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Planning Adaptation To Climate Change: Practices And Perspectives Of Farmers In Select North Central Nigeria States

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Abstract

Climate adaptation has been established as key to safeguarding the livelihoods of local communities in Africa dependent on agriculture. However, planning adaptation to mitigate climate change via adaptation in North Central Nigeria is unknown; therefore, the purpose of this study was to understand planning adaptation practices to mitigate climate change among farmers in select North Central Nigeria states. The study is based on Robert Chambers' bottom-up model framework and employed participatory action research (PAR) as the research method, ensuring the continuous and meaningful involvement of farmers and incorporating their knowledge, priorities, and concerns into adaptation programs in North Central Nigeria. Data collection methods included field observations and a focus group discussion. Six themes were identified as adaptation planning strategies (i.e., traditional ecological knowledge, risk of climate change to farmers, irrigation and dry-season farming, improved seedlings, and greenhouse farming/technology). The study also found that farmers in North Central Nigeria have abundant local knowledge and traditional ecological signs to detect climate change. For example, the occurrence of a certain bird species, commonly known as *madjankala* or sparrows in English, is considered a trustworthy indicator of rainfall fluctuations. The study recommended direct participation of North Central Nigerian farmers in participatory adaptation through the channels of local knowledge documentation, sharing climate experience, and adaptation measures by means of discussion, learning from others, and needs assessments to sustain these adaptation planning strategies.

Keywords: Climate adaptation, local knowledge, participatory action research (PAR), smallholder farmers, culturally-relevant strategies, North Central Nigeria

Adaptation de la planification au changement climatique : pratiques et perspectives des agriculteurs dans certaines régions du centre-nord du Nigéria

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Résumé

L'adaptation au changement climatique a été établie comme essentielle pour protéger les moyens de subsistance des communautés locales en Afrique dépendant de l'agriculture. Cependant, la planification de l'adaptation pour atténuer le changement climatique dans le centre-nord du Nigeria est encore inconnue. Par conséquent, l'objectif de cette étude était de comprendre les pratiques de planification de l'adaptation pour atténuer le changement climatique parmi les agriculteurs dans certains États du centre-nord du Nigeria. L'étude repose sur le modèle ascendante de Robert Chambers et utilise la Recherche-Action Participative (RAP) comme méthode de recherche, garantissant la participation continue et significative des agriculteurs, en intégrant leurs connaissances, priorités et préoccupations dans les programmes d'adaptation du centre-nord du Nigeria. Les méthodes de collecte de données comprenaient des observations sur le terrain et une discussion en groupe focal. Six thèmes ont été identifiés comme stratégies de planification de l'adaptation (c'est-à-dire la connaissance écologique traditionnelle, les risques du changement climatique pour les agriculteurs, l'irrigation et l'agriculture en saison sèche, les semences améliorées et l'agriculture sous serre/technologie). L'étude a également révélé que les agriculteurs du centre-nord du Nigeria disposent d'une grande connaissance locale et de signes écologiques traditionnels pour détecter le changement climatique. Par exemple, la présence d'une certaine espèce d'oiseau, communément appelée "madjankala" ou moineaux en anglais, est considérée comme un indicateur fiable des fluctuations des précipitations. L'étude recommande la participation directe des agriculteurs du centre-nord du Nigeria à l'adaptation participative à travers des canaux tels que la documentation des connaissances locales, le partage d'expériences climatiques et les mesures d'adaptation par le biais de discussions, d'apprentissage mutuel et d'évaluations des besoins pour soutenir ces stratégies de planification de l'adaptation.

Mots-clés : Adaptation climatique; Savoirs locaux; Recherche-action participative (RAP); Petits exploitants agricoles; Stratégies culturellement pertinentes; Le Nord-Nigéria

1.0 Introduction

Climate change is one of the most pressing issues of the 21st century, posing a threat to human development across the world (Bhadouria & Macknight, 2025). The UN Environment Programme popularized *climate change* as one of the "triple planetary crises" confronting human livelihoods (Medium-term strategy 2022–2025), with severe impacts across multiple sectors, including agriculture, education, health, tourism, and transport. In the rural communities of Africa, climate change is increasingly disrupting local agricultural practices, leading to an urgent need to address the challenges caused by severe weather events. Climate change effects are direct (floods, droughts, rising temperatures) and indirect (conflicts and forced migration) (Ayompe & Epie, 2025).

North Central Nigeria suffers from extreme climate change effects, such as unpredictable rainfall, drought and lower crop output. The question of which has been answered positively by 81% of those surveyed, who said that they have witnessed at least one incident of climate change that seriously jeopardizes their agricultural livelihoods (Farauta et al., 2013). Notwithstanding high awareness levels, farmers in North Central Nigeria have to deal with substantial obstacles to adaptation such as lack of financial resources, poor infrastructure facilities, limited availability of credit and technology, and lack of government policy support for long-term resilience planning (Bello et al., 2013; Farauta et al., 2013). Therefore, this study aimed to understanding planning adaptation practices to mitigate climate change among farmers in select northern Nigeria states. Specifically, this study seeked to explore local knowledge systems for stemming climate change and its associated risks and examine local and modern climate adaptation practices by farmers in North Central Nigeria and their coping mechanisms against climate risks.

Today, the need to adapt to climate change has become a priority for many developed and developing countries as these countries increasingly note prolonged droughts, rising temperatures, rainfall variability, floods, cyclones in Southern Africa, and water scarcity that challenge the continent's ecosystems, economies, and populations. In a developing country, Uhuru Kenyatta, former President of Kenya, called for the urgent need to adapt since the African economy relies heavily on climate-sensitive sectors and the acceleration of climate-related emergencies and conflicts across Africa continues to divert resources and hamper development (African Union, 2023). Adaptation involves deliberate and strategic adjustments to various systems (agriculture, water resources, or infrastructure), policies (national adaptation plans, climate budgeting, inclusive programs), and opportunities (youth development, empowerment, and training) for frontline communities. Local adaptation is particularly important, and strategies should integrate local knowledge, cultural, social, political, and even religious backgrounds.

In this research, agriculture in Nigeria was explored as a case study. Rural communities are linked by complex family ties, work in an integrated economy with similar occupations, and usually have traditional organizations. Farming is not just an occupation but also a way of life—farmers are born and raised in farming communities with practices passed down across generations. They learn specific responses to climate change, with local or communal knowledge serving as a reservoir of traditional practice and a framework for adopting new, climate-resilient farming methods. In many cases, there may be a limited understanding and misconceptions about the causes of climate change that affect the ability of rural populations to adapt. This is a result of poverty, limited access to credit, education,

household size, gender, land ownership, extension services, government support, and income levels (Maddison, 2016; Deressa et al., 2010; Elshirbiny & Abrahamse, 2020; Okunola et al., 2022). Umar and Musa (2017) documented a notable scarcity of information concerning the perceptions and responses to climate change within resource contexts by rural farmers of Nigeria.

Planning adaptation to climate change involves leveraging the knowledge of rural populations to guide and execute actions that inform decision-making processes. This includes facilitating access to tools and information necessary to equip communities with the awareness and preparedness to tackle the impacts of climate change. It also aims to address the vulnerability, loss, food insecurity, conflicts, and forced migration in Northern Nigeria by assessing historical climate trends, projected future impacts, and the specific vulnerabilities of agricultural practices and livelihoods.

With growing awareness, programs to influence adaptation are being developed by the international public sector, governments at the national or sub-national levels, non-governmental organizations, and now even interfaith organizations to build the capacity of people and scale up adaptation to climate change. Yet, there are concerns about how well people, particularly smallholder farmers, can or will adapt to extreme weather events in Sub-Saharan Africa, whether because of their unique vulnerabilities (African Development Bank, 2022) Notably, smallholder farmers have been adapting to changing weather patterns. For instance, pastoral communities in Ethiopia combine modern weather forecasts from radios with their observations of environmental and biological indicators. These include analyzing animal behaviors and plant growth, which are then matched with forecast information to make decisions (Balehegn et al., 2019). The Fulani pastoralists in the Sahel region of Burkina Faso use astronomical knowledge to inform their agricultural and pastoral activities, predicting the onset of the rainy seasons (UNESCO, 2018).

Populations targeted by adaptation programs must feel a sense of ownership and inclusion. Their existing knowledge should be recognized and integrated into the design of context-specific initiatives that are evidence-based and tailored to local needs. As Nakashima and colleagues (2018) noted, that Indigenous knowledge, local knowledge, ethnoscience, and the translation of adaptation strategies are crucial to climate change adaptation. These local perspectives, if developed, can foster learning and capacity building within a region. Research has shown that Indigenous communities have developed complex systems of weather and climate forecasting, which are deeply rooted in their traditional knowledge systems ((Balehegn et al., 2019; UNESCO, 2018). Although the scientific community uses specific terminologies, local or rural populations have more diverse ways of framing or perceiving these changes based on their experiences. Understanding climate change is not merely about recognizing the term but also about observing changes and responding to them. This study explored how these local knowledge systems possessed by rural farmers can offer practical strategies for adaptation.

The communities facing such uncertainties are thus identified according to the mentioned factors which correspond to the acknowledgment of Klepp and Chavez-Rodriguez (2018) that where growing complexity in decision-making, increased transnational interactions, and changing technological and scientific processes are pointed out. To this end, the United Nations Development Programme (UNDP) asserts that every adaptation plan should allow both communities and governments to foresee the climatic changes, and, therefore, their plans and investments should be adjusted accordingly (UNDP Synthesis of Experiences and Recommendations 2000–2015).

Nevertheless, there are still some first-generation adaptation projects in Africa that use the case of Kiribati where external consultants hailing from different places have designed the projects. These projects have failed because of limited participation and insensitivity to the context which has resulted in poor outcomes and waste of funds (Klepp & Chavez-Rodriguez, 2018). These failures, in turn, reveal the neglect of the knowledge, needs, and priorities of local people in adaptation policies (Eriksen et al., 2015).

Local knowledge or experiential, time-tested, cultural knowledge is still the mainstay of adaptation and resilience practices that are sustainable (UNESCO, n.d). Senanayake (2006) called it "growing on a specific spot and through a particular set of people's experiences and staying with those people who inhabit such places" (p. 87). Numerous researchers point out the crucial role of Indigenous and local knowledge systems in Africa as a source of sustainable climate strategies and scientific knowledge to inform each other and thereby fill the information gaps where modern climate services are not operational (Filho et al., 2022; Nyadzi et al., 2021). In Nigeria, local knowledge has been the basis of a number of adaptive practices, such as the making of mounds, rotating crops, composting, and the use of resources in a sustainable manner by farmers working with roots and tubers (Butu et al., 2022; Olaniyan & Govender, 2023).

The study is built on the "Robert Chambers'" bottom-up model, which supports this study as it claims that developments should be based on the wisdom of the local people. They are also not the ones who will decide but rather support in applying the community's inherent knowledge for its own change (Kapoor, 2002). The bottom-up model of Robert Chambers reflects a participatory development strategy that gives priority to the active role of local people in their own development process. Termed Farmers-First-and-Last, it considers communities as partners who can determine their needs and propose solutions instead of being mere recipients of external interference (Chambers & Ghildyal, 1985). Critics, however, acknowledge the model's impact on changing the development practice but say it can still lack sufficient theorization along the lines of power relations (Kapoor, 2002).

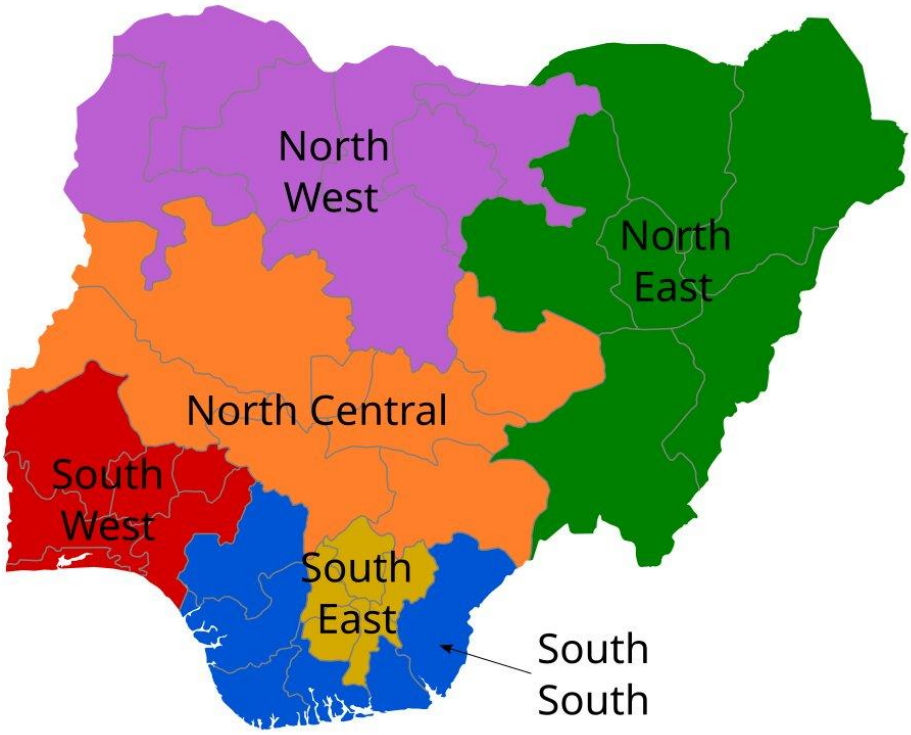
2.0 Methodological Approach

2.1 Participatory Action Research

The methodological approach draws on participatory action research (PAR), which involves the continuous and meaningful participation of several role players, especially farmers, who were central in the planning process and fieldwork. PAR, according to Kemmis and McTaggart (2000), considers the needs and opinions of ordinary people, including those with limited education and resources. In this context, PAR was used to emphasize locally led adaptation strategies, particularly for local farmers who have limited access to Western education, technology, incentives for adaptation, as well as land rights and ownership. The essence of PAR for the project lies in its ability to inform climate adaptation programs tailored to local farming communities, recognizing the specific challenges and opportunities faced by farmers.

2.2 Study Area

Figure 1: Geopolitical zones of Nigeria.



Source: Leviavery (https://commons.wikimedia.org/w/index.php?curid=95656348).

North Central Nigeria is predominantly an agricultural region where farming constitutes the primary economic activity. However, the region's agricultural sector has experienced significant impacts from climate change. For the project, three states from North Central Nigeria were selected as case studies:

1. *Plateau State*: The state is known for agricultural diversity and boasts fertile arable land and an accommodating climate. Plateau State is a leading producer of vegetables and Irish potatoes in Nigeria, contributing to 95% of the nation's total potato production (Jimwan et al., 2022). Specific areas within Plateau State, such as Barkin Ladi, Jos North, and Bokkos, were visited.

2. *FCT, Abuja*: The Gwagwalada Area Council was chosen for the study. The area is home to Indigenous people and is characterized by significant farming activities. Crops cultivated in this area include cereals, guinea corn, millet, and barley, as well as root crops such as sweet potatoes and yams.

3. *Nasarawa State*: The state is another agricultural hub. Crops grown include rice, maize, sorghum, soybean, yam, cassava, melon, sesame, millet, and groundnut. Languages spoken in these areas include English, *Hausa, Berom, Eggon, Ron, Kulere, and Gbagyi.*

2.3 Access to Community and Participants

Formal access to the selected areas was facilitated by community and youth leaders. The goals and objectives of the research were communicated to them to ensure their comprehension of severe weather changes in their farming communities. They assisted in identifying active or full-time farmers who could provide knowledge to the research and directed field visits. Also, efforts were made to identify organizations working closely with farmers in these target areas. For example, in Gwagwalada (Abuja), access was facilitated through Bennie Agro Ltd., a company that mechanizes local agricultural products through the development of machinery, tools, and equipment for both small and large-scale farming. Similarly, in Nasarawa State, access was obtained through the Women Environmental Programme (WEP) Nigeria, an organization implementing a climate-smart agriculture project in the state.

2.4 Sampling & Recruitment

The project employed a snowball sampling technique to identify and recruit participants, leveraging referrals from community and youth leaders, including existing contacts within farming communities. This method, as described by Sadler et al. (2010), involves identifying an initial participant (referred to as the source or seed) who possesses the desired characteristics and then utilizing their social networks to recruit similar participants in a multistage process. Fieldwork started with a set of participants (local farmers) who met the study's criteria. Local farmers served as introducers to other farming communities, connecting the researchers with additional participants. This process continued iteratively until the desired number of participants was attained, after which the researchers moved to engage with other farming villages. Using snowball sampling was essential for this project as it facilitated the participation of local farmers and ensured a diverse range of context-specific experiences. The use of snowball sampling in the research presented challenges, such as the potential for bias in participant selection since farmers with the same stories or adaptation methods were overrepresented and oversampled in certain study populations, like Plateau State and Abuja. This was a disadvantage of snowball sampling noted by Sadler and colleagues (2010). Efforts were made to balance the sample by ensuring representation from diverse farming communities and states that were visited. This was done by revisiting farming communities in Nasarawa State to get new participants.

2.5 Data Collection Procedures

The research employed field observation, i.e., visiting and observing 17 farmlands, and a focus group discussion (FGD) with six discussants, to arrive at findings and recommendations. The justification of one FGD was due to the embedded design of the study, where the field observation formed the primary research method, and the FGD was the supplementary method. The study’s inclusion criteria ensured that recruited participants were farmers, lived in the study area, had at least five years of farming experience, were able to perceive climate variability, could communicate in either Hausa or English, and were willing to take part in the field observations and

group discussions. In the initial phase of the research, field observations and group interviews were conducted in informal settings, particularly on farmlands, to facilitate firsthand monitoring of farming practices, conversations, and experiences. Engaging with participants in their everyday life setting provided an opportunity for workshops, where learning materials were used to illustrate severe weather changes, aiming to evoke resonance and encourage the sharing of lived experiences. This approach stimulated oral accounts from both the researcher and farmers. Questions were semi-structured and non-directive, with some conducted in the local language (Hausa) to ensure clear communication and cultural sensitivity. This draws from Hammersley and Atkinson (2019), who suggested the benefits of combining participant observation with interviews, since interviews give contextual understandings of some observations.

Figure 2: Researcher in a farm in Plateau State with farmers.

2.6 Data Analysis

The data analysis process followed Braun and Clarke's (2022) six-step framework: familiarization with the data, coding, generating initial themes, reviewing themes, defining and naming themes, and report writing. This approach facilitated the identification of meaningful patterns and insights grounded directly in the participants' narratives. The data analysis was largely descriptive, starting in the early stages of research and employing thematic analysis to discuss results. Taking notes during field observations and interviews allowed the researchers to capture key points. The researchers coded the transcripts of the group interviews with farmers, identifying key themes, patterns, and recurring concepts, thereby developing structured interview questions based on the coded data. Coding allowed the researchers to consolidate the qualitative data into coherent and structured categories, allowing for more focused and targeted data collection with program officers and development partners. Initial coding enabled the researchers to uncover participants' perspectives and challenge the assumptions that researchers and participants shared views and worlds (Charmaz, 2002).

3.0 Thematic Analysis

3.1 Objective 1: Identify the Local Knowledge for Framing Climate Change and its Associated Risks by Farmers in Northern Nigeria

3.1.1 Theme one: Traditional ecological knowledge. In North Central Nigeria, cultural practices are often intertwined with perceptions of climate change and its impacts. This perception is reflected in the existence of the traditional ecological knowledge (TEK) used to predict weather changes and agricultural outcomes in North Central Nigeria. These indicators serve as early warning systems for droughts, temperature rise, and rainfall, guiding agricultural practices. For instance, the presence of a particular bird species, referred to as *madjankala* or sparrows in English, is regarded as a reliable predictor of rainfall variability in Plateau State. The timing of their migration in colonies is observed closely by local farmers, with their arrival signaling imminent rainfall. These birds are said to move from east to west during the dry season, which begins in February, with rainfall occurring in early March, allowing farmers to plant earlier. Their movement from east to west signifies a sense of humidity for farmers. However, farmers are concerned about the decline or extinction of the population of these birds, which has had implications for the reliability of predicting rainfall, thereby, making them believe that "times are changing."

A farmer respondent said, "Even when you see these birds now, they move late, and the rain comes late as well, delaying planting and other things for us farmers" (personal communication, January 12, 2024).

There is a belief in a cyclical pattern of *men's year*, and *women's year*, which demonstrates a gendered understanding of climatic conditions, with men's years associated with early cessation of rains and women's years with prolonged rainfall, which can be productive or result in floods. These patterns do not alternate yearly but there seems to be some consistency with the *men's year* for the past three years, making adaptation planning critical. This knowledge is based on the observations of weather patterns over 1–5 years to inform the crop planting calendar. Farmers in this community believe that the women are more fertile and have higher life expectancy than the men in the community, hence, the rationale. An excerpt from the FGD indicates*, "*Women's Year helps farmers plant crops that will grow well since the rains will be there and there will be a lot of water bodies and flooding". (personal communication, January 13, 2024).

Farming communities further predict weather changes with the direction of the wind from the west in the Bokkos Local Government Area. If the wind starts arriving from the west, it is an indication that there will be a bountiful harvest, but lately, that wind only starts coming around the first week of December, resulting in a bad yield of Irish potatoes.

In addition, the appearance of whitish dust called *kabun*, when observed in November rather than late December, is usually a sign of drought; most years after the dust is observed, farmers experience a lack of water for irrigation. Kabun is regularly observed annually, and there is a lack of water if it is seen before late December. Additionally, some farmers narrated how the decline in traditional festivals and rituals, such as the Njakawa festival has led to severe weather changes. The festival is often observed by the elderly to honor the gods and secure bountiful harvests. The abandonment of these rituals is seen as a reflection of traditions that

have led to the displeasure of the gods and subsequent severe weather changes, "Farmers don't want to change from their inherited culture because farmers have infused or adopted this mentality" (personal communication, January 12, 2024).

Evidence from the FGD revealed how farmers of the communities view climate change and this includes (i) changes, alterations, and fluctuations in rainfall patterns; (ii) cessation or short and prolonged period of drought; (iii) delay or break in rainfall; and (iv) climate change is what nature holds. In other words, the rainfall patterns have turned to be more erratic, thus disrupting the usual farmers' calendars. Frequent, longer-lasting droughts have been occurring, and the dust of kabun, which indicates that the water for irrigation is running out, has started to appear earlier than usual, thus worsening the situation. The late coming of rain, especially after the madjankala birds have changed their migration cycle, has resulted in different periods for planting and thus crop failures. The farmers consider the changing of the weather patterns along with the traditional indicators being disrupted as the most obvious signs of climate change being an uncontrollable natural force that is reaping its yield in terms of changing their environment and agricultural practices. As one person stated, "Our weather is not like before, things have changed, we don't usually experience heat (temperature increase) like this, and we don't usually get low amounts of rainfall, many things have changed, and these have shaped our behavior" (personal communication, January 12, 2024).

The research has also found that farmers view climate change as what "*nature holds*" and climate change is for advanced countries to worry about. For example, a farmer stated, "We have our way of reasoning, and the issue is observed in advanced countries and most people here care only about their basic needs" (personal communication, January 13, 2024).

3.1.2 Theme two: Risk of climate change to farmers. Since farmers reported that they perceive and are informed of climate change as what *nature holds*, they identified contributing human-made factors such as: (i) deforestation for firewood and construction; (ii) burning that occurs when farmers burn plants or stems in preparation for the new planting season; (iii) mining of tin and columbite, which have degraded lands and have also resulted positively in creating water bodies; and (iv) population growth leading to conflict of environmental resources and unsustainable agricultural practices using excess chemicals. Considering this, farmers expressed the risk of changing weather patterns that result in shocks and affect food production and profitability through crop failure or loss, low yield, pest and disease infestation, changes in the pattern of rain (short and prolonged periods of drought), flooding, and leaching of soil nutrients. These risks lead to an increase in livelihood loss since some are no longer farmers due to shock, others are forced to migrate and compete for limited land and water resources. Abraham and Fonta (2018) also reported that the increased occurrence of climate vagaries affected most farming households in Northern Nigeria, who are rural dwellers, through rising temperatures, prolonged periods of dry seasons, floods, and drought, which in turn reduce harvests and farm income.

An occurring crop disease mentioned by farming communities was *blight*. Blight is caused by rain dew, i.e. when there should be rainfall or insufficient rainfall for farmers in Northern Nigeria.

Figure 3: Irish potatoes harvested from a farm in Bokkos, Plateau State.

A potato farmer explain that:

> There's a blight for Irish potatoes that arises from too much sunshine and less breeze. Irish potatoes require a lot of wind, cold, water, and sunshine at the same time and the absence of any of these variables reduces potato yield (personal communication, January 12, 2024).

In Gwagwalada, Abuja, the scarcity of water bodies limits the ability of farmers to practice irrigation, forcing them to rely solely on rain-fed agriculture. This reliance makes farming vulnerable to variations in weather patterns and increases the risk of crop failures during periods of drought or erratic rainfall. Additionally, the movement of herders seeking greener pastures further intensifies competition for land resources, exacerbating tensions between farmers and herders. Internal conflicts among farmers were observed during fieldwork. These conflicts are attributed to land distribution and division since large tracts of land in the community are divided per plot and conflict emanates from trespassing and water access.

In conclusion, there is a considerable level of awareness of climate change and its risks to farmers in Northern Nigeria given their level of understanding and description of climate change. However, the level of knowledge and perception are often defined as poor in several discussions of climate change and rural communities. This also aligns with the report by Klepp and Chavez-Rodriguez (2018) that climate change and its proposed risk management are predominantly used by developed nations to advance their geopolitical interests in many developing countries, as it often ignores local values and traditions. Hence, this suggests there might be a need to restructure the knowledge of climate change of those involved by including their perception and identified risks in designing appropriate frameworks for adaptation, especially within the local context of northern Nigeria.

3.2 Objective 2: Catalogue Local and Modern Climate Adaptation Practices by Farmers in Northern Nigeria and Their Coping Mechanisms to Climate Risks

3.2.1 Theme three: Irrigation and dry-season farming. Given the frequent occurrence of prolonged or short-duration droughts, some farmers use irrigation and dry-season farming to adapt. For example, in certain farmlands visited, there are designated sections for rain-fed and dry farming practices. Farmers identified the sections with excessive water retention that can potentially damage crops, so they utilize these sections for dry-season farming, optimizing their agricultural practices for the varying climatic conditions. Farmers employ both traditional irrigation methods and modern techniques facilitated by technology. For instance, farmers describe the process of manually controlling the flow of river water or digging small ponds to collect or retain water for irrigation. The water is manually pumped and then directed by gravity to the fields through irrigation channels, with farmers using traditional tools, such as calabashes or containers, to fetch and pour into the fields. The traditional irrigation method described is inefficient and characterized by high water usage, with large volumes of water required to irrigate crops. However, in Barkin Ladi, Plateau State, farmers described the availability of water from a small river in their farmlands, which becomes increasingly scarce in March, leading to the need for rationing among farmers.

Figure 4: The researcher joining a local farmer to irrigate his farm due to water scarcity and an adaptation planning strategy in Barkin Ladi.

Anoher comment was, “We ration water, and farmers in this community take turns to access water for irrigation. There are dates and times for each group or area to utilize water to ensure equitable distribution” (personal communication, January 23, 2024).

In other communities, there is a shift as farmers are encouraged to adopt modern techniques such as drip tape and sprinklers to maximize water efficiency and optimize crop yields, yet there are complaints about the expenses and insecurity of using drip tape and sprinklers. Another excerpt from the FGD reveals that, “ Drip irrigation uses the amount of water that the plant needs at a given time into the plants so that helps to conserve water” (personal communication, January 23, 2024).

Soil mulching serves as an adaptation technique, conserving moisture in the soil and reducing the need for frequent watering, enabling crops to withstand dry periods. An excerpt from the FGD reveals:

> When you mulch your plant, you only water twice a week and that will be enough for the plant. Mulching helps us to conserve water, and these are some of the adaptations one can get used to survive the dry season (personal communication, January 13, 2024).

Communal support networks and climate awareness were identified as adaptation practices. Farmers in these areas are forming cooperatives or groups to enhance their collective capacity and access to resources. Farmers' cooperatives facilitate access to support from external organizations such as NGOs and government agencies for adaptation programs. Organizations like the European Union and GIZ provide technical assistance and capacity-building programs to support farmers. This includes training on seed preservation and the construction of mini dams to enhance water availability for irrigation. These interventions are said to build farmers' resilience to climate variability.

3.2.2 Theme four: Improved seedlings. The sustained growth of local grains, such as maize, guinea corn, vegetables, tomatoes, cabbage, and potatoes, is a form of adaptation, as farmers have a specialty in these crops and understand the climate conditions that affect their growth. Improved seed selection is another coping mechanism. Opting for seeds called *F1 and F2 hybrids* increases the likelihood of successful crop yields in the face of erratic weather patterns. An excerpt from the FGD illustrates this point:

> It yields differently because it's genetically bred to give you good products. if you save from your harvest and plant the next season, there is a tendency that your yield will reduce by 50%. If you try to go further, it will fall below a 75% reduction in yield (personal communication, January 13, 2024).

Additionally, most of the varieties used by the farmers are said to be produced three times a year, pest-resistant and drought-resistant, which helps to reduce losses. Thus, farmers are continuously adapting by adopting different cropping mechanisms such as crop rotation, mulching, and crop diversification.

3.2.3 Theme five: Climate information services. The government, through the Nigerian Meteorological Agency, provides awareness and weather information to farmers to improve their adaptation. An excerpt from the FGD reveals, "NIMET helps predict the rains and this helps us as farmers. They send the information through Agric organizations and create workshops" (personal communication, January 12, 2024).

Accordingly, weather prediction plays an important role in minimizing future disasters. One strategy to reduce the impact of extreme weather is to improve weather forecasting and the transmission of weather warnings (Agyekum et al. 2022). While the government provides climate information services, the NGOs, especially those associated with churches in these rural communities, are more

proactive and are involved in practical demonstrations and providing support for climate change, significantly benefiting farmers' incomes and livelihoods. A farmer shares his perspective:

> Farmers are aware of the term “Climate Change” through NGOs not even through the government. The government provides information and gives farmers the option of participating or not. NGOs present instances of what they want the community to do and demonstrate (personal communication, January 23, 2024).

Innovative climate information services are delivered through sensor-based mobile apps, designed to gather soil and atmospheric data, which assist in decision-making processes, such as when to irrigate. The development of such apps integrates AI technologies to diagnose plant diseases and provide solutions, making it user-friendly even for those with little agricultural knowledge. However, the effectiveness of AI is contingent on the availability of comprehensive data to train it properly.

3.1.6 *Theme six: Greenhouse farming/technology*. Another key strategy for adaptation is the adoption of greenhouse farming. Farmers who use greenhouses are classified according to their level of knowledge and exposure to technology, direct climate impacts, funds, and motivation (farming for profit or family). These farmers regarded greenhouses as both capital-intensive and extremely profitable. Farmers using greenhouses in the study areas describe theirs as "semi-controlled," meaning they allow some natural elements like air to flow in and out, unlike "fully controlled" greenhouses common in Western countries that regulate environmental conditions. The semi-controlled greenhouses often lead to crop damage if weather conditions change unexpectedly, as was the case with a recent untimely rainfall in Jos that damaged the greenhouse structure. Additionally, rainfall variability has led to significant losses in open-field crops. For example, some farmers document the ruins of maize which were left to dry in the field due to unexpected rain. The rain caused mold, resulting in substantial yield loss.

A farmer commented:

> I changed to green farming to control the climate. We are not actually affected by climatic changes since we can keep the place at any temperature we want, and the humidity can be controlled in a way, and we can also keep out pests and diseases (personal communication, January 25, 2024).

Figure 5: A greenhouse located in Gwagwalada, Abuja, as a planning adaptatio strategy against climate change.

While greenhouses are encouraging, there are still challenges with water access, electricity costs, and temperature that affect their humidity in North Central Nigeria. For instance, the use of electric pumps for irrigation is efficient during the rainy season, especially since the area benefits from hydroelectric power and decreases during the dry season. Most farmers using greenhouses in the study area have resorted to using air conditioning or fans to maintain a consistent temperature and prevent excessive humidity. According to some, too much heat can cause plants to fold their leaves as a protective measure to conserve water.

Some farmers were observed to practice a mixed farming system (open fields which are rain-fed and greenhouses), "Our practice here mixes rain-fed agriculture and greenhouse farming. We practice dry season farming by using greenhouses" (personal communication, January 23, 2024).

This adaptation strategy is very crucial as greenhouse farming technology is grossly underutilized by developing countries, and Nigeria in particular. Greenhouses optimize growing conditions, protect crops from extreme weather events, pests, and diseases, and enable effective crop management (Ahuchaogu et al., 2022). These climate control methods are essential to ensure optimal growing conditions within the greenhouse. There is also the practice of digital agriculture.

4.0 Discussion

Six themes were produced as adaptation planning strategies (i.e., traditional ecological knowledge, risk of climate change to farmers, irrigation and dry-season farming, improved seedlings and greenhouse farming/technology) and these research findings show that North Central Nigerian farmers have an extensive store of Indigenous knowledge alongside orthodox environmental indicators to perceive climate change, and evaluate the hazards—namely droughts, floods, unpredictable rainfall, and crop diseases like blight. This agrees with the finding that Traditional Ecological Knowledge has been characterized as very effective by Nigerian farmers, noting that the more farmers get exposed to climate disasters, the more their awareness and capacity to adapt grows (Madaki et al., 2023). Furthermore, these native practices are believed to be less costly and easier to implement than scientific methods (Olaniyan

& Govender, 2023). Through this knowledge, they practice different forms of adaptation such as irrigation, dry-season agriculture, use of better seeds, soil mulching, greenhouse farming, climate information services, and cooperatives. Also, it was pointed out that cultural beliefs, community practices, and gendered views shape not only the level of understanding but also the response mechanisms. Jellason et al., (2020) noted that, based on their beliefs, farmers pray and make sacrifices to God as a way of trying to combat the effects of climate change. Offering prayers and making sacrifices were indeed very evident and became the principal methods farmers choose in both towns, which might result in reduced adaptation actions thus indirectly exposing the at-risk communities to more shocks.

Efforts towards augmenting risks with climate adaptation in North Central Nigeria's agriculture reveal significant opportunities, capability deficits, and obstacles. Indigenous crops, organic inputs, mobile applications, and AI are opportunities to build resilience using climate-smart agriculture. Group farming and local cooperatives are incentives that can be leveraged to augment access to information, funding, and assistance. Traditional knowledge, enhanced drought-resistant crops, and the inclusion of modern and traditional methods can build sustainability. Demonstration projects and collaboration with provincial governments are strategic points for entry in adaptation. Otitoju et al. (2023) stated that Climate-Smart Agricultural Technologies will bring changes in the way crops are produced, especially if they incorporate the use of sensors, automation and data analytics. Digital integration is viewed as an opportunity, but Balogun et al. (2024) pointed out that training of farmers and policy support are still the most important factors to be considered in climate-smart agriculture.

5.0 Conclusion and Recommendations

Adaptation must be rooted in locality, be inclusive of planning, and focused on mobilizing resources. Enhancing these conditions holistically can help farmers in North Central Nigeria. In collaboration with government and development agencies like UNDP, this approach can lead to the development of climate-resilient agricultural programs that serve the interests of farming communities. The study recommends that North Central Nigerian farmers must be directly engaged in participatory adaptation. This can include documenting and sharing local knowledge, discussing climate experiences, and learning from peers. They must also collaborate with development actors, like UNDP, to develop and implement context-relevant solutions integrating traditional methods and innovative climate adaptation measures with inclusive participation, especially of youth and women. However, this study acknowledges limitations, including gaps in climate planning adaptive capacity. These gaps involve misaligned policy, climate illiteracy, limited access to climate tools, and inadequacy of government extension services that constrain the adaptive capacity of farmers, as indicated by field observation data. These factors observed need further investigation individually or collectively. Further studies are needed to understand issues such as insecure land tenure, farmer-herder conflict, very costly technologies, negative attitudes towards farming among youth, and poor access to finance. These factors hinder farmers' capacity to adopt long-term alternatives such as agroforestry and greenhouses.

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