez vous que le climat a changer

○ Oui ○ Non

Quels son les changement majeurs

☐ Rarete des pluies ☐ Arret precoce des pluies ☐ Elevation de temperature ☐ vent violen ☐ tempete de sable ☐ Autre a preciser

quels sont les risques climatiques auquels vous etes exposes

☐ secheresse ☐ innondation ☐ forte temperature ☐ Attaques d'insectes ☐ Autre a preciser

parmis ces risques lequel vous etes le plus exposes

○ secheresse ○ Innondation ○ forte temperature ○ attaques d'insectes ○ Autre a preciser

Quel est l'effet de ce risque sur votre production agricole

○ forte dimunition ○ petite dimunition ○ forte augmentation ○ petite augmentation ○ pas de changement

quel est l'effet de ce risque sur votre betail

○ forte dimunition ○ petite dimunition ○ forte augmentation ○ petite augmentation ○ pas de changement

quel est l'effet sur votre revenu

○ forte dimunition ○ petite dimunition ○ forte augmentation ○ petite augmentation ○ pas de changment

quelles sont pratiques/strategies d'adaptation face a ce risques climatiques

☐ culture associe ☐ culture de rotation ☐ utilisation des varietes ameliore ☐ application des fertilisants ☐ irrigation ☐ utilisation des pesticides ☐ diversification des cultures ☐ diversification du betail ☐ plantation d'arbre(agroforestry) ☐ diversification du revenu ☐ migration ☐ conservation des sols et de l'eau ☐ modification du calendrier ☐ Planter des cultures de couverture pour aider à conserver l'humidité du sol ☐ Labour minimum/zéro pour ne pas exposer le sol à la perte de nutriments ☐ Paillage accru des cultures pour conserver l'humidité et réduire l'effet de la chaleur ☐ utilisation de fumier organique ☐ pas d'adaptation ☐ Autre a preciser ▭

face au risque climatique quels sont les appuis que vous avez beneficier

☐ subvention de l'Etat ☐ distribution gratuite ☐ cash for work ☐ renforcement des capacites ☐ Autre a preciser ▭

Avez vous acces a l'information climatique

○ Oui ○ Non

coment accedez vous a cette information

☐ radio ☐ telephone ☐ TV ☐ A travers la cooperative/organisation paysanne ☐ Meeting/foyandi ☐ Autre

Autre a preciser ▭

Quelles sont les pratiques d'adaptation qui ont fortement augmente votre production agricole

☐ culture associees ☐ culture de rotation ☐ utilisation des varietes ameliorees ☐ application des fertilisants ☐ irrigation ☐ utilisation des pesticides ☐ diversification des cultures ☐ diversification du betail ☐ plantation d'arbre/agroforestry ☐ diversification du revenu ☐ migration ☐ technique de conservation des sols et des eaux ☐ modification du calendrier ☐ Planter des cultures de couverture pour aider à conserver l'humidité du sol ☐ Labour minimum/zéro pour ne pas exposer le sol à la perte de nutriments ☐ Paillage accru des cultures pour conserver l'humidité et réduire l'effet de la chaleur ☐ utilisation de fumier organique ☐ Autre a preciser ▭

Quelles sont vos contraintes face a ces pratiques d'adaptations

☐ insuffisant ou faible acces au credit☐ probleme d'acces liee a la terre☐ manque/insuffisance de la main d'oeuvre☐ faible revenu☐ connaissances techniques insuffisante☐ cout eleve des engrais et autres intrants☐ probleme lie a l'attaque des ravageurs et maladies☐ manque/faible acces aux informations climatiques☐ manque/faible appui des services de vulgarisation agricole☐ mauvaise installation de stockage et de traitement☐ faible niveau de competence☐ manque/faible appui governemental☐ probleme lie a la disponibilite dans l'approvisionnement des intrants agricole☐ faible acces aux informations sur les strategies d'adaptation au changement climatique☐ analphabetisme des agriculteurs☐ croyance religieux et coutumes☐ distance du champ☐ Autre a preciser______

parmis ces barrieres laquelle est le plus contraingnant

○ insuffisant ou faible acces au credit○ probleme d'acces liee a la terre○ manque/insuffisance de la main d'oeuvre○ faible revenu○ connaissances techniques insuffisante○ cout eleve des engrais et autres intrants○ probleme lie a l'attaque des ravageurs et maladies○ manque/faible acces aux informations climatiques○ manque/faible appui des services de vulgarisation agricole○ mauvaise installation de stockage et de traitement○ faible niveau de competence○ manque/faible appui governemental○ probleme lie a la disponibilite dans l'approvisionnement des intrants agricole○ faible acces aux informations sur les strategies d'adaptation au changement climatique○ analphabetisme des agriculteurs○ crouyance religieux et coutumes○ distance du champ○ Autre a preciser______

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