CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

ADAPTATION STRATEGIES ON CLIMATE CHANGE AMONG MAIZE FARMING HOUSEHOLDS IN OYO STATE, NIGERIA

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled "*Adaptation Strategies on Climate Change among Maize Farming Households in Oyo State, Nigeria*" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, April 2021

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Oluwaseyi Olasoji

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Abstract

The world's population is growing at an exponential rate putting more pressure on agricultural productivity. It is expected that by the year 2050, there would be 3.5 billion more people in the world to feed. To meet up with the ever-growing demand, agricultural production is expected to increase. However, all over the world, the climate is changing and negatively influencing agricultural productivity due to changes in temperature and rainfall patterns. To cope with these changes and the adverse effects that accompany it, farmers need to adapt.

This study was conducted to identify the factors influencing the adoption of adaptation strategies among maize farming households in Oyo State, Nigeria. A total of 197 respondents were interviewed for this study. About 85.8% of the respondents claimed that they were highly concerned about their future as farmers. About 58.4% of the farmers believe that rainfall patterns have become unpredictable while 62.9% of the respondents believe that the average temperature has increased. The most practised adaptation strategy was mixed cropping (89.8%) while the least practised adaptation strategy was conservation tillage (12.7%).

The binary logit regression model was used to analyse the factors influencing the adoption of organic fertilizers, irrigation, cultivation of different crops, cultivation of improved cultivars and agroforestry adaptation strategies. The study showed that marital status, age, respondent as household heads, off-farm employment, years of farming experience, the use of family labour, farm distance to the market, cooperative membership, access to credit, access to weather information, practice of contract farming and information sourced from research institutes, friends and family were statistically significant and influenced the adoption of adaptation strategies. It is very important for farmers to improve their adaptive capacities. This way they can cope better with the adverse effects of climate change. The government and research institutes also have important roles to play in enabling the farmers cope with the adverse effects of climate change.

Key words: Climate Change, Adaptation Strategies, Maize, Farming Households, Binary Logit Model

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List of the abbreviations used in the thesis

Acronym	Full Meaning
SSA	Sub-Saharan Africa
LGA	Local Government Areas
GDP	Gross Domestic Product
Ha	Hectares
BLM	Binary Logit Model
CC	Climate Change
SPSS	Statistical Package for Social Sciences

1. Introduction and Literature Review

1.1. Introduction

The world population is growing at such an exponential rate that by the year 2050, agriculture is expected to cater to the needs of 3.5 billion more people in the world (Cairns et al. 2013). This translates to increasing agricultural production to meet the growing demand that would emanate from the growing population especially from countries that currently have low levels of agricultural production (van Beek et al. 2010).

However, these production needs are being hindered by climate change and variations (Smit & Wandel 2006; Harvey et al. 2018). Climate change and variations has led to increasing temperatures and changes in the precipitation patterns which affects agricultural production (Uddin et al. 2014; FAO 2017a; Simotwo et al. 2018). These changes in climatic conditions affects the yield and productivity especially of major cereal crops farmers in Sub-Saharan Africa (Cairns et al. 2012; Simotwo et al. 2018) and thus has adverse effects on the livelihood and food security of many agriculture reliant economies especially for developing countries (Uddin et al. 2014).

It is expected that the production of the three main staple foods that is, maize, wheat and rice should increase to meet the increasing consumption demands, hence there is a growing and viable market for staple foods (Macauley & Ramadjita 2015). Maize as a crop has multiple uses which has been brought about by the growing population all around the world. Some of these uses include human consumption, bio-energy and animal feed production (FAO 2017b). Yet, Africa is falling behind in having a significant share and impact on this market with a measly 7.1% contributed to the world maize production (FAOSTAT 2019). Maize production in Sub-Saharan Africa is predominantly practiced by smallholder farmers under the rainfed farming system (Yesuf et al. 2008; Cairns et al. 2013). This reliance on rainfall in conjunction with other characteristics of these farmers that increase their vulnerabilities to the adverse effects of climate change has brought about the need for adaptation.

Nigeria is home to the largest population in Africa and the 7th most populous country in the world with a population of 178.7 million people (World Bank 2017), based on this, it is necessary for the nation to increase its agricultural production to meet the needs of its expanding population.

Maize is the 4th most consumed food item in Nigeria just behind sorghum, millet and rice thereby making it a staple food that is consumed all over the country (FAO 2013). Despite this, maize production is mostly carried out by smallholder farmers that cultivate maize under rainfed systems on less than 2 hectares of land that make up a large percentage of the nation's farming population (Hinjari et al. 2020). With the changing climate affecting precipitation patterns, increasing average temperatures and increasing the onset of drought (Cairns et al. 2012; Khanal et al. 2018), the impact of climate change is thereby adversely felt by farmers especially smallholder farmers in Nigeria (Ezeaku et al. 2014).

Essentially, climate change is not only an issue for the local agricultural economy but also for the global economy at large, therefore adaptation is imperative in cushioning the negative effects of climate change on agriculture (Uddin et al. 2014).

Moreover, adaptation is not a novel concept to individuals and farmers. Farmers all over the world have a history of needing to adjust to changes in climate from time to time (Ndamani & Watanabe 2015). The difference now is the frequency and intensity of the climatic variations that transcend their previous experiences and call for immediate and needful action.

Despite the growing concerns on climate change and numerous studies done on adaptation strategies on climate change even in Nigeria, there has not been any studies focusing on the level of awareness and adoption of adaptation strategies employed by maize farming households based in the agricultural zones of Oyo State, Nigeria; this sparked my interest into diving further into this topic.

1.2. Literature Review

In this chapter, an overview of previous studies conducted as well as the current scientific knowledge available on climate change and adaptation strategies on climate change among maize farmers is reviewed and summarized to provide a background into the study. These available literatures are reviewed in corresponding sub-chapters on the global scope of climate change and agriculture, the impact of climate change on maize production as well as patterns that emanate from adaptation practices.

1.2.1. Climate Change and Agriculture

1.2.1.1. Climate Change and Global Agriculture

Climate change is one of the world's biggest environmental issues and its impact is being felt in many areas and sectors; agriculture being one of them (Kalai et al. 2017). In fact, climate change is such a global issue that most farmers can attest to having heard of it and are well aware of its adverse effects (Hasan & Kumar 2019). It is also important to note that there is a strong relationship between climate change and agriculture; they both affect each other.

The changing climate affects agricultural production and the livelihoods of farmers due to the increased frequency of extreme weather events while agriculture is one of the biggest contributors to climate change via the emission of greenhouse gases from its activities such as tillage, harvesting and livestock production (FAO 2007a). This is particularly interesting as the world is experiencing a population boom and agricultural production is expected to increase to meet the growing demand. The best way is forward; and forward sustainably. It is important that agriculture engages in sustainable production (Teklewold et al. 2013; Udemba 2020).

Therefore, it is important that as much as farmers adapt to climate change, there are practices that are adopted to also reduce the contribution of agriculture to climate change. This is possible via sustainable agricultural practices (Tey et al. 2014). According to Zhai et al. (2018), in order to promote more sustainable environments i.e. ecosystems; the farmers' attitude towards climate change is important. These include the perceptions of the farmers, the adaptive strategies employed by the farmers as well as their beliefs and barriers regarding climate change.

According to Harvey et al. (2018), the most vulnerable farmers to the effects of climate change are smallholder farmers. A large percentage of the farmers are aware of climate change, its adverse effects and are currently experiencing the occurrence of extreme weather conditions. One of the biggest hindrance to the effective adoption of adaptation strategies to cope with climate change is the lack of information (Zhai et al. 2018).

1.2.1.2. Climate Change and Agriculture in Africa

Africa as a continent is dominated with developing economies. It is predominantly made up of Sub-Saharan countries hence the frequency of the use of the phrase "Sub-Saharan Africa (SSA)". A recent World Bank report showed that Africa is the poorest continent in the world with most of its countries being low income and lower middle-income countries. There are only six out of fifty-four countries that are considered upper middle-income countries (World Bank 2018).

Agriculture is very sensitive to climate and in most developing countries especially those in SSA, smallholder farmers have limited capacities to adapt to climate change (Makuvaro et al. 2018). Most communities in developing countries especially in African countries have been found to be the most susceptible and vulnerable to climate changes; these can be attributed to limitations amongst the farmers in the communities (Yesuf et al. 2008). The limitations to the adoption of strategies that can help cushion the adverse effects of climate change can be attributed to the fact that these practices are not easily accessible or readily available for farmers especially the small-scale farmers, because these adaptation strategies tend to be resource intensive. It is also important to remember that most small-scale farmers are resource poor, lack access to finance or credit and are mostly reliant on family labour (Hasan & Kumar 2019).

1.2.1.3. Climate Change and Agriculture in Nigeria

Nigeria is fondly referred to as the giant of Africa. The country boasts of a population of over 178 million people over a land area of 923,768 Km^2 and a GDP of 448.12 billion dollars (NBS 2015; World Bank 2017). The country is a booming economy with great prospects. The agricultural sector which is mainly dominated by smallholder farmers who practice rainfed agriculture contributes over 20% to the nation's GDP. Nigeria has over 34 million ha of arable land on which agriculture is carried out on. The agricultural sector currently employs over 36% of the Nigerian labour force (World Bank 2017).

When it comes to food production and consumption, Nigeria is mainly a net importer of food items. The nation's production manages to meet domestic needs. However, with a growing population and weak institutions that does not necessarily encourage improvements in agricultural productivity, sometimes agricultural production falls shorts of meeting the immediate need of the populace (FAO 2013; Chukwuone & Amaechina 2021).

Agriculture in Nigeria is heavily reliant and dependent on rainfall; as such only 1% of the country's farmlands are recorded as being irrigated (You et al. 2018). Given, the recent issues of climate change and variability affecting precipitation patterns in terms of rainfall frequency, intensity, and distribution; farmers need to find ways to continue farming to meet up with the growing demand as well as to ensure productivity and profitability for themselves as well (Ayinde et al. 2010). A recent study showed that Nigeria was ranked as one of the vulnerable countries to climate change in terms of its current level of exposure and vulnerability of the nation to extreme events (Eckstein & Kreft 2020).

The accompanying effects of droughts and erosions has negatively influenced crop yields and performances. This is being felt across the nation by the farmers whose productivity is affected which tells on their income and their profitability (Ezeaku et al. 2014; Gbode et al. 2019). The reduction in agricultural production means there is a supply gap which automatically drives up demand and leads to increase in the prices of agricultural commodities.

1.2.2. Impact of Climate Change on Maize Production

Maize cultivation like any other crop has its own optimal conditions for production. The maize crop thrives best with a considerable amount of rainfall and at a mean daily temperature of somewhere between 16^0C and 19^0C (Riccetto et al. 2020).

The changing climate is leading to increasing temperatures. This rise in temperature is currently having and would have further adverse effects on the production of maize especially for farmers in naturally warm climates. In addition to the increasing temperature, there is a high probability of increasing occurrence and intensity of drought in these areas. Most SSA countries fall into this category unfortunately which just seems to worsen the adverse effects as they are some of the most vulnerable (Yesuf et al. 2008).

Aside from the direct effects of climate change like increasing temperature and fluctuating precipitation patterns. There are the indirect effects of climate change that affect maize farming (Salami 2004). Some of these indirect effects of climate change include the adverse effects on the livelihoods of the farmers and economic implications on a national and global scale (FAO 2007a; Asravor 2018; Riccetto et al. 2020). There are also food security issues that arise from production losses due to climate change (direct) effects (Macauley & Ramadjita 2015; Harvey et al. 2018). There are the water crises (in terms of water supply and availability) emanating from droughts and variations in precipitation patterns that affect water supply and availability (FAO 2007b; Mavuso 2015). Susceptibility in terms of health risks to the farmers and increasing the occurrence and spread of pests and diseases for the crops (Harvey et al. 2018; Rahut et al. 2021).

It is important to note that the cultivation of crops is a physiological process. Some physiological processes are respiration, transpiration, and evaporation (Ezeaku et al. 2014; Adeagbo et al. 2021). These processes are also affected adversely by erratic and harsh climatic conditions. These affects crop performance and yield adversely. The overall effects of climate change on maize production is felt most by the farmers as their productivity is greatly affected (Ayinde et al. 2010).

There have been world-wide reports of decreasing production of maize in Central America, China and Ethiopia (Macauley & Ramadjita 2015; Harvey et al. 2018; Zhai et al. 2018) just to name a few.

That is why it is important that climate resistant cultivars – varieties that have heat - stress resilience need to be developed and distributed to farmers especially those in the most vulnerable areas (Cairns et al. 2013). This can be done also in conjunction with flexibility in sowing dates by changing the sowing dates to coincide with the best time to cultivate the maize for optimal productivity (Rahimi-Moghaddam et al. 2018). These and so many other reasons are why adaptation is very important.

1.2.3. Adaptation Strategies for Climate Change

Adaptation is very important because of the circumstances related to the global issue of climate change. It is a course of action that needs to be taken to cope with the effects of climate change among farmers (Simotwo et al. 2018).

Adaptation in the broad sense of what it stands for; has been long regarded as necessary for survival and success. According to the IPCC (2001) , "Adaptation is defined as adjustments in human and natural systems, in response to actual or expected climate stimuli or their effects, that moderate harm or exploit beneficial opportunities". Smit et al. (2006) defined adaptation as "a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity".

In terms of adaptation to climate change, Adaptation can then be defined as measures undertaken to lighten and maybe nullify the adverse effects of climate change while also using and maximizing the positive effects for the benefit of man and the environment (IPCC 2001; Smit & Wandel 2006; Mendelsohn 2012).

The FAO (2017) defined adaptation in the agricultural sector as "modifying natural, agricultural production, socio-economic, institutional systems and policymaking in response to and in preparation for actual or expected climate variability and change and their impacts, to moderate harmful effects and exploit beneficial opportunities”.

Adaptation strategies studies are usually done to evaluate the effects and impacts of the changing climate as well as to evaluate the effects adaptation could have. The two key concepts to take into consideration are vulnerability and adaptive capacity (Smit & Wandel 2006).

Adaptations are means of diminishing vulnerability as well as an indication of adaptive capacity and the farmers’ willingness to adopt adaptation strategies are dependent on their socioeconomic characteristics, their farm characteristics, their level of awareness and perceptions and institutional factors (Shiferaw et al. 2009; Uddin et al. 2014; Simotwo et al. 2018; Kassem et al. 2019; Ojo & Baiyegunhi 2020; Muench et al. 2021).

That is why the level of willingness of farmers to improve their adaptive capacity as well as to adapt are key decisive factors on adaptation strategies on climate change adopted by farmers (Zhai et al. 2018).

Adaptation strategies have numerous objectives. Some adaptation strategies are adopted to reduce land (or soil) degradation, some to increase profitability (Shiferaw et al. 2009; Uddin et al. 2014). However, this study is focused on those adaptation strategies that are adopted for coping with the effects of climate change.

Adaptation strategies can be grouped into numerous types. The first grouping is based on the type of actors which could either be private (autonomous) or public sector (planned) adaptation strategies (FAO 2007b; Tompkins & Eakin 2012). Here the private adaptation strategies are those strategies employed by individuals, communities or firms to adapt to the adverse effects of climate change; while the public sector adaptation strategies are those actions undertaken by different levels of government that involves the provision of institutions and infrastructure for public use for helping people cope with the effects of climate change (Shongwe et al. 2014). The second grouping is based on the timing of the use of the adaptation strategies that is , proactive (anticipatory) adaptation strategies if the strategies are used in anticipation of climate change or reactive adaptation strategies if strategies are used for the effects of climate change (Bruin 2011).

According to the FAO (2007b), there are generally six major classes of adaptation and eight main actions that can be carried out in terms of response to climate change.

The six major classes for adaptation according to the FAO (2007b) were seasonal changes and sowing dates, different crop variety or species, water supply and irrigation systems , the use of other inputs, the cultivation of new crop varieties, forest practices.

Therefore, the areas of adaptation in agriculture are crop management practices that are in tune with the seasonal changes and sowing dates of crops; the cultivation of different species or plant varieties; the planting of new crop varieties. The other is land use management that has to deal with the water supply and irrigation systems ; the utilization of other inputs and the management of forests (forest fire management practices, the practice of agroforestry and silviculture) (FAO 2007b; Bruin 2011; Bryan et al. 2013).

These adaptations are necessary as they are done in response to climate change – the eight main actions. The adaptation responses are to reduce the food security risk ; identify the current state of vulnerability, adjusting the priority and focus of agricultural research; protection of genetic resources as well as intellectual property rights, improving the agricultural extension and communication systems; adjusting the policies on trade and communities, increasing training and education on the subject matter and the identifying and promoting of the climatic benefits and environmental services of trees and forest (FAO 2007b).

There are a lot of actions and plans in place to slow down and possibly reverse climate change. However, the present situation calls for farmers to adapt and mitigate the effects of climate change. Hence, adaptation strategies on climate change can be said to be the main strategy that can be embarked on by farmers to help reduce the adverse effects of climate change on agriculture and agricultural productivity (Alam et al. 2017).

Adaptation is dependent on perception. This is because farmers or communities must be conscious of the consequences or benefits of the adaptation strategies on their farms or livelihoods before embarking on them (Maddison 2007). Therefore, most adaptation strategies would not be effective or efficient if there is not a clear understanding of the perceptions of the farmers on climate change. Nevertheless, in most developing countries, the rates of adoption of adaptation strategies are quite low due to the resource constraints that characterize those countries (Tey et al. 2014).

However, it is important to note that just as there is climate variability; there is also adaptation strategies variability. Adaptation strategies depend on and vary over time and places, even within certain societies (in some cases) because they tend to be context specific (Smit & Wandel 2006; Malone 2009).

In the world today, the level of implementation and adoption of adaptation strategies varies greatly across different countries.

1.2.4. Adaptation Strategies for Maize Production

Given the main classification of adaptation strategies according to FAO (2007b) and Bryan et al. (2013), it can be said that adaptation strategies can be somewhat generic. However, there are slight variations when it comes to certain crops given that different crops have different levels of resilience to their environment and climate (Komba & Muchapondwa 2018). Also, some adaptation strategies are location-specific, and it is very important to study and understand the adaptation strategies that are viable for this study. The choice and adoption of these adaptation strategies are dependent on the effect of climate change on production which in turn affect the profitability of the farmers and hence the choice and willingness to adopt and practice these adaptation strategies (Ayinde et al. 2010).

Hence, for maize production in SSA, the adaptation strategies for climate change options include conservation agricultural practices, irrigation practices, crop diversification, agroforestry, integrated pest control.

- Crop Diversification

This is a viable and highly recommended adaptation strategy for climate change. This is because it has the potential to protect the farmers from crop failure or poor yield by diversifying the farm’s income (Uddin et al. 2014; Simotwo et al. 2018).

Some of the adaptation strategies under this umbrella are planting of different crops, mixed cropping (or intercropping) and crop rotation.

Crop rotation not only benefits the farmer but also the environment at large. Crop rotation when practiced effectively increases carbon sequestration in the soil thereby using the soil more as a carbon sink (FAO 2007; Cairns et al. 2012).

- Irrigation and water harvesting

Irrigation and water harvesting are very important adaptation practices for the most vulnerable regions. Due to changes in precipitation patterns, the quantity and timeliness of water needed for crop production tends to be distorted (Douxchamps et al. 2016; Makuvaro et al. 2018). Also, one of the extreme climatic conditions resulting from changing climate is drought which also adversely affects water availability and accessibility (Yesuf et al. 2008). Irrigation and water harvesting are adopted to cushion these effects by ensuring that water is provided to the crops when needed. Also, it is important that effective irrigation practices are adopted which can lead to a reduction in CO_2 emissions (FAO 2007a; Bryan et al. 2013).

- Conservation Agricultural Practices

One of the anthems of today is sustainability. It involves making the most of what we have access to today as well as ensuring it is used effectively and efficiently to ensure the future generation is catered for as well. Some conservation practices in agriculture are conservation (or minimal) tillage, contour planting, integrated pest management, mulching (cover-cropping) and agroforestry.

The use of organic fertilizer is also a very good adaptation practice. Organic fertilizer when adopted help to reduce greenhouse gases emission as well as increase carbon storage by using the soil as a carbon sink (FAO 2007a; Cairns et al. 2012). Agroforestry is also another important strategy as it not only helps the farmers cope with the current effects of climate change on their farms but also ensures that they contribute to the mitigation of climate change (Bryan et al. 2013; Pandey et al. 2016).

- Cultivation of Improved Cultivars

This is an anticipatory adaptation strategy and there have been studies done to suggest that the use of improved cultivars can offset crop losses by up to 40% (Cairns et al. 2013; Shongwe et al. 2014). However, the use of improved cultivars alone is not enough to reach and maintain optimum levels of production as effective crop management practices must also be brought into the mix (Simotwo et al. 2018).

1.2.5. Factors Influencing the Adoption of Adaptation Strategies for CC

As stated earlier, according to Smit & Wandel (2006), adaptation is dependent on vulnerability and adaptive capacity. Vulnerability to climate change and adaptive capacity are closely related. Vulnerability can be defined as the degree of susceptibility of a system to climate change and the degree to which it is unable to cope with the adverse effects of climate change. Vulnerability is a function of a system's adaptive capacity (IPCC 2001). Adaptive capacity is a measure of the capacity of a system to cope with the effects of climate change by adopting the necessary measures and practices (Pandey et al. 2016).

The adaptive capacity of the most vulnerable farmers is dependent on their characteristics and external factors. SSA has been found to be vulnerable to climate change (Bryan et al. 2013; Ayanlade et al. 2018). Gender plays an important role in terms of the extent of vulnerability and adaptive capacity. Most female farmers in developing economies are more vulnerable to climate change than their male counterparts. This is because most female farmers and female-headed households are more vulnerable to poverty which hampers on their adaptive capacity. This is due to less access to education, credit, income, and assets which are all important (Shongwe et al. 2014; Tambo 2016).

Access to assets and credit increases the adaptive capacity of the farmers. Farmers with more access to assets and credit are more likely to own their lands, have larger farm size and can afford new technologies (Kassem et al. 2019).

Off-farm income had both negative and positive effects on the willingness to adapt to climate change. For some, it was negative because they would rather focus on the other source of income than try to adapt while for some others it meant they could use the extra income to invest in adaptation strategies (Belay et al. 2017; Kassem et al. 2019).

Age also plays an important role in adaptive capacity. Older farmers were most likely not willing to adopt new strategies. The older farmers were likely to adapt to climate change only if the strategies were easy to implement and they had longer farming experience, larger households, more capital and were more literate; which means they had access to information on adaptation strategies and new technologies (Yesuf et al. 2008; Belay et al. 2017; Aryal et al. 2018).

The importance of timely information and applicable knowledge cannot be overemphasized for human survival. The same is the case for farmers that are vulnerable and would need to increase their adaptive capacity in response to the adverse effects of climate change (Smit & Wandel 2006; Simotwo et al. 2018).

Institutions and social groups also provide information on new technologies and adaptation strategies as well as help the farmers improve their adaptive capacity. Membership of cooperatives, access to extension services, access to market, proximity to the market and access to information on weather and adaptation strategies have been found to increase the likelihood of farmers adapting to climate change (Yesuf et al. 2008; Shiferaw et al. 2009; Teklewold et al. 2013; Shongwe et al. 2014; Khanal et al. 2018; Simotwo et al. 2018; Tessema et al. 2018; Ojo & Baiyegunhi 2020; Muench et al. 2021; Adeagbo et al. 2021).

The practice of contract farming is a booming concept that can increase farmers adaptive capacity. Contract farming can increase production and increase access to market if implemented effectively (Abdullah & Terengganu 2013; Azumah et al. 2017).

There is also the need to investigate the perception of the farmers regarding adaptation strategies.

In terms of perception, the focus has been on the understanding of the farmer's perception of climate change and its effect. This is important as to whether they need to adapt to climate change (Tey et al. 2014; Zhai et al. 2018).

This is because the perception tends to vary across different variables. Some of the older generations are of the opinion that climate change is an act of God. According to a study done by Zhai (2018), the older farmers believed that climate change was "God's arrangement", some farmers even believed that climate change was a way God was punishing mankind for their wrongdoings (Schuman et al. 2018). These findings agree with findings from Ghana where some farmers claimed that their traditional god and ancestors were responsible for climate change as repercussions for bad behaviours by the people (Ndamani & Watanabe 2015).

There are also variations about the effects of climate change in terms of rainfall, temperature, and the occurrence of extreme weather events. There are some farmers that do not believe that there are any changes in the amount of rainfall, average temperature, and the occurrence of extreme weather events. Some believe that these phenomena are increasing while some think they are decreasing (Yesuf et al. 2008; Zhai et al. 2018; Paudel et al. 2020; Muench et al. 2021). These variations would affect the willingness to adapt. The predominant perception responses were decreasing rainfall and increasing temperature.

1.2.6. Summary of Theoretical Findings

The previous subchapters provide a broad and insightful background to factors influencing the adoption of adaptation strategies.

In the figure below (Figure 1), the most important findings from the literature review are summarized and highlighted for easy perusal.

Here, the commonly adopted adaptation strategies among maize farmers are listed, followed by the factors that influence the adoption of these adaptation strategies.

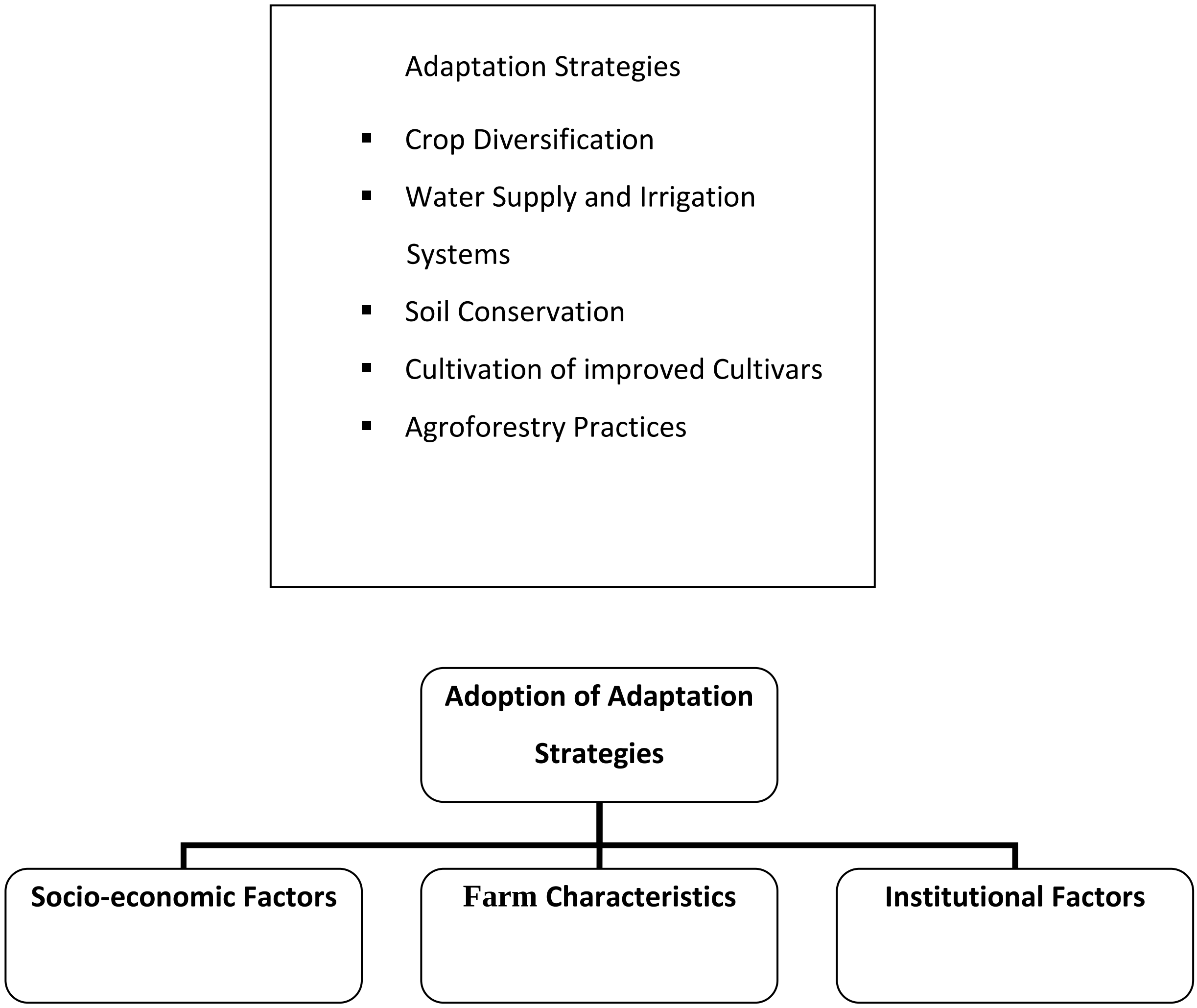

Figure 1: Adaptation Strategies and Factors influencing Adoption

2. Aims of the Thesis

Climate change is a very important as well as an ever-evolving topic of discussion. Almost every sector of the world economy is affected directly and/or indirectly by climate change. This study was conceived out of the urgency of the need for action as well as adaptation. This is not a novel topic on the effect of climate change on agriculture neither is it a new topic on the adaptation strategies employed by crop farmers; it is however a continuation of the work started by numerous researchers but with an aim of better understanding and focusing on staple food farmers in agricultural zones ; therefore this study was carried out with focus on the major agricultural zones in one of the most prominent rainforest zones in Nigeria that is Oyo State, with emphasis on the farming households that were involved in maize production.

The broad objective of the study is the factors influencing the adaptation strategies on climate change employed among maize farming household in Oyo State, South West, Nigeria, while the specific objectives are to:

1. Identify the farmers' perception of climate change effects on farming in the study area;
2. Describe the practices adopted to adapt to climate change among the respondents in the study area;
3. Analyze the factors influencing the adoption of practices to adapt to climate change among the respondents in the study area.

The main questions this study aims to answer are;

1. What are the perceptions of the farmers on climate change in the study area?
2. What are the practices that are adopted by the farmers to adapt to climate change?
3. What are the factors influencing the adoption of practices among farmers to adapt to climate change?

3. Methods

3.1. Study Area

The study was carried out in Oyo State, Nigeria. Nigeria is in the western part of Africa. Nigeria is the most populated country located in Africa and the 7th most populous country in the world. The economic hub of the country is Lagos State; Lagos is the largest city in Africa by population (World Bank 2017).

The country is very diverse with different cultures and ethnicities that make up its thirty-six states and Abuja, the administrative headquarter is referred to as the Federal Capital Territory (FCT). Nigeria has a population of over 178 million people and has a total land area of 923,768 Km^2. The population is a mixture of two main religions which are Christians and Muslim; and a small fraction of other religions (National Bureau of Statistics 2015; World Bank 2017; NIPC 2020).

Nigeria is a SSA country located on latitudes 4^0 16'N and 13^0 52'N and longitudes 2^0 49'E and 14^0 37'E. It is mainly characterized by hot weather and based on this is classified as a tropical country but sometimes the climate of the country varies from tropical to sub-tropical. The two main predominant seasons in Nigeria are the rainy season and the dry season. The rainy season usually starts in March and ends in October while the dry season usually starts in November and ends in March (Areola & Fasona 2018).Based on this, the rainfall in the North is modal while the rainfall in the south is bimodal.

The average temperature in Nigeria is 28^0C with the temperature ranging from a minimum of 6^0C to a maximum of 45^0C. The temperature varies in the coastal areas compared to the temperature in the North which is characterized by drier and more extreme conditions (Egbinola & Amobichukwu 2013; Ogungbenro & Morakinyo 2014).

The country has eight ecological zones used to describe the vegetation which is dependent on the rainfall namely, the mangrove forest, the fresh water swamp forest, the rain forest, the derived savannah, the southern guinea savannah, the northern guinea savannah, the Sudan savannah and the Sahel savannah (Ogungbenro & Morakinyo 2014; Ayanlade et al. 2018; Areola & Fasona 2018).

Figure 2: Map of Nigeria showing Oyo State

3.1.1. Oyo State

Oyo State is in the South-Western geopolitical zone of Nigeria. The capital city is Ibadan, and it has 33 local government areas and a tropical savanna with a rocky topography. Oyo state has a land area of 26,500 km^2 with an estimated population of 7,796,670 (NBS 2017).

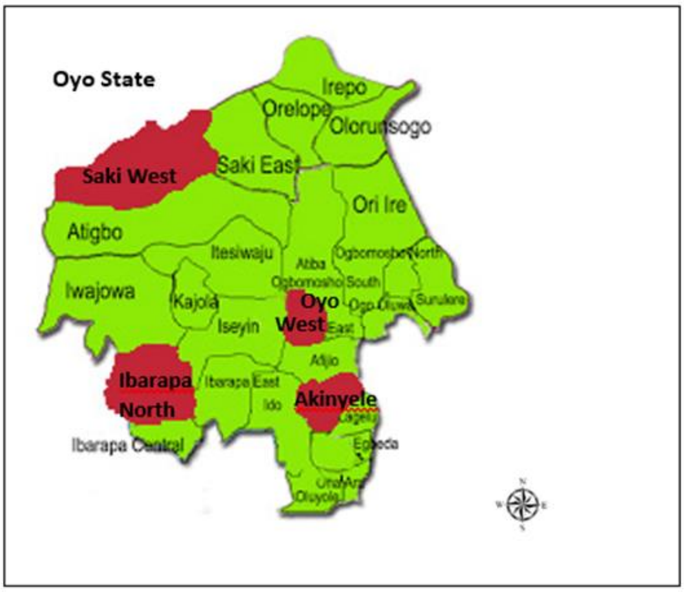

Figure 3: Map of Oyo State highlighting the study areas

There are four main agricultural zones namely Ibadan/Ibarapa, Oyo, Shaki and Ogbomoso zones. The agricultural zones are made up of LGAs which are listed in the figure above (Jiboye & Ogunshakin 2010; NIPC 2020).

The state is characterized with a derived savannah towards its north and the rain forest towards its south.

Oyo state is located between latitudes 8.1196^0 North and longitudes 3.4196^0 East. It occupies a total land area of 28,454 km² ranking in as the 14th by size of Nigeria's total land mass. The state is characterized by an equatorial climate with high humidity. The average daily temperature ranges between 25^0 C and 35^0 C almost throughout the year (Ayanlade et al. 2018; NIPC 2020).

The economy of the state is mainly agrarian and has over 2.7 million ha of arable land with eleven farm settlements on 103,163 ha. The climate of the state favors the cultivation of crops like maize, yam, cassava, rice amongst other crops (NIPC 2020).

However, recent studies have found variations in average temperature and precipitation patterns to be erratic due to climate change which affects agricultural production in the state (Areola & Fasona 2018).

In terms of agricultural research and development, there are a lot of research institutes in the state with the capital city of Ibadan being the headquarters for the International Institute for Tropical Agriculture (IITA); one of the Consultative Group for International Agricultural Research -CGIAR's research group and the National Cereal Research Institute (NCRI) (Maji & Fagade 2002).

3.2. Data Collection

For this research study the data was sourced from primary sources. The primary data was for inferential purposes from the research topic.

3.2.1. Data Sources

The primary data was acquired with the aid of a quantitative tool – a structured questionnaire. The questionnaire that was designed with inspirations from the secondary data reviewed.

3.2.2. Selection of Respondents

The multi-stage sampling technique was used for the selection of the respondents of this study.

First, the agricultural zones in the state were selected purposively for the sake of this study. The study area was selected because of the high numbers of farmers located in this area. Out of the 4 main agricultural zones; 2 agricultural zones were selected randomly (using the random number generator).

Then, out of the 2 agricultural zones selected; 2 LGAs were randomly selected to form a total of 4 LGAs selected. Out of the 4 LGAs selected; 2 communities from each LGAs were randomly selected to make up a total of 8 communities. From each of the 8 communities selected 25 farming households were selected using the snowball sampling technique.

The data was collected with the aid of data enumerators. The data enumerators were trained on the questionnaire before they were taken to the field. A pre-test was conducted with some of the farmers in the study area to test the level of understanding of the questionnaire.

The data was collected over a period of three weeks in August 2019 with the aid of the data enumerators. A total of 200 questionnaires were administered across the study area and the number of viable responses were 197 which shows a high response rate (98.5%).

The questionnaire was divided into sections which are as follows; the socio-economic characteristics of the farmers, the perception of the farmers, level of awareness and level of adoption of adaptation strategies.

The pen and paper survey technique was practiced for this study. The questionnaire was printed and given to each of the respondents individually as there was no means of digital distribution because of the poor state of digital infrastructure in the study area.

There were some personal interviews carried out in the study area undertaken to get better acquainted with some of the members of the communities in the study.

The measures taken to improve Data Reliability were;

- The data enumerators were trained before going to the field
- The questionnaires were pre-tested and corrections were effected based on the outcome

3.3. Data Analysis

The study was conducted to get information on the perception of the farmers on climate change, the level of awareness and adoption of adaptation practices for climate change and the factors influencing the adoption of adaptation strategies among the respondents in the study area.

The tools used for the data analysis were Microsoft Excel 2016 and IBM Statistical Package for Social Sciences (SPSS) Version 25.

3.3.1. Data Analytical Tools

The data analytical tools used were descriptive statistics, Likert scales and Binary Logit Regression Model.

The Likert scales and descriptive statistics were used to measure farmers' perceptions, level of awareness and adoption of practices for climate change.

The Binary Logit Model was used for the data on the factors influencing the adoption of adaptation strategies among the respondents.

3.4. Theoretical Framework

The Theoretical framework for this study is based on the theory of utility maximization. This means that the decision of farmers to adopt (or to not adopt) adaptation strategies for the effects of climate change is dependent on the utility to be derived from the decision.

This theory was also used in previously referenced literatures to explain the decision of farmers to adapt or not to adapt to climate change (Mendelsohn 2012; Mabe et al. 2014; Nigussie 2017; Thoai et al. 2018; Dasmani et al. 2020; Khan et al. 2020).

The premise is that a farming household will choose an adaptation strategy – Strategy 1, for example, if the utility to be derived from that strategy is better than not adapting any strategy. The utility in this case would be to help cope with and/or reduce the adverse effects of climate change on their farms.

This relationship can be expressed with a linear equation that can be referred to as linear random utility model.

$$U_{ij} = x_i\beta_j + \mu_j$$

$$U_{ik} = x_i\beta_k + \mu_k$$

where;

i = number of farming household

j , k = adaptation strategies

U_{ij} = the utility to be derived from the j^{th} adaptation strategy

U_{ik} = the utility to be derived from the k^{th} adaptation strategy

x_i = the vector of the explanatory variables

β_j , β_k = the vectors of the parameters

μ_j , μ_k = the stochastic error terms

3.5. Model Specification

The Binary Logit Model is the empirical model for this study. The BLM was also used and referenced from some previous studies (Mabe et al. 2014; Uddin et al. 2014; Alemayehu & Bewket 2017; Thoai et al. 2018; Khan et al. 2020; Muench et al. 2021).

The aim of this study is to analyse the factors influencing the adoption of adaptation strategies for climate by the farming households; for this purpose, the BLM was chosen.

The BLM was chosen because the dependent variable is binary. The farming household has 2 options which are to adopt or not to adopt the adaptation strategy. This implies that if a farmer adopted an adaptation strategy then the choice is labelled 1; otherwise, the choice is labelled 0.

$$P_i\,(Y_i = 1) = \frac{e^{x\beta}}{1 + e^{x\beta}}$$

Where;

P_i = Probability of the occurrence of an event (adoption of adaptation strategies)

Y_i= 1 (Yes ; farming household adopted strategy) or Y_i = 0 (No ; farming household did not adopt strategy)

X_i = explanatory variables and $i = 1,2,3, \ldots, n$

β = the vector of the parameters

β_0 =constant

Therefore,

$$Log\left(\frac{P}{1-P}\right) = B_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n$$

Here, the dependent variable Y_i is defined as thus

1 = Organic fertilizer;

2 = Irrigation;

3 = Cultivation of new and improved cultivars

4 = Cultivation of new/different crops

5 = Agroforestry

3.5.1. Selection of Variables

Based on previous literature, the following explanatory variables were found to have significant effects on the adoption of adaptation strategies for climate change.

Table 1: Description of Explanatory (Independent) Variables for the Model

Explanatory Variable	Type	Label	Literature Reviewed
Gender	Dichotomous	Male = 1, Female = 0	Shongwe et al. 2014; Uddin et al. 2014; Khanal et al. 2018; Solomon 2019
Marital Status	Dichotomous	Married = 1, Others = 0	Shongwe et al. 2014; Solomon 2019
Age	Ordinal	≤30, 31-40, 41-	Yesuf et al. 2008; Shongwe et

		50, 51-60, ≥60	al. 2014; Uddin et al. 2014; Belay et al. 2017; Ayanlade et al. 2018; Simotwo et al. 2018; Kassem et al. 2019
Household Head	Dichotomous	Yes =1 , No = 0	Yesuf et al. 2008; Tesfaye & Seifu 2016; Belay et al. 2017; Kassem et al. 2019
Educational Level	Ordinal	Primary, Secondary, Diplomas, Bachelors, Post-Graduate	Shongwe et al. 2014; Uddin et al. 2014; Belay et al. 2017; de Sousa et al. 2018; Khanal et al. 2018; Simotwo et al. 2018; Tessema et al. 2018; Solomon 2019
Household Size	Continuous	Number of persons	Uddin et al. 2014; Tesfaye & Seifu 2016; Belay et al. 2017; Zhai et al. 2018
Farm Size	Continuous	Number of Hectares	Yesuf et al. 2008; Tesfaye & Seifu 2016; Belay et al. 2017; Khanal et al. 2018; Simotwo et al. 2018; Zhai et al. 2018; Thoai et al. 2018; Kassem et al. 2019
Off-farm Employment	Dichotomous	Yes = 1, No = 0	Simotwo et al. 2018; Kassem et al. 2019
Years of Farming Experience	Continuous	Number of years	Belay et al. 2017; Ayanlade et al. 2018; Tessema et al. 2018; Thoai et al. 2018; Solomon 2019

Land Ownership	Dichotomous	Privately owned = 1; others = 0	Shongwe et al. 2014; Zhai et al. 2018
Contract Farming	Dichotomous	Yes = 1, No = 0	Abdullah & Terengganu 2013; Azumah et al. 2017
Access to Credit	Dichotomous	Yes = 1, No = 0	Yesuf et al. 2008; Shongwe et al. 2014; Khanal et al. 2018; Tessema et al. 2018
Membership of cooperative	Dichotomous	Yes = 1, No = 0	Uddin et al. 2014; Kassem et al. 2019; Solomon 2019
Use of family labour	Dichotomous	Yes = 1, No = 0	Akinnagbe & Irohibe 2015; Khanal et al. 2018
Farm Distance to the market	Ordinal	0.5 -0.9km, 1 – 1.4km, 1.5 – 1.9km, 2 – 2.4km, more than 2.5km	Tesfaye & Seifu 2016; Belay et al. 2017
Information sources	Ordinal	1-5 on level of importance	Yesuf et al. 2008; Belay et al. 2017; de Sousa et al. 2018; Khanal et al. 2018

4. Results

4.1. Characteristics of the Respondents

4.1.1. Socio-economic Characteristics of the Respondents

The socio-economic characteristics of the respondents is expressed in table 2. The gender distribution showed that there were more men in the study than women. Men accounted for 80.2% of the respondents while 19.8% of the respondents were women. Also, the most predominant marital status was the married status which was 94.4% of the study sample. The age distribution was somewhat varied with majority of the respondents ranging from 51 – 60 years of age. Most of the respondents were not household heads as only 26.4% of the respondents were household heads. The mean household size was approximately 7 persons. The respondents in the study area had a high literacy level with 82.8% of the respondents being literate.

In terms of the farming experience, the average years of farming experience was 27.68 years; ranging from 3 to 50 years of farming. 70.1% of the respondents were members of a cooperative while 29.9% of the respondents are not members of a cooperative, also 77.7% of the respondents claimed to have access to weather information while 22.3% of the respondents claimed they did not have access to weather information. Only 34.5% of the respondents have access to credit or loans while 65.5% of the respondents do not have access to credit or loans.

Table 2: Description of the Respondents

Variable	Total	Percent	Minimum	Maximum	Mean
Gender					
Male	158	80.2%	-	-	-
Female	39	19.8%	-	-	-

Marital Status					
Single	3	1.5%	-	-	
Married	186	94.4%	-	-	-
Divorced	2	1.0%	-	-	-
Widowed	6	3.0%	-	-	-
Age					
<30 years	0	0.0%	-	-	-
31 – 40 years	17	8.6%	-	-	-
41 – 50 years	45	22.6%	-	-	-
51 – 60 years	82	41.6%	-	-	-
≥60 years	53	26.9%	-	-	-
Household Head					
Yes	52	26.4%	-	-	-
No	145	73.6%	-	-	-
Educational Level					
No Formal Education	35	17.8%	-	-	-
Primary Education	33	16.8%	-	-	-
Secondary Education	84	42.6%	-	-	-
NDE/Diploma	32	16.2%	-	-	-
Bachelors' Degree	8	4.1%	-	-	-
Post-Graduate	5	2.5%	-	-	-
Household Size					
>15 years	-	-	0.0	6.0	2.12
16 -59 years	-	-	0.0	11.0	3.67
60 years and above	-	-	0.0	6.0	1.34
Total Household Members	-	-	3.0	18.0	7.13

4.1.2. Farm Characteristics of the Respondents

For the respondents in the study area, the average farm size was 3.35 hectares.

Most of the respondents lived near the markets; with 61.4% of the respondents living within less than 1.5km to the nearest market. More information is provided in the table 3 below.

Table 3: Farm Characteristics of the Respondents

Variable	Total	Percent	Minimum	Maximum	Mean
Farm Size (in hectares)			0.20	14	3.35
Farm Distance to the Market					
0.5 – 0.9 km	40	20.3%	-	-	-
1.0 – 1.4 km	81	41.1%	-	-	-
1.5 – 1.9 km	46	23.4%	-	-	-
2.0 – 2.4 km	18	9.1%	-	-	-
More than 2.5 km	12	6.1%	-	-	-

4.2. Perception of the Respondents

4.2.1. Discussions on Climate Change

Climate change is a very important and recurrent discussion topic even among farmers with 163 respondents (82.7%) of the farmers claiming that they frequently hear about climate change, 31 (15.7%) respondents responded to hearing of climate change sometimes and just 3 (1.5%) respondents claimed to hear about climate change rarely.

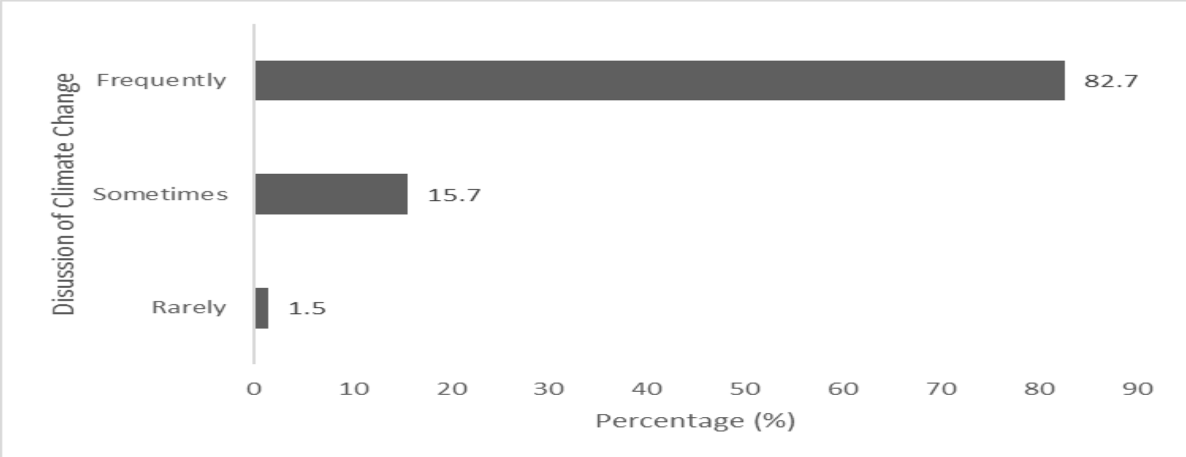

Figure 4: Frequency of discussion of Climate Change

4.2.2. Concerns about their futures as farmers

In terms of their level of concern about their futures as maize farmers, 85.8% i.e., 169 out of 197 of the farmers expressed that they were highly concerned about their futures as farmers because of climate change, 9.6% (19 respondents) expressed that they were somewhat concerned about their futures as farmers and 4.6% (9 respondents) expressed that they were not concerned about their futures as farmers.

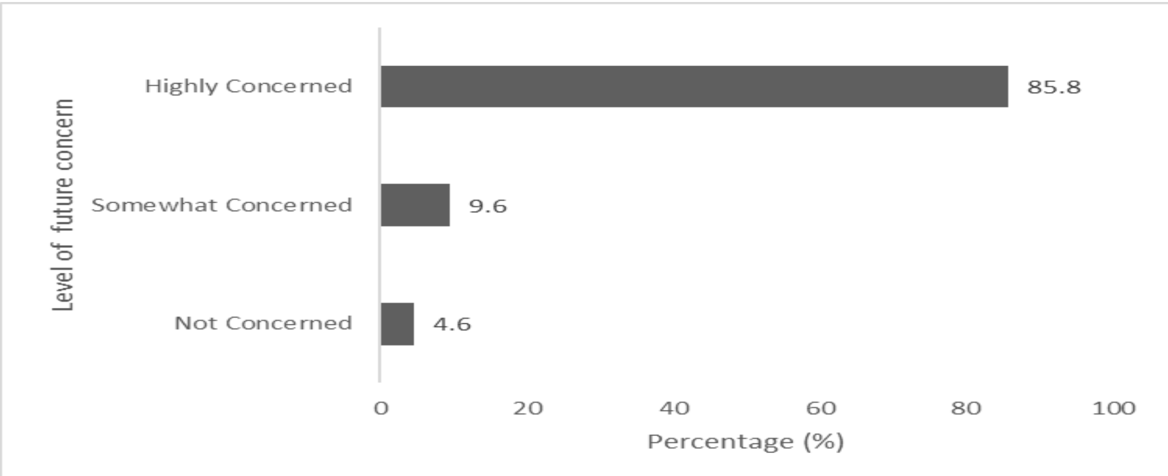

Figure 5: Concern about their future as farmers

4.2.3. Perception of temperature and rainfall

Most of the farmers 58.4% and 62.9% responded that rainfall has become unpredictable, and the average temperature has increased within the last 10 years respectively. This is in line with studies done on the changes in temperature as well as precipitation patterns and amounts in Nigeria.

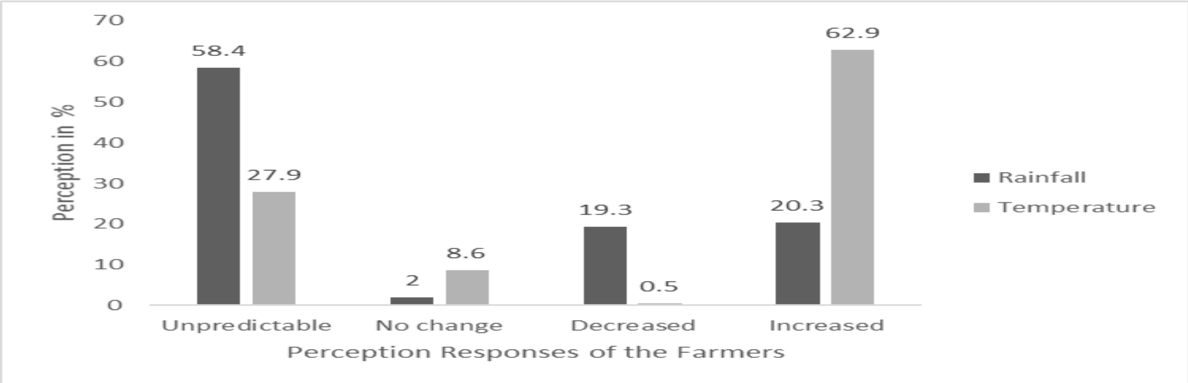

Figure 6: Perception of the respondents on rainfall and temperature

4.2.4. Perceived Impact of Climate Change

The farmers were also asked to provide insights on their perceptions on the effects of climate change on their farms. The results showed that farmers perceived that changes in precipitation patterns, changes in the occurrence of extreme weather conditions, increased temperatures and reduced productivity were the most predominant effects climate change had on their farms.

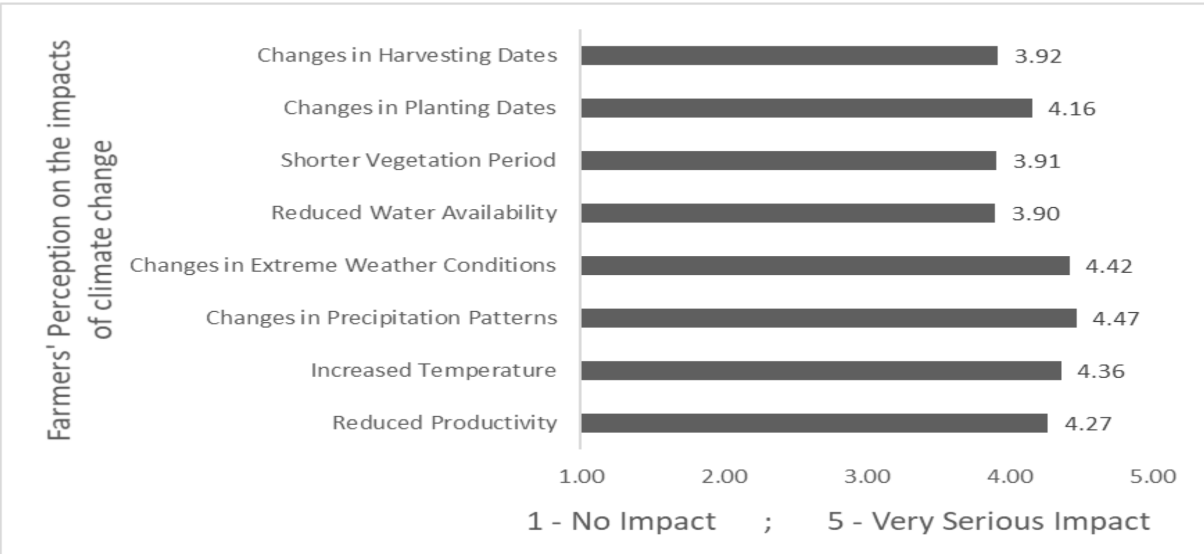

Figure 7: Perception on the impact of Climate Change

4.2.5. Information sources and perception of their relative importance

The respondents were also questioned on their information sources on adaptation strategies and the perceived importance of their information sources. According to the farmers, the most important information sources ranked in order of importance were extension officers, agricultural programs, and research institutes.

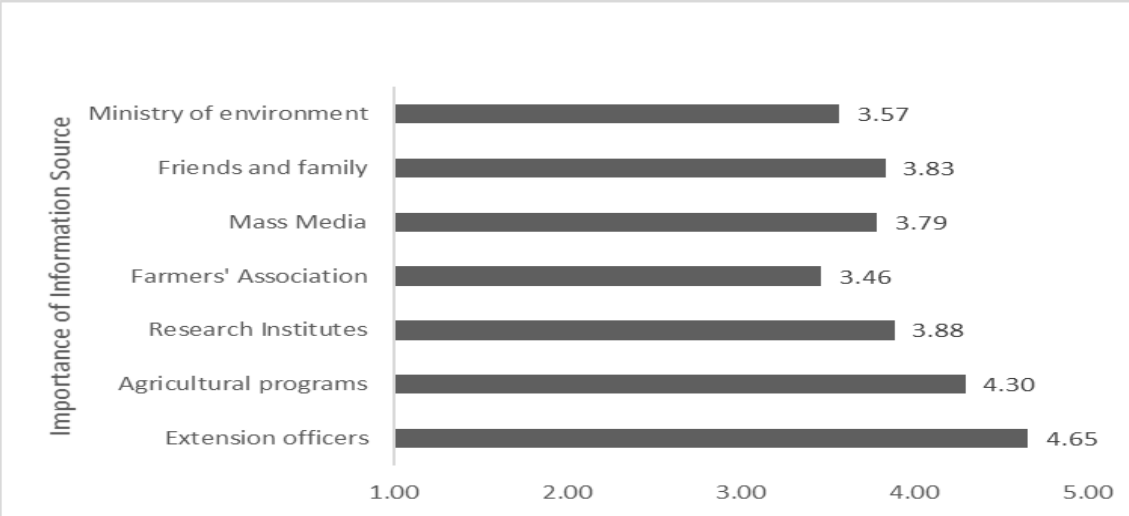

Figure 8: Perception of the importance of information sources

4.3. Level of Awareness and Adoption of Adaptation Strategies on CC

One of the aims of this study was to profile the level of awareness and adoption of climate change adaptation strategies among the respondents in the study area.

The results showed that there was a high level of awareness among the respondents on the listed adaptation strategies. More information on this provided in the figure 9 below.

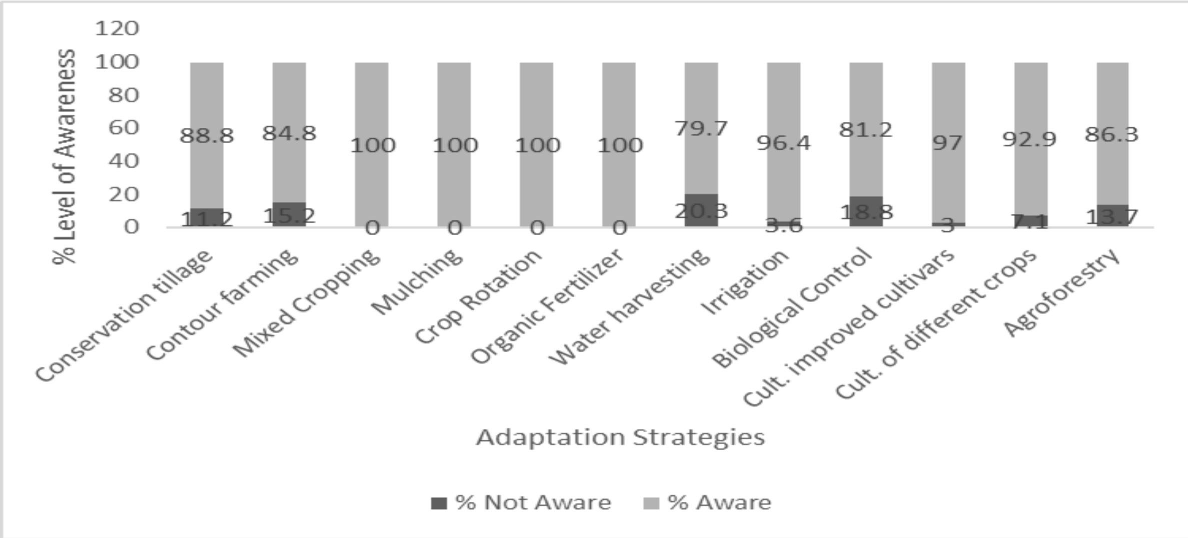

Figure 9; The level of awareness of Adaptation Strategies among the Respondents

However, when it comes to the level of adoption; there are variations in the level of adoption of the adaptation strategies. This is best expressed in the figure 10 below.

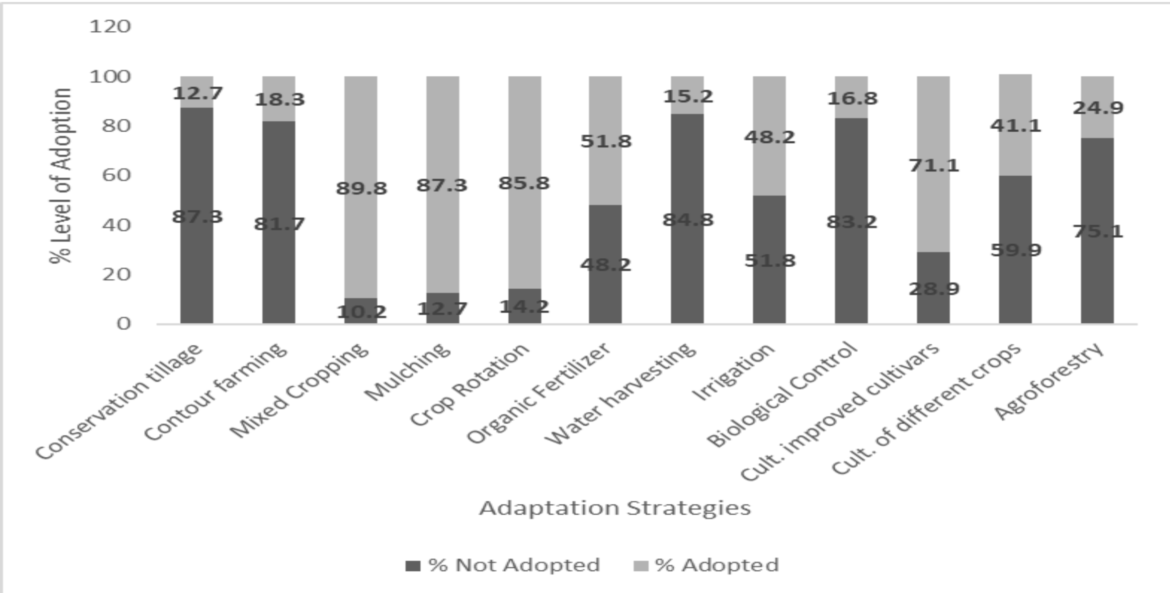

Figure 10: The level of Adoption of Adaptation Strategies among the Respondents

4.4. Factors Influencing the Adoption of Adaptation Strategies

4.4.1. Specific Adaptation Strategies

For this study, five adaptation strategies were selected to further study the factors influencing the adoption of these strategies. These adaptation strategies were selected based on two criteria.

1. The level of adoption (and non-adoption) was closely distributed

The selected adaptation strategies were organic fertilizers, irrigation, and the cultivation of different crops (as referenced in Figure 10 above)

2. Innovation and Sustainability

Here, the cultivation of improved cultivars was selected to study the factors influencing the adoption of improved crop varieties because of advances in technology. In terms of sustainability, agroforestry was studied as it goes beyond adaptation but also enables mitigation.

Table 4: Dependent and Independent Variables used for Data Analysis

Variables	Type	Mean
Dependent Variables (Adaptation Strategies)		
1 = Adopted		
0 = Not Adopted		
Organic Fertilizers	Dichotomous	0.52
Irrigation	Dichotomous	0.48
Cultivation of Different Crops	Dichotomous	0.41
Cultivation of New & Improved Cultivars	Dichotomous	0.71
Agroforestry	Dichotomous	0.25

4.4.2. Results from the Empirical Models

The table 5 below shows the fit of the models. All five models are significant at 1% level of significance with their corresponding overall percentages as well as their respective R-Square values.

Table 5: Fit of the Models

Indicators	Organic Fertilizer	Irrigation	Cultivation of Improved Cultivars	Cultivation of Different Crops	Agroforestry
Omnibus Test					
Chi-Square	167.163	61.248	54.017	105.953	59.351
DF	17	17	18	18	18
Sig.	0.000	0.000	0.000	0.000	0.000
Classification of the model					
Overall Percentage	95	73.1	78.1	86.3	80
Coefficient of Determination					
Nagelkerke R- Square	**0.871**	**0.424**	**0.400**	**0.650**	**0.446**

The variables for the models were tested for multicollinearity. The multicollinearity was tested using the Pearson correlation using SPSS. There was a high correlation between the monthly income and the farm size of the respondents. To correct for this the monthly income was removed from the model. This can be explained as there is a direct relationship between the farm size and the monthly income of the farmers.

The test for multicollinearity was then run again and there was no multicollinearity found among the variables for the models.

The tables 6, 7 & 8 below shows the results of the binary logit models for the five selected dependent variables.

The first model – Organic Fertilizer, the BLM showed that being married, increasing age, the respondents being household heads, the farmers having access to credit, the practice of contract farming and information from research institutes had positive effects of the likelihood of adopting organic fertilizers. Whereas off-farm employment, increase in the years of farming experience, the use of family labour, longer farm distance to the market and cooperative membership had negative statistically significant effects on the likelihood to adopt this strategy.

The second model – Irrigation, the BLM showed that longer farm distance to the market and cooperative membership had positive statistically significant effects. On the other hand, higher educational levels, off-farm employment, and the increase in the years of farming experience had negative statistically significant effects on the likelihood of adoption.

Table 6: Factors influencing the adoption of Organic Fertilizer and Irrigation

	Organic Fertilizer			Irrigation		
Variables	**β**	**Std. Error**	**P- Value**	**β**	**Std. Error**	**P-Value**
Gender	2.834	1.787	0.113	-0.631	0.583	0.279
Marital status	**6.007**	**2.587**	**0.02****	0.671	0.72	0.351
Age	**3.007**	**1.186**	**0.011****	0.411	0.325	0.207
Household head	**2.992**	**1.497**	**0.046****	-0.384	0.562	0.495
Educational level	0.323	0.5	0.519	**-0.424**	**0.232**	**0.068***
Household size	-0.227	0.229	0.32	0.016	0.109	0.885
Off-farm employment	**-4.415**	**2.263**	**0.051***	**-3.893**	**1.218**	**0.001*****
Years of farming experience	**-0.281**	**0.115**	**0.014****	**-0.06**	**0.027**	**0.024****
Use of family labour	**-13.5**	**5.513**	**0.014****	0.379	1.423	0.79
Land ownership	0.514	1.841	0.78	-0.141	1.287	0.913
Farm size	-0.637	0.415	0.125	0.032	0.147	0.828
Farm distance to market	**-2.899**	**1.241**	**0.019****	**0.487**	**0.268**	**0.069***

Cooperative Membership	**-9.498**	**3.491**	**0.007*****	**1.335**	**0.509**	**0.009*****
Access to credit	**5.075**	**2.06**	**0.014****	1.439	0.963	0.135
Contract farming	**12.155**	**4.138**	**0.003*****	0.595	0.753	0.429
Information from Research Institutes	**1.38**	**0.833**	**0.098***	-0.424	0.401	0.29
Information from Friends and family	0.494	0.668	0.459	0.307	0.305	0.315
Constant	-0.759	6.464	0.907	1.244	2.984	0.677

*** - 1% level of significance ** - 5% level of significance * - 10% level of significance

The third model- Cultivation of Different Crops, the BLM showed that the use of family labour had a negative statistically significant effect while the increase in the years of farming experience, practice of contract farming and information from friends and family had positive statistically significant effects and thus would influence adoption.

The fourth model – Cultivation of Improved Cultivars, the BLM showed that the off-farm employment, access to weather information and the practice of contract farming had positive statistically significant effects while higher educational levels and the access to credit had negative statistically significant effect on the likelihood of the adoption of the strategy.

Table 7: Factors influencing the adoption of Cultivation of Different Crops and the Cultivation of Improved Cultivars

	Cultivation of Different Crops			Cultivation of Improved Cultivar		
Variables	**β**	**Std. Error**	**P- Value**	**β**	**Std. Error**	**P-Value**
Gender	0.084	0.709	0.906	-0.569	0.663	0.391
Marital status	-0.888	0.579	0.125	-0.359	0.533	0.501
Age	-0.308	0.435	0.479	-0.548	0.402	0.173

Household head	-0.298	0.654	0.649	0.15	0.583	0.797
Educational level	-0.039	0.261	0.881	**-0.566**	**0.234**	**0.016****
Household size	-0.238	0.184	0.196	-0.049	0.125	0.694
Off farm employment	-1.835	1.127	0.103	**2.027**	**0.902**	**0.025****
Years of farming experience	**0.124**	**0.038**	**0.001*****	-0.019	0.031	0.541
Use of Family labour	**-3.809**	**1.943**	**0.050****	-1.177	1.626	0.469
Land ownership	0.887	1.454	0.542	1.531	1.161	0.187
Farm size	-0.15	0.17	0.378	0.088	0.184	0.633
Farm distance to the market	0.288	0.296	0.330	0.078	0.265	0.767
Cooperative Membership	-2.224	1.555	0.153	0.107	1.078	0.921
Access to Weather information	0.936	0.664	0.159	**1.975**	**0.604**	**0.001*****
Access to credit	0.356	0.558	0.524	**-1.173**	**0.557**	**0.035****
Contract farming	**3.542**	**1.017**	**0.000*****	**2.293**	**0.816**	**0.005*****
Information from Research Institutes	-0.206	0.520	0.691	-0.709	0.45	0.115
Information from Friends and Family	**0.885**	**0.373**	**0.018****	0.434	0.328	0.185
Constant	1.4	3.756	0.709	3.002	3.229	0.353

*** - 1% level of significance ** - 5% level of significance * - 10% level of significance

The fifth model – Agroforestry, the BLM showed that increasing age, access to credit and information from research institutes had positive statistically significant effects while the increase in the years of farming experience and cooperative membership had negative statistically significant effects on the likelihood of adoption.

Table 8: Factors influencing the adoption of Agroforestry

Variables	β	Std. Error	P-Value
Gender	0.562	0.681	0.409
Marital status	-0.114	0.572	0.842
Age	**0.713**	**0.387**	**0.065****
Household head	0.153	0.632	0.809
Educational level	0.138	0.24	0.567
Household size	0.119	0.134	0.375
Off farm employment	0.747	1.096	0.496
Years of farming experience	**-0.065**	**0.031**	**0.037****
Use of Family labour	21.782	17770.89	0.999
Land ownership	-0.718	1.169	0.539
Farm size	0.113	0.162	0.485
Farm distance to the market	-0.105	0.259	0.684
Cooperative Membership	**-3.034**	**1.389**	**0.029****
Access to Weather information	-0.606	0.625	0.332
Access to credit	**1.897**	**0.546**	**0.001*****
Contract farming	1.336	0.861	0.121
Information from Research Institutes	**0.885**	**0.494**	**0.073***
Information from Friends and family	0.293	0.357	0.412
Constant	-28.762	17770.9	0.999

*** - 1% level of significance ** - 5% level of significance * - 10% level of significance

5. Discussion

5.1. Characteristics of the Respondents

As described in the previous chapter, the most predominant features of the respondents were in the gender distribution with 80.2% of the respondents being male this is in line with findings that there are more men in agriculture as a profession than there are women (Shongwe et al. 2014; Ndamani & Watanabe 2015). In terms of marital status, most of the respondents were married (94.4%) which varies from the marital distribution in Nigeria with about 50% of the population being recorded as married. The mean household size of the farming households was 7 persons. This is higher than the average household size in Nigeria which is 5 persons (NBS 2015). The literacy level was high in the study area with 82.8% of the respondents being literate. This is higher than the literacy rate of Nigeria which is about 62%. In terms of farm size, the average farm size was 3.35 hectares which is a steep rise from the average farm size among farmers in Nigeria who own about 0.5 hectare (FAOSTAT 2019). This could be because the study was conducted in an agricultural zone.

5.2. Perception of the Farmers

Majority of the respondents that is, 82.7% claimed that they discussed climate change frequently. This implies that climate change is a pressing topic even among farmers.

In terms of concerns about their futures as farmers because of climate change on their farms, 85.8% of the respondents have responded to be highly concerned about their futures as farmers; this is in line with studies that have found that there is growing concern among farmers on how climate change is negatively influencing their productivity and livelihoods (Ndamani & Watanabe 2015; Muench et al. 2021).

The respondents also expressed their perception on temperature and rainfall over the last 10 years, while 2% of the respondents did not perceive any changes in rainfall, 19.3% responded that they feel rainfall has decreased while 20.3% of the farmers responded that they feel rainfall has increased. Most of the farmers that is, 58.4% of the respondents responded that they believe rainfall patterns have become unpredictable. This is in line with recent studies on climate change and variations in Nigeria as well as studies done in Ghana, Nepal and China that has found that the rainfall patterns are becoming more and more unpredictable within the last 10 years (Ndamani & Watanabe 2015; Zhai et al. 2018; Muench et al. 2021) ; which negatively affects agricultural productivity (Daramola et al. 2017; Areola & Fasona 2018).

The results were different for perceptions on temperature over the last 10 years. 0.5% of the respondents claimed that the average temperature has decreased, 8.6% of the respondents responded that there has been no change in the average temperature while 27.9% responded that they feel like temperature has become unpredictable. Most of the respondents, 62.9% responded that the average temperature has increased within the last 10 years. This is in line with studies that have shown that the world's temperature is increasing as well as the evident global warming as well as previous studies on the perception of farmers on temperature (Ndamani & Watanabe 2015; Muench et al. 2021).

5.3. Level of Awareness and Adoption of Adaptation Strategies for CC

In terms of the level of awareness, there are varying but high levels of awareness on the adaptation strategies for the adverse effects of climate change.

There are some adaptation strategies that are commonly used by the farmers on the farm to mitigate adverse effects of climate that are sort of well-known and well adopted. From this study, four out of the twelve adaptation strategies had a 100% level of awareness among the respondents. These were practicing mixed cropping, mulching, crop rotation and the use of organic fertilizers. These practices listed above have a high level of adaptation due to the relative ease of adoption as well as the relatively low cost of implementation especially among the farmers in the study area.

The adaptation strategy with the lowest level of awareness among all the adaptation strategies was the water harvesting adaptation strategy (79.7% level of awareness).

This can be attributed to the poor information dissemination on this strategy as well as the high-cost implications associated with the equipment needed to utilize this strategy effectively (Pandey et al. 2016).

On the other hand, when it comes to the level of adoption of these adaptation strategies the variations are more distinct.

The studies showed that three out of the four adaptation strategies that had the highest levels of awareness had the highest level of adoption as well (as depicted in Figure 10). The three most adopted adaptation strategies were mixed cropping with 89.8% level of adoption followed by mulching in second place with 87.3% level of adoption and the third most adopted adaptation strategy with 85.8% level of adoption was crop rotation.

In terms of non-adoption, the three adaptation strategies with the lowest level of adoption were conservation tillage (87.3%), biological control (83.2%) and contour farming (81.7%). These low levels of adoption can be attributed to the high-cost implications as well as the need for technical know-how that is not readily available and accessible to the farmers.

5.4. Factors Influencing the Adoption of Adaptation Strategies for CC

5.4.1. Socio-Economic Factors Influencing the Adoption of Adaptation Strategies for CC

The gender of the respondents was not statistically significant and did not influence the likelihood of adopting any of the five adaptation strategies. This result contrasted with previous studies in which male respondents were more likely to adopt adaptation strategies than female respondents. This is because male farmers have been found to have more adaptive capacity than the female farmers (Shongwe et al. 2014; Khanal et al. 2018; Solomon 2019).

The respondents being married had a positive and statistically significant effect on the likelihood of adopting organic fertilizers. This is in line with findings from previous studies that showed that being married positively influences the likelihood of adopting adaptation strategies. This can be attributed to the fact that married people have more proprietor rights, can combine their resources, and can also access credit better (Shongwe et al. 2014; Simotwo et al. 2018).

The results also showed that the older the farmers were, the more likely they were to adopt organic fertilizers and agroforestry as adaptation strategies. This result contrasts with some of the previous findings that found that older farmers were less likely to adopt adaptation strategies (Shongwe et al. 2014; Simotwo et al. 2018). Despite that, this study found that the older farmers were more likely to adopt organic fertilizer and the practice of agroforestry as some other studies suggested (Yesuf et al. 2008; Belay et al. 2017; Kassem et al. 2019). This can be attributed to the fact that the older the farmers get, some of them tend to more organic and natural means in various aspects of their lives – their farms included. One of the farmers mentioned how it would be nice to have the natural forest cover (agroforestry) for him to sit under and relax on a sunny day while sipping on a natural beverage.

The respondents as household heads increased the likelihood of the adoption of organic fertilizers as an adaptation strategy. This agrees with findings on how the respondent being a household head positively affected the adoption of adaptation strategies. They were more likely to adopt strategies that had the least effects on their households in terms of their livelihoods as they were the breadwinners while trying to increase the productivity of the farms as well (Yesuf et al. 2008; Tesfaye & Seifu 2016; Belay et al. 2017; Kassem et al. 2019). This can be further supported by the fact that organic fertilizer are relatively cost efficient and easy to use (Muller 2009).

A higher educational level had a negative and statistically significant effect on the adoption of irrigation and the cultivation of improved cultivars. This result contrast the findings from previous studies which suggested that higher educational levels have a positive influence on the adoption of adaptation strategies for the effects of climate change. The premise was that the more literate farmers were, the more their understanding of adaptation strategies (Yesuf et al. 2008; Shongwe et al. 2014; Uddin et al. 2014; Belay et al. 2017; de Sousa et al. 2018; Khanal et al. 2018; Simotwo et al.

2018; Tessema et al. 2018). Therefore, these findings are very interesting as one would believe that the higher the level of literacy, the more the understanding of the adaptation strategies and then the more the likelihood of adopting the adaptation strategies. However, this appears to not be the case for farmers in these agricultural zones. A possible explanation for this would be the more learned the farmers are, the more informed they were on policies and the situation of the market and the nation's economy. Hence, they were sceptical of the added cost implications of these new technologies as there was no visible plan or action in place to ensure they are rewarded.

Surprisingly, the household size had no influence and statistical significance on any of the five adaptation strategies studied. Previous literatures reviewed showed that am increase in the household size could have a positive influence on the adoption of adaptation strategies (Tesfaye & Seifu 2016; Belay et al. 2017) while some other studies postulated that an increase in the household size could have a negative effect on the adoption of adaptation strategies (Uddin et al. 2014; Zhai et al. 2018).

The farming household having off-farm employment had both negative and positive yet statistically significant effects on three out of the five adaptation strategies studied. It had negative effects on the likelihood of adopting the use of organic fertilizers and irrigation. Whereas, it had a positive effect on the likelihood of adopting the cultivation of improved cultivars. This is in line with previous studies, as an increase in the off-farm income negatively influences the likelihood of adopting the use of organic fertilizers and irrigation. This is because an increase in the income from off-farm employment does not encourage the need to increase the income from the farm itself. The off-farm income could be used to augments the income from the farm (Kassem et al. 2019). On the other hand, an increase in the off-farm income has a positive influence on the cultivation of improved cultivars in the sense that the income earned from the off-farm activities can be invested in the farm to improve farm productivity (Simotwo et al. 2018).

The years of farming experience influenced four out of the five adaptation strategies studied. The higher the years of farming experience of the farmers the more the likelihood of them adopting the cultivation of different crops. This is in line with previous findings from literatures reviewed (Belay et al. 2017; Ayanlade et al. 2018; Tessema et al. 2018; Thoai et al. 2018; Solomon 2019). It however had a negative influence on the likelihood of the adoption of the use of organic fertilizers, the use of irrigation and agroforestry. This is another surprising finding from this study. This implies that the higher the years of farming experience of the farmers the lesser the likelihood of adopting these adaptation strategies. The possible explanation to give here would be that most of these farmers are "set in their ways". Therefore, as the number of years farming increases the less likely the farmers are to adopt these adaptation strategies for the farmers in these agricultural zones.

The use of family labour had a negative statistically significant effect on the adoption of the use of organic fertilizers and the cultivation of different crops. This result matches the findings from past studies that shows that the use of family labour negatively influences the likelihood of adopting adaptation strategies. The premise here is that farming households have their household members employed in off-farm employment to increase the overall earning capacity of the household; thereby diversifying the household income and increasing their willingness to adopt new strategies (Akinnagbe & Irohibe 2015; Khanal et al. 2018).

The land ownership had no statistically significant effect on the likelihood of the adoption of any of the five selected adaptation strategies. This somewhat contrasts the findings from previous studies that suggested that land ownership would have a positive influence on the likelihood of the adoption of adaptation strategies. The idea was that a farmer would be more likely adopt a strategy if he owned the land (Shongwe et al. 2014; Zhai et al. 2018). The possible explanation for this disparity might be that the farmers in this study are in agricultural zones and they are part of the major producers of food crops in the country hence, productivity is key for them irrespective of land ownership.

5.4.2. Farm Characteristics Influencing Adoption of Adaptation Strategies for CC

Surprisingly, the farm size did not have any statistically significant effect on the likelihood of adopting any of the 5 adaptation strategies studied. This was different from the findings from previous studies which postulated that an increase in the farm sizes had a positive effect on the likelihood of adopting adaptation strategies (Yesuf et al. 2008; Belay et al. 2017; Khanal et al. 2018; Simotwo et al. 2018; Zhai et al. 2018; Thoai et al. 2018; Kassem et al. 2019). The reason for this deviation could be because these farmers are located in agricultural zones and they had more farmland per person i.e., 3.35 hectares when compared to farmers in the nation at large i.e., 0.5 hectare (FAOSTAT 2019).

This study showed that an increase in the farm distance to the market had a negative effect on the likelihood to adopt organic fertilizer while an increase in the farm distance to the market had a positive influence on the likelihood to adopt irrigation as an adaptation strategy. This was in line with previous findings which shows that distance to market in terms of remoteness tends to favour the adoption of certain adaptation strategies over others in terms of the overall benefit to be derived (Shongwe et al. 2014; Tesfaye & Seifu 2016; Belay et al. 2017; Zhai et al. 2018) .

5.4.3. Institutional Factors Influencing the Adoption of Adaptation Strategies for CC

The membership of cooperative had a positive effect on the likelihood of adopting irrigation as an adaptation strategy for climate change. This is in line with previous research findings on how cooperative membership positively influence the adoption of adaptation strategies (Uddin et al. 2014; Kassem et al. 2019; Solomon 2019).

However, being a member of a cooperative had a negative influence on the likelihood of adopting the use of organic fertilizer and agroforestry. The possible explanation for this could be that the farmers that are members of cooperatives are not very keen on adopting new technologies that do not come from their cooperatives. This can be that they were attracted to cooperatives because of the benefits and subsidies that come from being members of cooperatives.

A farmer having access to credit had a positive influence on the likelihood to use organic fertilizers as well as agroforestry. This is in line with previous research findings that suggest that access to credit increase the likelihood of farmers adopting adaptation strategies (Yesuf et al. 2008; Khanal et al. 2018; Tessema et al. 2018; Solomon 2019). On the other hand, a farmer having access to credit had a negative influence on the likelihood of the adoption of the cultivation of improved cultivars. A possible explanation here would be that the farmers would rather use the credit they get to get some more input for the cultivation of their present cultivar than get the improved cultivar.

Access to weather information had a positive and statistically significant effect on the likelihood of adopting the cultivation of improved cultivars. Based on previous studies, the access to timely weather information is important in effectively handling the new crop varieties (Mabe et al. 2014; Harvey et al. 2018).

The practice of contract farming had a positive and statistically significant effect on the likelihood of adopting the use of organic fertilizer, cultivation of different crops and the cultivation of improved cultivars. This is in line with previous findings that suggested that those who practice contract farming are more likely and willing to adopt adaptation strategies as they have a market waiting for their produce (Abdullah & Terengganu 2013; Azumah et al. 2017).

5.4.4. Information Sources and their Influence on the Adoption of Adaptation Strategies for CC

The results showed that the higher the perceived importance of information sourced from research institutes, the more the likelihood of a farmer adopting organic fertilizers and agroforestry. This can be attributed to the fact that the farmers attribute importance to research institutes as they believe they can proffer workable solutions to their problems (Etwire et al. 2013) Some of the farmers expressed this confidence by claiming that the researchers in these institutes had the best minds and had access to necessary information and technologies.

The higher the perceived importance of information from friends and family the more likely the farmers were to adopt the cultivation of different crops. This can be attributed to the fact that the farmers share experiences and information among themselves (Belay et al. 2017). This type of personal information is very important to the farmers. One of the farmers said he felt it was better than having a training session where all they saw were pictures and videos but no physical proof of success.

6. Conclusions

6.1. General Remarks

According to the perception of the farmers in this study, the average temperature has increased, and the rainfall patterns have become unpredictable over the last 10 years. The effect of climate change is negatively impacting farm activities and the livelihoods of the farmers. Hence, the majority of farmers are concerned about their future.

This study also showed that there is a relatively high level of awareness of adaptation strategies among the respondents in the study area. The level of adoption varies across the different adaptation strategies studied. The adaptation strategy that was most adopted was mixed cropping (89.8%) while the least adopted adaptation strategy was conservation tillage (12.7%).

Based on the findings from this study, different factors had varying effects on the adoption of the different adaptation strategies. In contrast to previous studies, the educational level had a negative effect on the likelihood of adopting irrigation and the cultivation of improved cultivars as adaptation strategies. Age also contrasted findings from previous literature as it had a positive effect on the likelihood of adopting the use of organic fertilizers and agroforestry.

The respondents being married and the respondent as the household head had positive statistically significant effects on the likelihood of adopting the use of organic fertilizers.

The practice of contract farming had a positive influence on the adoption of organic fertilizer, the cultivation of different crops and the cultivation of improved cultivars. This provides some more insights into the benefits of contract farming to the farmers as it helps improve their adaptive capacity.

The outcome of this study shows that it is imperative that perception of the effects of climate change as well as climate change adaptation strategies be studied deeper and further to better understand the views and specific needs of the farmers to ensure effective and timely implementation.

6.2. Recommendations

Based on the findings from this study, the following recommendations can be made;

Farmers need to increase their adaptive capacity to be able to cope with and/or reduce the adverse effects of climate change. To increase the adoption of organic fertilizers and agroforestry, the government needs to support credit accessibility.

The Government also needs to implement favourable climate change policies for the farmers (Cairns et al. 2012; Ndamani & Watanabe 2015), as the right policies would play a vital role in helping the farmers mitigate the effects of climate change effectively and hence improve their productivity and livelihood.

The Government and all her agencies should invest adequately and effectively to the needs of the farmers as well as the other key players by providing basic social amenities, proper education, training programs (for both farmers and extension agents), research equipment, relevant technologies, adequate funds, and subsidies as well as beneficial policies (Zhai et al. 2018).

Research institutes in conjunction with government agencies should ensure that the best climate change adaptation strategies are developed and implemented. Researchers should try to find out more ways to assist with the limitations faced by farmers by carrying out more research on this extensive topic and providing tangible and timely insights and information necessary for action and improvement.

Agricultural finance should be made available and accessible to the farmers to encourage the adoption of strategies for climate change. Farmers who have access to credit are more likely to adopt strategies to mitigate climate change effects (Shongwe et al. 2014; Muench et al. 2021).

6.3. Limitations

The limitations faced during this study were:

- Poor state of infrastructure in the country made it difficult accessing the farmers due to the bad state of the roads.
- Self-reporting of the respondents could hamper on the validity of the data.
- Some of the questionnaires were administered with the help of data enumerators without supervision.
- Random sampling was not entirely possible as the focus was on farming households and there was no record of farming households or their address lists to go by.
- Generalization of the data is not possible because the sample was not entirely randomly selected.

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