Nigerian Root and Tuber Farmers' Responses to Climate Change: The role of Indigenous Knowledge

by

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DECLARATION

I, Bolanle Susan Olaniyan, hereby declare that

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This research project is submitted to the School of Education, College of Humanities at the University of KwaZulu-Natal for the award of the Doctor of Philosophy Degree.

Supervisor

Professor Nadaraj Govender (UKZN)

Signature Date

[redacted]

DEDICATION

This study is dedicated to the memories of my late cousin

Chief (Barr.) George Opeyemi Okusanya JP LL. B (Hons), B.L, LL.M
April 12, 1968- March 5, 2019
Whose last words to me were “make sure you complete your Ph. D programme and aim for professorship like Oluwaniyi”

And my daughter

AraOluwanimi Esther Olaniyan

May 15, 2020- May 2, 2022

Thanks for cooperating with me on this journey and enduring the times when Mummy was not available to play and forcing me to leave the system when I’m exhausted. It’s so painful you’re not here to see the dream come through. You’ll always be my baby.

Ó dàrìnàkò
Ó di gbéré
Ó di ojú àlá
Tijesunimi lives on!
Wonder of God lives on!

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To myself, Omobolanle you have done well. I say thumbs up for staying the cause and finishing despite all odds.

ABSTRACT

This study explores the role of indigenous knowledge (IK) in Nigerian root and tuber farmers' responses to Climate Change (CC). Root and tuber production in Nigeria has been steadily increasing despite the adverse effects of Climate Change. A literature review by the researcher showed that the farmers deploy their indigenous knowledge extensively in root and tuber production and respond to CC in the process, hence the need to document these indigenous practices for inclusion into mainstream climate change adaptation strategies and education curricula, which have hitherto been dominated by scientific knowledge.

The study was framed by postcolonial theory, which is about how formerly colonized people write their narratives in their own words, without the coloured lens of the colonizers. Since IK is learnt by doing, situated learning theory (SLT), which posits that learning is a social phenomenon that occurs during everyday interactions, was employed in the exploration of IK used by the root and tuber farmers. Participatory phenomenology, which is a combination of participatory research and phenomenology was the methodology used to document the farmers' experiences and report their responses concerning CC and IK. Focus group discussions were held in six villages across Kwara state, Nigeria, to elicit their experiences of CC and one participant per village was then selected for in-depth interview and participant observation. Inductive thematic analysis was applied to the data generated.

The findings showed that the major experience of CC by the root and tuber farmers has been changes in the rainfall pattern, which takes the form of early or delayed onset of rainy season, and reduction in the amount and intensity of rainfall. Other indicators of CC were also identified. The farmers also responded to CC by use natural resources in a sustainable manner. They used their IK of soil water conservation by making mounds on which they planted, they maintained soil fertility by practising crop rotation, and used compost made from household waste. The farmers' preference for IK in adapting to CC was attributed to IK being effective, easily accessible and inexpensive along with their antipathy towards scientific interventions.

The study leads to suggested ways of including the documented IK into mainstream adaptation strategies in Nigeria, and the agricultural curriculum at the secondary and tertiary education levels, to engender adoption of the blended strategies by all members of the society.

Keywords: indigenous knowledge, climate change, Root and tuber production, Adaptation strategies, Responses, Environmental sustainability

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ACRONYMS AND ABBREVIATIONS

IK	Indigenous Knowledge
CC	Climate Change
KWADP	Kwara Agricultural Development Programme
IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
SLT	Situated Learning Theory
WK	Western Knowledge
DES	Director Extension Services

CHAPTER ONE: ORIENTATION

1.0 Introduction

Iyán l'óunję;
Ọkà l'oogun;
Àìrí rárá la n jękọ;
Kénu má d'ilę ni ti gúgúrú!

Pounded yam is the right food; Yam or cassava flour mixed with boiled water is the medicine. It's in the absence of any food that we eat solid pap. Eating of popcorn is just to keep the mouth busy!"

The preceding is a popular saying in Yorùbá indicates the high esteem in which the people hold root and tuber crops. They eulogise pounded yam as the 'king of foods', amala a product of yam or cassava flour as being the medication for a sick person, or a woman that just give birth to help with recovery and lactation (this I experienced recently). The other two foods mentioned are made with maize which is a cereal that is seen as supplemental food and sometimes referred to rice as 'food for the birds'. The importance of root and tuber crops is entrenched in the fabric of the folklore, stories, livelihood and traditional rites of the Nigerian people. This has been passed down through the ages concurrently with their indigenous knowledge on cultivation and processing of the crops.

1.1 My background

I was born and bred in the city of Ibadan, Oyo state which is situated in the south-western part of Nigeria. As a city girl, I thought all foods came from the market until I was taught in agricultural science class that they had been grown on the land. So, I was intrigued and decided to start a farm, but I was staying in a house that the yard was already concreted over. The only available unsurfaced land was the untarred road past my house so I had to drop the idea. Then when the dry season came and my grandma hired some Hausa men (a tribe in northern Nigeria) to de-silt the underground well that supplied water to the house to ensure a constant water supply for the subsequent year, so I had a mound of earth just outside our gate to farm on. I ran into the store took some grains of maize, rice and beans and planted them. Some days later the maize and beans sprouted but the rice never did. Unfortunately, I never got to harvest any of them as one of my neighbours got jealous and uprooted them. Later, in life I realized that I would probably have gotten a harvest only from the maize as the rice was parboiled so it would not have germinated and the particular variety of beans I had planted needed 14 hours of sunlight per day which does not happen in my rainforest agro-ecological zone, as I learnt in the university some 20 years later. My next contact with farming was while at senior secondary school when we were taken to the school farm to clear the land in preparation for the farming season, it was a time to catch some fun and jest with friends away from the classroom, since we were all city kids. Our teacher got tired of the fooling around and sent us back to class. So, I never knew what happened to that farm I never knew. Suffice to say my contact with agriculture was limited to textbooks and the farms we passed when travelling for holidays in Lagos or to the village for family functions. Although at these functions we were always under the watchful eyes of an adult, to ensure we did not wander and get involved in some taboos or some envious person afflict us with an ailment; the fear was so palpable we complied readily.

Then I gained admission to the university to study Agriculture which had not even been one of my choices. With a good aggregate I had chosen Medicine and Physiology, but the competition was stiff for the only category I fell into, so after trying for medicine for 3 years, agriculture it was. The first three years of study were spent in the classroom learning the theoretical aspects of the course with a few practical classes on identification of crop pests and diseases, seedling bed preparation etc. When the farm practical year arrived for 400 level agriculture students, I had a culture shock; we had to clear the land in preparation for dry season vegetable farming. The ground was compacted because of lack of rainfall and I had a tough time preparing the bed. The instructor kept saying kids younger than us have larger plots in the villages but my city mind could not comprehend why a kid would be subjected to such hardship. That is until I went round the school farm and saw the vegetable beds apparently already prepared by those that grew up in the villages; who had not only finished their plots but were helping others to work on theirs. This motivated me so I summoned up courage and finished the task. We (the students) planted leafy vegetables, beans, maize, and cassava and raised some chickens from day-old to table size (the agricultural term for matured chicken ready for the market). Though the work was 'back-breaking,' the certificate I would receive at the end of my studies was a great motivator and the fact that the farm practical training was a 30-unit course that had to be passed before graduating kept me going. As if that was not enough the faculty came up with community-based experience scheme (COBES) where we had to be immersed in a village for at least 3 weeks, interacting with the farmers and engaging in farm work.

There was so much trepidation on my part: how would I survive the 3 weeks? On sampling opinions amongst my classmates I discovered I was not alone, so I calmed down. The class students were sent to several villages in Kwara state, my group ended up in Malete village and were camped in the youth farm founded by the government to train young school leavers in Agriculture and empower them to do large-scale farming after the programme. I was relieved as the environment was similar to that which I was used to at university. We were introduced to commercial farming; the intricacy of it, and the business side. Then we had to go to the village and meet the farmers to learn their indigenous farming methods. I was in a group that went to the farm run by a father and son duo. The boy was about 10 years of age and he took us to his personal farm where he had done intercropping. Among his answers to our numerous questions I learnt that the bigger the heap size, the larger the tuber of yam. This was confirmed by the manager of the youth farm. He also taught us a lot of farming techniques that were neither in our textbooks nor taught in the classroom. Techniques such as breaking off a part of the tuber of yam and leaving the root intact instead of uprooting it; the part left in the soil is known as egùn. This ensures that he gets more tubers from one seed as the tuber will continue growing as long as it is in the soil.

My subsequent foray into research at undergraduate and postgraduate levels opened my eyes further to what I have come to know as indigenous knowledge. My interest was piqued. My undergraduate research was on knowledge and attitude to climate change by rice farmers and I found that most of their coping strategies were developed using their indigenous knowledge rather than the formal agricultural knowledge espoused by the extension agents. During my master's programme, I looked at challenges faced by women in processing oil palm. In the processing plant was a processing machine, provided by the Ministry of Agriculture in conjunction with some partners, but the women were still using the traditional method because there was no means of electricity and the generator had no fuel. So although the 'supposed solution' was evidently not suited to their circumstances, they nevertheless found a way to continue production. Since the advent of climate change, the production of root and tuber crops in Nigeria has been on a steady rise and my experience working with Kwara Agricultural Development Programme (KWADP) revealed that root and tuber crop farming is based solely on indigenous knowledge and methods. Hence my interest in knowing what, how and why they do what they do to ensure continued production of root and tuber crops, which has led to the pursuit of indigenous knowledge concerning adaptation to climate change for this study. My being a Yorùbá woman, an agricultural scientist and a former employee of KWADP opened the doors for me with KWADP and the farming communities to do my PhD research. Presenting the study as attempting to learn from them rather than proffering solutions further melted the barriers and the farmers talked freely and were joyful that their knowledge is being preserved for future generations, and useful particularly to 'city people' like the researcher and other agricultural scientists.

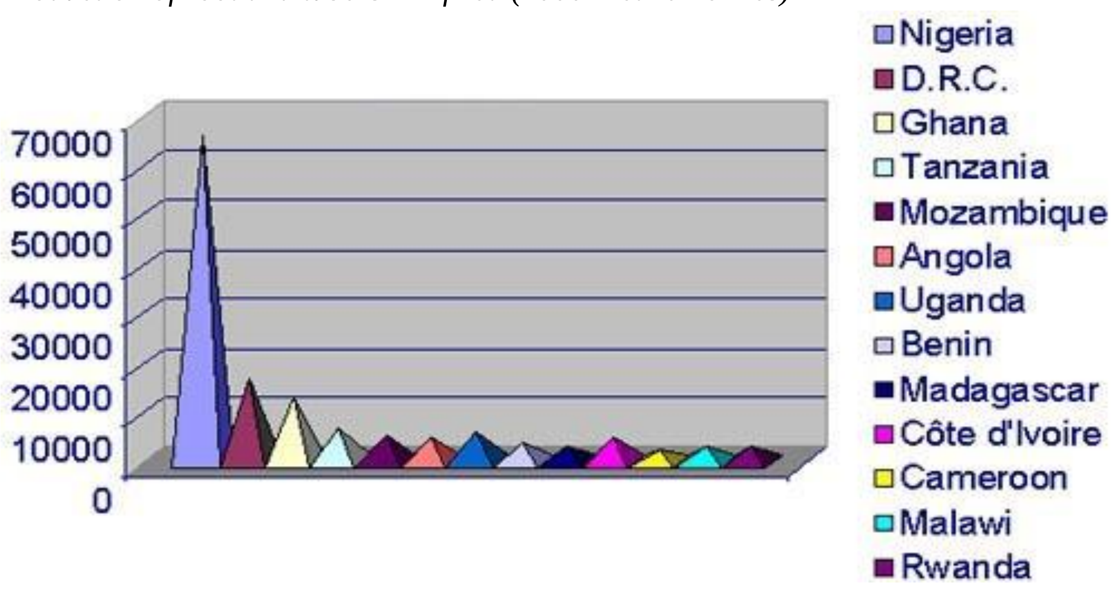
1.2 Root and Tuber Production in Nigeria

Root and tuber crops include all plants that produce starchy roots, tubers or stems that are consumed by man and/or animals. "Root crops are the edible energy-rich underground plant structure developed from modified roots while tubers are those crops in which edible energy-rich storage organs develop wholly or partially from underground stems" (Okigbo, 1989b), p. 123, (Nanbol et al., 2019). Ojiako et al. (2007) noted that the major root crops grown in Nigeria, are cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) while the tuber crops are yam (*Dioscorea* spp.*)* potato (*Solanum tuberosum*), ginger (*Zingiber officinale*) and cocoyam (*Xanthosoma sagittifolium*). For the purpose of this study, ginger was not one of the root and tuber crops examined because it is not grown in the study area. Root and Tuber crops are plants that store edible material in root, stem or corm underneath the ground and so provide energy in the form of carbohydrates (Chandrasekara & Josheph Kumar, 2016b). This differs from cereals in which the edible part grows above the ground. Root and Tuber crops are of great economic importance in Nigeria, where they are grown and consumed in almost all states of the country because they will grow in conditions in which other crops will fail. They provide a major source of food for Nigerians and the farming of these crops is the largest employer of labour in Nigeria now and in the foreseeable future (Scott et al., 2000a). Root and tuber crops are the preferred local food so form an important part of the diet, they produce more edible energy per day than any other crop groups. They are good sources of income derived from direct sale of the fresh produce and value-addition by processing into more stable food and non-food products (Okigbo, 1989a). They contribute to food security, nutrition and Climate Change adaptation as they are highly tolerant to marginal conditions and thrive where other food crops would not (Allemann et al., 2004). They provide a substantial proportion in the food needs of both rural and city dwellers in Nigeria. As far back as 1980s, Chandra (1984) reported that China, Nigeria and Brazil were the leading producers of root and tuber crops in the world, with Nigeria having the highest rate of annual per capita consumption; that is 364kg, comprising yam (195kg), cassava (143kg), cocoyam (23kg) and sweet potatoes (3kg). This makes root and tuber crops staple food in Nigeria, thus helping in the quest of the country to become 'food secure' as emphasized by (Nayar, 2014).

Akinola et al. (2019) reported that Nigeria is the highest producer of yams in the world, accounting for about 70 to 76 percent of world production see Figure 1.1. This is supported by the United Nations Food and Agriculture Organization (FAO) in its report on root and tuber production in Africa FAO (2002). Cassava production in Nigeria also contibutes 35% of the total production for Africa, which in turn is 53% of the world production. The chart in Figure 1.1 is a representation of the spread of root and tuber production in Africa with Nigeria leading the production.

Figure 1.1

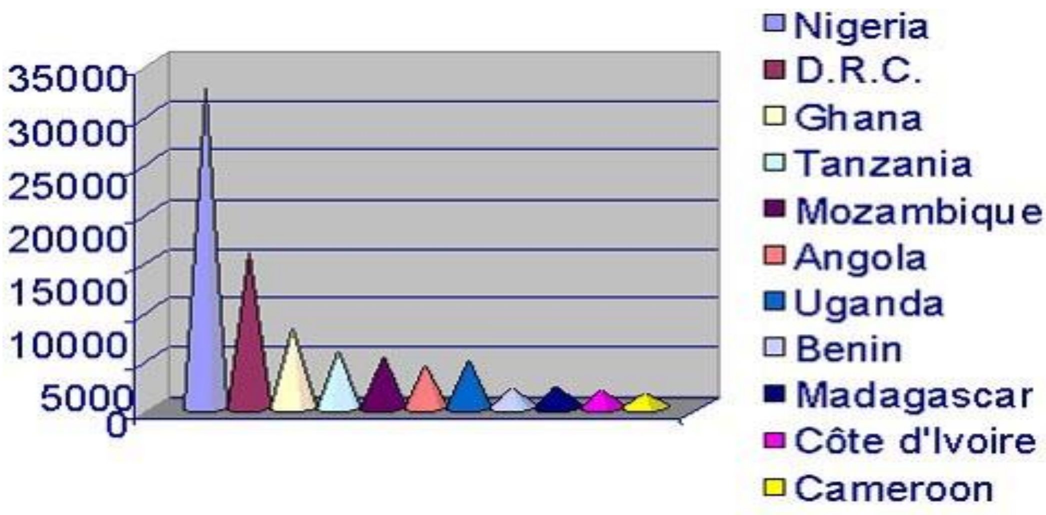
Production of root and tubers in Africa (1000 Metric Tonnes)



Source: (FAO, 2002)

It is evident that root and tuber crop are entrenched for Nigerians with cassava production by Nigeria being (35% of the African total), followed by D.R.C (17%), Ghana (9%), Tanzania (6%), Mozambique (6%), Angola (5%) and Uganda (5%) as shown in Figure 1.2.

Figure 1.2 ***Production of Cassava in Africa (1000 Mt)***



Source: FAO (2002)

Yam is produced in Africa mainly by Nigeria (71%), Ghana (9%), Côte d'Ivoire (8%) and Benin (5%) as shown in Figure 1.3.

Figure 1.3

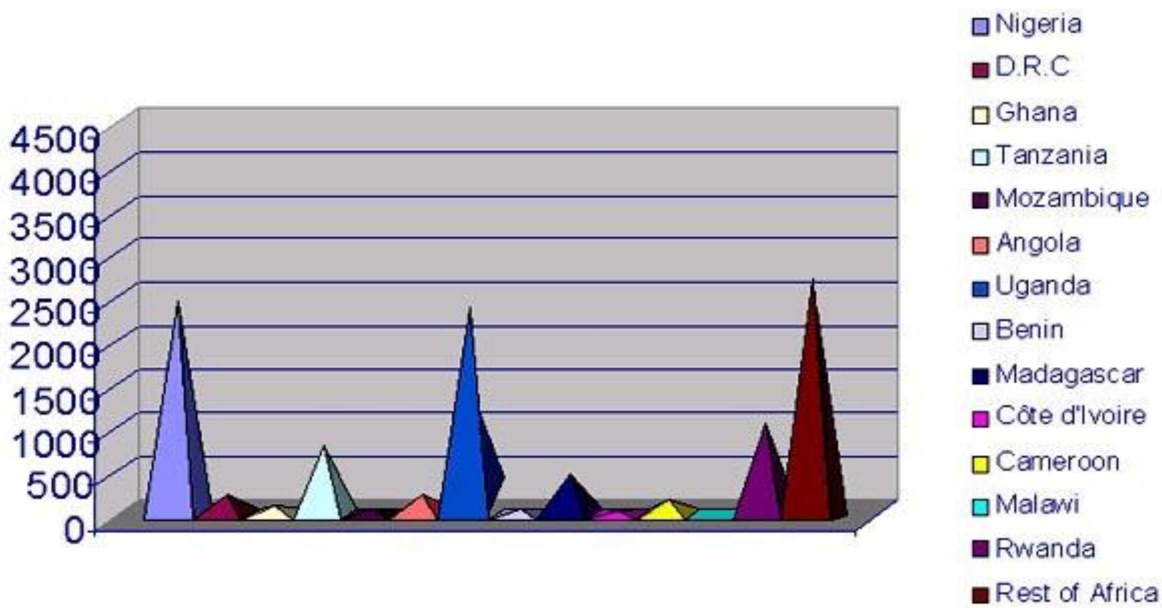
Yam production in Africa (1000 Mt.)

Source:(FAO, 2002)

Sweet potato production in Africa, also comes primarily from Nigeria (24%), followed by Uganda (23%), Rwanda (10%), Tanzania (8%) and Madagascar (5%). The distribution of the production of sweet potatoes in Africa is shown in Fig 1.4.

Figure 1.4

Production of sweet potatoes in Africa

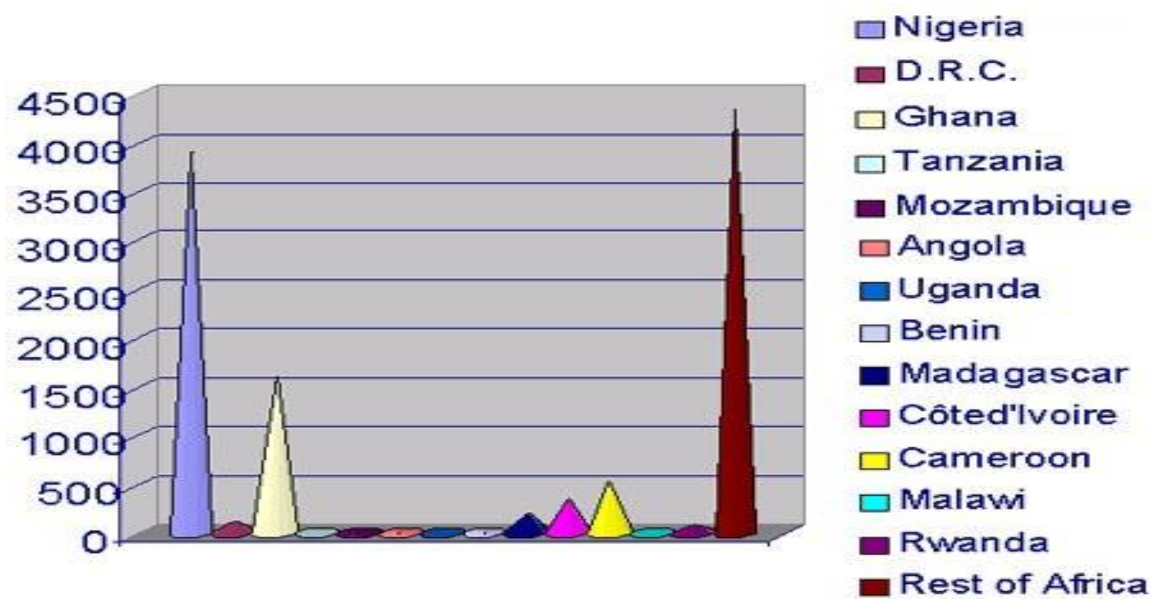


Source: (FAO, 2002)

Other root and tuber crops produced in Africa are also primarily from Nigeria (35%), followed by Ghana (14%), Cameroon (5%) and Côte d'Ivoire (3%). All other African countries together produce 43% as shown in Figure 1.5. In Nigeria these other crops are generally are taro and cocoyam. Potatoes (Irish potatoes) production in Nigeria lags behinds others because few places in the country have weather favorable for production.

Figure 1.5

Production of other root and tuber crops



Source: (FAO, 2002)

1.3 Climate Change and Root and Tuber Crops production

Response to climate change takes two forms namely, mitigation and adaptation. Several scholars have explained mitigation as the process of reducing our impact upon the cause of climate change, while adaptation is adapting to the changes that have already occurred or will occur (Mendelsohn, 2000; Tompkins et al., 2010). For this study, the focus will be on adaptation as interpreted as the response to climate change. The carbon footprints of the rural farmers are negligible because they practice organic farming using minimal agrochemicals in production, so the resources at their disposal best suits adaptation.

Tubers are grown because they easily adapt to unfavorable environmental conditions like drought, rising temperatures and other effects of climate change. Hence they serve as a solid back up plan to enhance food security (Nayar, 2014). The crops have long been regarded as the 'saving grace' during times of drought and other problems like crop failure, but recently have moved up the ladder to be significant for economic growth. Petsakos et al. (2019) referred to root, tuber and banana as 'famine reserve' because they can grow on marginal lands where other crops will not thrive and naturally adapted to climate change. The ability of these crops to adapt to resource-limited environments, thereby ensuring household food security, and the ease with which they can be intercropped made them a major part of the farming systems in the poor communities (Weerarathne et al., 2017). Chandrasekara and Josheph Kumar (2016a) reported that in addition to the nutritional benefits of root and tuber crops, they also have a high ratio of proteins, vitamin C and beta-carotene in comparison to cereals. They also have the advantage of growing under diverse soil, environmental conditions and farming systems, using minimal inputs. Also, the variety of growth patterns has made root and tuber crops easily adaptable to cultural practices of the smallholder farmers.

Adhikari et al. (2015) reported that cassava is resilient to climate change as it is tolerant of high temperatures and drought although if a prolonged drought period falls during the root thickening initiation state, the yield may be reduced by 60%. De Bruijn and Fresco (1989) indicated that cassava grows well even under the adverse conditions that characterize climate change such as fluctuation in amount and duration of rainfall etc., and it is often the last crop standing on the heap in a multi cropping system. Sweet potato, potato and yam are affected by high temperature so they are vulnerable to climate change (Adewuyi et al., 2015). Tillage of root and tuber crops is practised in a way that ensures high productivity as well as soil conservation. Specifically the process from soil preparation until harvesting the crops involves considerable soil disturbance which could lead to erosion if not properly done (Howeler et al., 1993).

From their study, Nyikahadzoi et al. (2017, p.11789) found that root and tuber crops are drought tolerant and a “potentially feasible adaptation strategy” to reduce the impact of climate change on small scale farmers in southern Africa as the crops can withstand moisture stress and can survive in places experiencing prolonged drought, where other crops cannot. The crops were termed “important economic drivers” by Hartmann (2007, p. 1). He argued that, while they used to be ‘insurance crops’ providing safety nets during lean times, they have subsequently moved up the ladder and through commercialization have attained the status of industrial cash crops. They thus, serve as a major source of earnings, food production and employer of labour (Verter & Bečvářová, 2015), despite the advent of climate change. These crops are so entrenched in the day-to- day living of the people of West Africa that they appear in folklore; that is poems, songs, adages etc., and the people celebrate New Yam festivals which marks the beginning of the harvest and thanksgiving that the crop is ready. This festival encourages people to refrain from eating the new yam until it is most wholesome by giving the yam time to mature properly. There are variations in the festival across the tribes but the central theme is that the King and the priest must partake of the yam and call it blessed before general consumption (Coursey & Coursey, 1971).

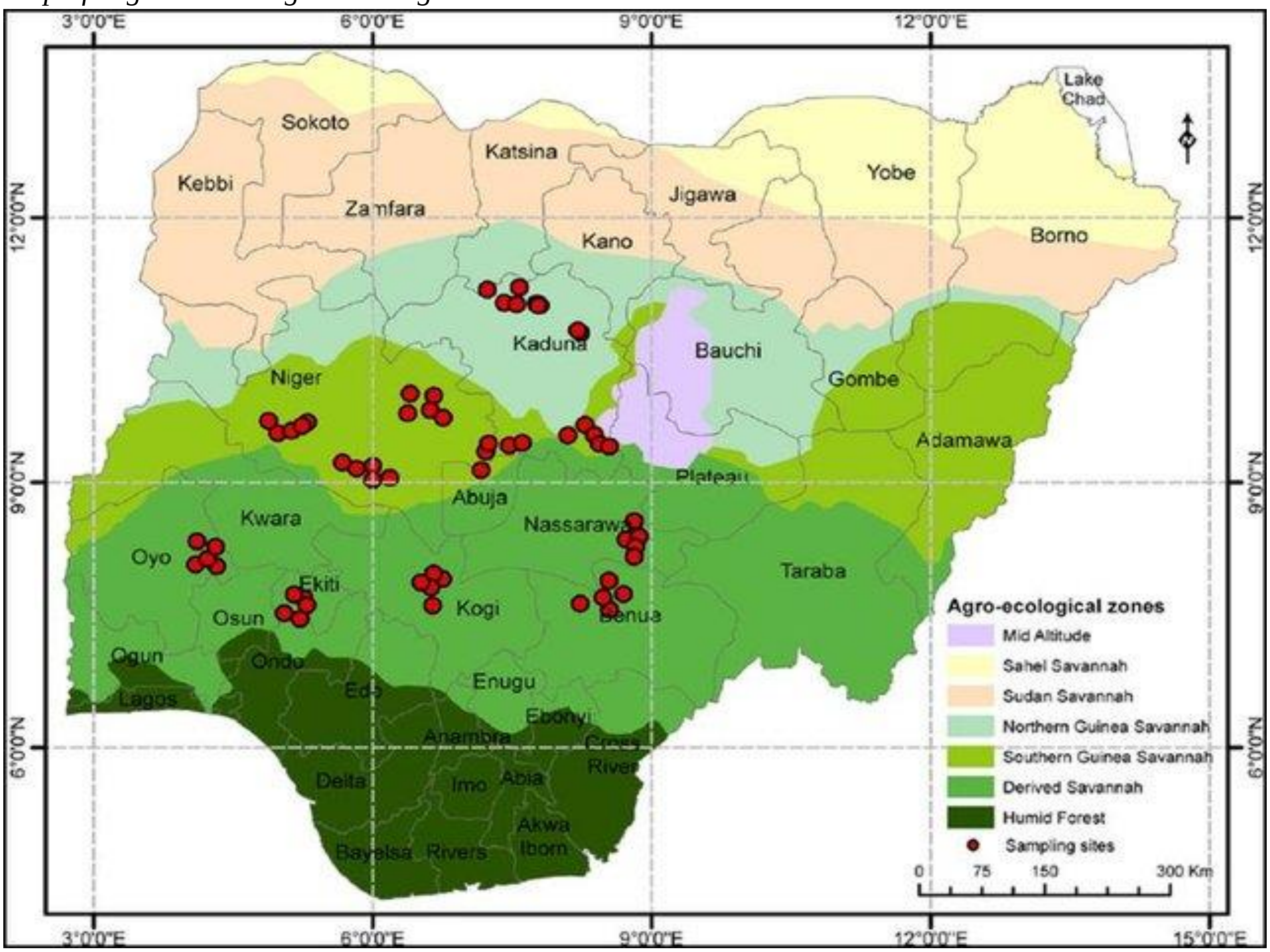
“Climate change is capturing the attention of the international community in an unprecedented manner” (Tauli-Corpuz & Lynge, 2008, p. 1). All over the world, climate variability has become a matter of grave concern at all levels of governance so that climate change is considered the leading problem of the 21st century with ‘serious catastrophic consequences’ (Kumar, 2014). Everyone is affected by climate change; that is developed, developing and underdeveloped countries. As reported by Anju et al. (2014), climate change is real and poses a great threat to “ecosystem, food security, water resource and economic stability” which are the core of human life. Several studies have shown that agriculture has borne the major brunt of climate change particularly in Africa which was identified as one of the most vulnerable continents (Smith et al., 2009).

The adverse effects of climate change are already evident in Nigeria. Weather-related disasters have become more frequent in recent decades and the trend continues. Increase in mean air temperatures, decline in rainfall pattern, late onset of rains are some of the changes that have been identified in the climate of Nigeria (Akpodiogaga-a & Odjugo, 2010). Samuel et al. (2018) argued that rainfall pattern has changed in Africa as a whole and Nigeria in particular which has led to adjusted planting dates with a resultant reduction in yields. Climate change was defined by United Nations Framework Convention on Climate Change (UNFCCC) as a change in climate that can be attributed directly or indirectly to human activity, which changes the composition of the global atmosphere and in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992).

The agro-ecological zones in Nigeria vary from the rainforest in the south, Guinea savannah in the north-central and Sahel in the north see Figure 1.6. These zones have their own distinct characteristics, but with some overlapping features like land forms, soil types, temperature, relative humidity, rainfall and solar radiation, which determine the type of crops planted and the general farming system (Kalu & Egbe, 2011). In essence, crop production in Nigeria depends on the availability of rain; in other words, it is rain fed. So, any variation in the lengths of the wet season adversely affects crop production. For instance, in the south there should be 8 months of rains with 4 months of dry season, but this could change to being a shorter wet period of 5-6 months of rainfall followed by 6-7 months of dry season. Such a deviation has been noticed over the years, with resultant flooding in the south and deforestation in the north (Abiwon Babatunde Oluwaseyi, 2017). Ayanlade et al. (2009) observed that climate change increases susceptibility to hunger, famine and economic losses; thus it is very crucial to understand the effects climate change and variability has on agricultural production in order to help formulate appropriate policies to enhance food production in Nigeria.

Figure 1.6

Map of Nigeria showing the ecological zones



Source: Oluwaseyi (2017)

1.4 Climate Change and Indigenous Knowledge

In their study, Mertz et al. (2009) identified the need to understand how farmers have coped with climate change because science has shown that climate is changing and these changes will continue in the future. Mortimore (2010) showed that farmers were managing the impacts of droughts effectively using their local knowledge. Because science needed to catch up with this local initiative he advocated for integrating indigenous knowledge into traditional science for adapting to climate change. For this integration to be possible we need to know, how and why the farmers approach adaptation.

Babatolu and Akinnubi (2016) suggested that climate change posed severe limitations on agriculture in Nigeria and if care is not taken it may disrupt the agricultural calendar and render the indigenous farmer jobless. Indigenous knowledge, such as the time to plant a specific crop based on the traditional seasonal calendar, may also be affected. Ogunlade et al. (2010) reported that the indigenous peoples in Nigeria, mostly farmers, have first-hand experience of the effects of global warming because of their relationship with the land. Their livelihood revolves around the land and have gained suitable knowledge of the environment through their interaction with it. Thus, indigenous peoples have already developed coping strategies for the observed changes in temperature, rain and seasonal phenology (Page, 2008).

Over the years, indigenous peoples have preserved traditional farming practices that have maintained biodiversity and protected the world's natural resources, thereby enhancing food security. Francesca (2016, p. 5) stated that "there are approximately 370 million indigenous peoples in the world occupying or using up to 22 percent of the global land area, which is home to 80 percent of the world's biological diversity". These indigenous farming practices have helped shape environmental sustainability over the years. In African societies farmers have had their own ways of relating to their environment and this knowledge was employed to adjust the farming system according to needs (Kolawole, 2006).

1.5 Statement of the Problem

Agriculture ensures sustained livelihood as we depend on it for the basic needs of man, specifically food, clothing and shelter. It is a major economic contributor for livelihoods in Africa (Nkomwa et al., 2014). Nevertheless, the agricultural sector is one of the most vulnerable to climate variability. Any climate-change related threats to agriculture represent threats to global quality of life, hence the increasing attention paid to adaptation and mitigation strategies that would sustain agriculture. Community-based adaptation is necessary for resilience to the impact of climate change. Community-based adaptation serves to integrate local knowledge with scientific knowledge, to ensure people's right to participate in decisions that affect their lives, and thus to build adaptive capacity; all of which assist in reducing vulnerability. Most of the conventional responses to climate change have originated from the scientific community and Western world and so are not always culturally adapted to the indigenous peoples and their locations; leading to minimal success. Root and tuber production in Nigeria is on the increase despite their being on rain-fed farms that are vulnerable to climate change. This increase shows that root and tuber farmers are successful in adapting to climate change using their indigenous knowledge (IK). Adaptation may take the form of responding directly to change in weather conditions using their IK which may be modified as the need arises or as a result of their usual cultural practices which has the added advantage of adapting to CC. By exploring their use of IK, we can seek deeper understanding of how they adapt or coexist with climate change. Thus, this study sought to examine the role and impact that indigenous knowledge plays in root and tuber farmers' responses to climate change in Nigeria, by gathering data and analysing it from a post-colonial perspective, which includes the knowledge and skills of the farmers.

1.6 Justification of the Study

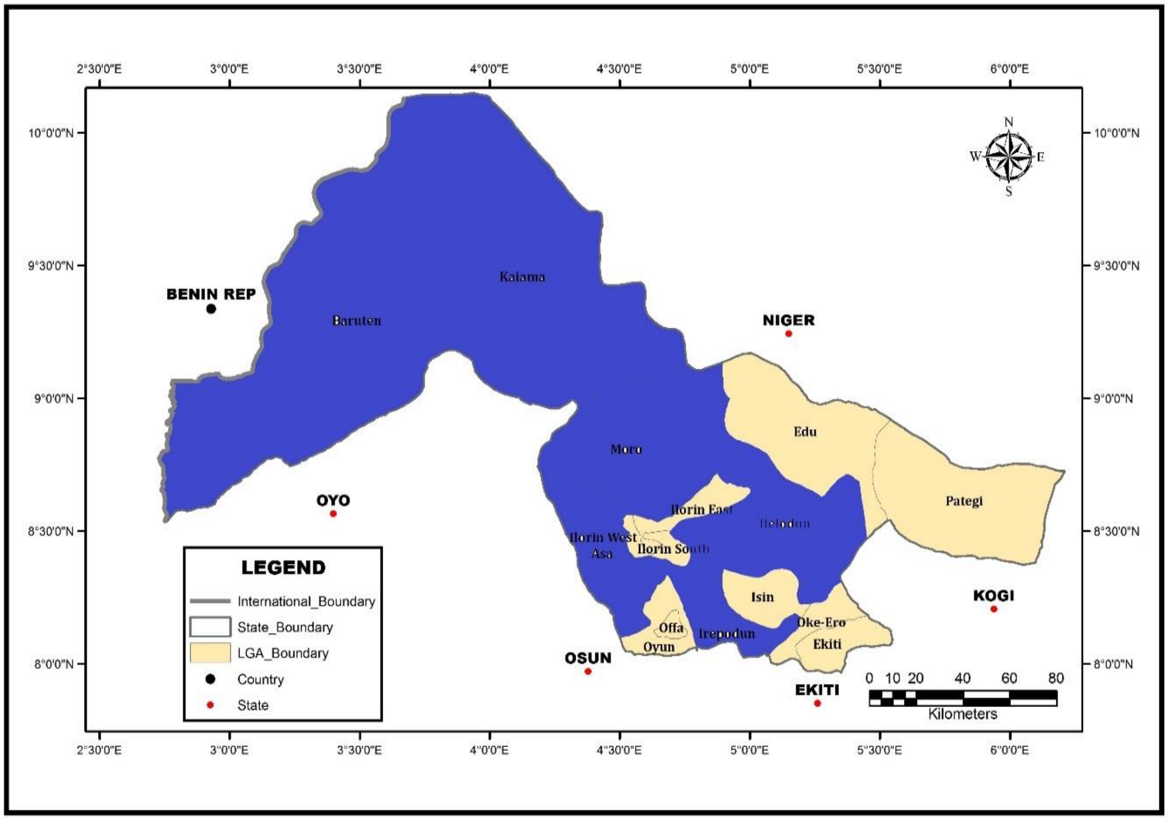
Root and tuber production depends solely on natural resources; hence it is vulnerable to uncertainties due to climatic variability. The farmers respond to these changes using various techniques passed down through the ages. It is therefore pertinent to find out specifically how root and tuber farmers respond to the problems of drought, decreased rainfall, shifting rainfall patterns, floods, strong winds, pest and diseases that are associated with climate change. This will help to identify the key components of indigenous knowledge that are employed in climate change adaptation. These components can then be integrated into mainstream climate change adaptation. Because rural farmers would identify more easily with such components that they could identify with, this integration would boost the adoption of adaptation strategies by rural farmers. Highlighting the relevant indigenous adaptation strategies could help integrate them into connected programs. Notwithstanding that this study being carried out in only one state in Nigeria, the findings will stand as reference for future similar studies in Nigeria and elsewhere.

1.7 Description of sites of research

This study was done in Kwara state, Nigeria, which is in the north-central area of the country. It is an agrarian society where the very vibrant Kware Agricultural Development Programme (KWADP) oversees the activities of farmers in the state. The state comprises 16 local government areas covering an area of 36,825 km^2. The study was carried out in six of the local government areas of Kwara, where root and tuber production are prevalent and farms were easily accessible by road, see Figure 1.7. The population of the study area is made up of the Yorùbá, Nupe, Baruba and other ethnic groups. These languages were used when gathering the communal knowledge of climate change and where a different dialect was spoken, the he researcher made use an extension agent assigned by KWADP to interpret and provide translations.

Figure 1.7

Map of Kwara state showing the study area



Source: Researcher

1.8 Research Objectives

The study had three objectives

- To explore how Nigerian root and tubers farmers' experience climate change.
- To identify the responses of Nigerian root and tuber farmers to climate change using indigenous knowledge.
- To examine Nigerian root and tuber farmers' reasons for responding to climate change using indigenous knowledge.

1.9 Research Questions

This research sought to answer the following main question: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** Sub-questions to be answered are:

1. What are Nigerian root and tuber farmers' experiences of climate change?
2. How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?
3. Why do Nigerian root and tuber farmers respond to climate change in the way that they do?

1.10 A brief description of methodology

The study documented indigenous knowledge employed in pre- and post-planting practices, pest and disease control, theft control/deterrence, clashes between farmers and herdsmen who had moved southward because of deforestation occasioned by climate change. Cultural practices were investigated, such as the New Yam festival that must be performed in each village before yam is eaten in individual households or even sold in the market. Data were collected through focus group discussion and key informant interviews conducted during the off season (June-August) when the farmers had some down time and were willing to participate in the study. Participant observation was carried out during the farming season, particularly for land preparation and weeding the plot after planting. The farmers were very happy to teach the researcher their methods; it seemed to be a breath of fresh air for someone from a higher institution seated in their class instead of telling them what to do.

1.11 Limitations of the study

Access to the farmers had to be through the extension agents deployed by Kwara Agricultural Development Programme (KWADP), so the study was dependent on their time schedule, availability and ability to convince the farmers to participate in the study. So the researcher had to attend a training session by KWADP for farmers on sustainable land management, which the extension agents attended, to familiarize herself with the intended participants. Access for the researcher to both the farmers and extension officers resulted from her attendance at that programme as she was viewed as one of them, in addition to her having worked with the organization during the compulsory youth service year.

The indigenous knowledge had to be documented from scratch; it was not in a readily available format. Some such knowledge was mentioned only in passing because it was believed to be sacred and so not open to younger people, or women, or those who needed to be trained. The researcher had to be silent in some communities and let the male extension agent take the lead as women were to be "seen and not heard' in such a gathering of men. As mentioned, the challenge of a language barrier was overcome by involving the extension agent who accompanied the researcher.

1.12 Definition of terms

1.12.1 Root and tuber crops

There have been many attempts to define root and tuber crops, but the general consensus is that they are annual food crops grown in tropical or near tropical areas that have edible parts of the root, stem or tuber that grow underground. Their propagation is vegetative. They are bulky and highly perishable crops. They enhance food security for the farming household and are used as feed for animals and raw materials for industries (Lebot, 2009). An attempt to differentiate between root and tuber crops defined them specifically as: "Root crops are the edible energy-rich underground plant structures developed from modified roots, while tuber crops are those crops in which the edible energy-rich storage organs develop wholly or partly from underground stems" (Nanbol & Namo, 2019).

1.12.2 Climate change

The Intergovernmental Panel on Climate Change (IPCC) discusses climate change as being:

> Any change in climate over time, whether due to natural variability or as a result of human activity. This differs from that of the United Nations Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (Parry et al., 2007b).

These definitions both emphasize the role humans play in disrupting nature by activities such as rapid industrialization, urbanization and aggressive exploitation of natural resources in a bid to attain such endeavours.

IPCC (2007) reported that many natural systems have been affected by regional climate changes, especially increases in temperature. In particular, in the Sahelian region of Africa, warmer and drier conditions have reduced the length of the growing season, which has adversely affected the crops. According to Wiggins and Wiggins (2006, p. 5), climate change also includes, among others, any or all of the following, "unpredictable rainfall, rising temperatures and drought, increased likelihoods of hazards such as floods, landslides and severe cycloids which result in hurricanes and typhoons" which leads to agricultural lands being submerged in water and environmental degradation.

1.12.3 Adaptive responses to climate change

"Adaptation is the process by which ecological, social or economic systems adjust in response to actual or expected climatic stimuli and their effects or impacts" (Smit & Pilifosova, 2003a, p. 881). Adaptation to global warming is a form of response to climate change which seeks to redress the vulnerability of social and biological systems to the impact of climate change. Climate change adaptation is especially pertinent for developing countries because it is predicted that they would bear the brunt of the effects of climate change and thus the need to enhance their adaptive capacity by identifying local vulnerabilities (Smit & Pilifosova, 2003b). Adaptation processes vary based on the following criteria: the system in which they occur, the person(s) undertaking them, the climatic stimuli that prompted them, their timing, functions, forms, and effects. Hence, the capacity and potential for adaptation (called adaptive capacity) would not be equally distributed across different regions and populations; with developing countries having less capacity to adapt (Kumar, 2014).

1.12.4 Indigenous knowledge

Indigenous knowledge is a body of knowledge native to a particular people and developed around their existence in a particular geographical location (Tella, 2007). This knowledge is acquired from their day-to-day experiences, and trial and error methods of solving problems in their interactions with their environment (Rankoana, 2017).

Dei (1993, p. 105) defined indigenous knowledge "as the common-sense knowledge and ideas of local peoples about the everyday realities of living which form part of their cultural heritage. It includes the cultural traditions, values, belief systems and worldviews of local peoples as distinguished from Western scientific knowledge". Indigenous knowledge was further explained by Ryser (2011b) as the knowledge accumulated by an indigenous community over generations of living in a particular environment. This often refers to a broad expression of knowledge peculiar to a people/peoples with historical ideas and practices associated with a particular location. Camacho et al. (2016, p. 5) posited that "this knowledge is not limited to know-how, skills, innovations, practices, processes, learning and teaching, but also includes knowledge that is associated with biodiversity, traditional lifestyles and natural resources".

1.13 Organization of this thesis

This thesis is organized in eight chapters. The first chapter gives a background to the study, the positionality of the researcher, the research objectives and research questions along with a statement of the problem and the rationale for the study. The context of the study, the constraints faced during the study and how they were navigated are also outlined.

Chapter 2 is a review of related literature, wherein an attempt was made to locate the thesis in the plethora of past research with a view to identifying the research gap to be filled. The importance of root and tuber crops in Nigeria is highlighted, the indigenous uses and products from the crops are also discussed as well as their role as safety nets in this era of climate change.

Chapter 3 gives a theoretical grounding for the thesis by looking at indigenous knowledge and its application in the adaptation to climate change. The hegemony of western knowledge and the corresponding exclusion or limitations of IK in climate change adaptation are also addressed. The influence of postcolonial theory and situated learning theory (SLT) on the study are also discussed to illustrate the process of learning indigenous knowledge in a certain area. The modification of phenomenology and participatory research methodologies into participatory phenomenology are also discussed.

Chapter 4 is a detailed explanation of the research methodology; that is, why and how the participants were selected, how entry into the field was negotiated, the research instruments used, the interplay between cultural sensitivity and responsiveness, the played by role proper use of language and a general account of the researcher's experience during the data generation process.

Chapter 5 is a detailed presentation of the findings concerning the farmers' experiences of climate change, giving a representation from each of the six villages sampled. A brief description of each village is given and the farmers' experiences detailed.

Chapter 6 is a presentation of the findings concerning farmers' responses to climate change; highlighting the indigenous knowledge involved in the production of root and tuber crops and how the farmers have responded to climate change, specifically across the six villages.

Chapter 7 is my attempt to give meaning to the findings as related to root and tuber production and adaptation to climate change. I looked at the reasons for root and tuber farmers having employed indigenous knowledge in responding to climate change and the nature of the indigenous knowledge used by the farmers. I also discussed the uneven spread of IK amongst people of the same tribe and how some IK has been lost over the years because of non-documentation.

Chapter 8 is a summary of my findings, the contribution of the study to general knowledge and its implication for theorizing and education, and an attempt to give a way forward to having really useful agricultural extension education.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter is a panoramic view of relevant prior literature. It provides a grounding for the thesis in the literature and the position the researcher takes in relation to the role of indigenous knowledge in responding to climate change by root and tuber farmers. This chapter has six sections dealing with issues of the importance of root and tuber crops in Nigeria, indigenous products and uses of root and tuber crops, indigenous knowledge in root and tuber crops production, interphase of root and tuber crops with climate change, adaptation to climate change and indigenous responses to climate change.

2.1 Importance of Root and Tuber Crops in Nigeria

Root and tubers crops occupy a central position in the day-to-day living of the people of Nigeria. Each tribe in the country have a proverb, song, or folklore about such crops. No traditional or contemporary ceremony is complete without the presentation of root and tuber crops, either as gift or as food served to the attendees. Sanginga and Mbabu (2015) posited that root and tuber crops, e.g., cassava, sweet potato, potato and yam, are very important food crops consumed by humans in Africa. Although they are also grown in Asia, Americas and sub-Saharan Africa, Nigeria ranks as the top producer of root and tuber production in Africa, specifically yam (71%), cassava (35%), sweet potato (24%) and cocoyam (35%) (Bokanga, 1999; FAO, 2003). The combined value placed on yam, cassava, potato and sweet potato by Nigerians exceeds that of all other African staples, including cereal crops, as is reflected in their folklores (Idusogie & Olayide, 1977; Neela et al., 2019).

In Nigeria, these crops contribute more than 600 calories of the 1800-2000 calories needed per day by adults. They are the major foodstuff in the country being consumed by all the tribes in Nigeria. As such versatile staples, they are touted as addressing food security issues because compared to many other crops they produce more food per unit area of land, as well as being cash crops with varied industrial uses such as starch and animal feed (Kibet Rono et al., 2017). Potato and sweet potato do very well in the rain-fed agricultural system of Nigeria because they have short growing cycles of about 3 months and so can be planted twice during the farming season. Although yam and cassava have longer cropping cycles, they can adapt to a wide range of agroecological conditions, thus ensuring availability of food (Sanginga & Mbabu, 2015). The variety of maturity periods for root and tuber crops and their ability to be stored in-ground makes harvesting easy; farmers only harvest what they need at the time, which prevents post-harvest losses (Degebasa, 2020; Opara, 2003).

Root and tuber crops are good producers of calorific energy, giving almost twice that produced by wheat and rice with the same resources. By providing protein, vitamin C, beta-carotene (a precursor of vitamin A), zinc, and iron, they are also a cheap source of nutrients for resource-poor farmers and by extension the Nigerian nation's growing population. They are able to grow in marginal conditions such as degraded soils in which other crops may fail, hence their production has been steadily rising in Nigeria among other places where they are cultivated. They, therefore, are a good source of income for the farmers (Sanginga & Mbabu, 2015; Scott et al., 2000b). Valenzuela and DeFrank (1995) have explained that the prevalence of root and tuber crops in the tropics can be attributed to their status as traditional crops, their versatility in intercropping with other plants and their ability to thrive in marginal lands. They are in demand, being popular in local, national and, more recently, international markets. They are less vulnerable to market shocks and price speculation than other crops because of the exclusivity of the consumers; hence they provide a more stable food system and predictable source of income (Sanginga & Mbabu, 2015; Terry et al., 1984).

Root and tuber crops are among the major cash crops in Nigeria because production is very profitable, despite the seeming high cost of production in terms of labour and land use. The high demand for the crops offsets any fluctuation in prices and has helped maintain a stable market for the crops so they are entrenched in the daily lives of the people, as mentioned above (Verter & Bečvářová, 2015). Root and tuber production is highly labour intensive because ridges or mounds have to be made by hand using a hoe. Hence, the farmers usually hire labourers for this backbreaking job. The labour intensity is particularly high for yam as they also require stakes to be placed into each mound on which vines will climb, the plots must be weeded and during harvest the tubers must be carefully uprooted to prevent scaring. There are, however, constraints in root and tuber production, such as inadequate storage facilities, a poor transportation system, antinutrient factors of hydrogen cyanide in some varieties of cassava and oxalate in cocoyam, pests and pathogens (Sharma & Kaushal, 2016).

Daryanto et al. (2016a) noted that for root and tuber crops, the effect of drought, and by extension other indices of climate change like unpredictable rainfall pattern, have not been sufficiently researched compared to the effect on cereals. With the projected increase in global temperature and the potential of root and tuber crops as alternative food sources, it has accordingly become expedient to know the tolerance of these crops to drought, unpredictable rainfall and other challenges of climate change, along with the effectiveness of cultural practices for water conservation like mulching. Root and tuber crops have different cropping systems so they are affected in diverse ways by climate change, with consequent variation in the indigenous knowledge involved. Hence they will be discussed individually in the following sections. The root and tuber crops of importance to this study are shown in Figure 2.1.

Figure 2.1

Root and tuber crops under study

Footnotes

A: Yam

B: Cassava
C: Sweet potato
D: Cocoyam
Source: Olaniyan B. S. 2021

2.1.1 Cassava

Cassava (*Manihot esculenta*) belongs to the family Euphorbiaceae, and is a major crop among tropical roots and tubers. Nigeria is one of the major world producers of cassava , with the crop being consumed in various forms across the country by man, animals and industry (Itam et al., 2014). Cassava goes by a variety of names across Nigeria: it is known as *ègé* by the Yorùbá s, *rogo* by the Hausas, *akpu* by the Ibos, *igari* by the Binis, *iwa unene* by the Efiks and *imidaka* by the Urhobos, to mention a few (Etejere & Bhat, 1985). Cassava is a calorie-rich vegetable with a root that has high carbohydrate content, primarily in the form of amylopectin and amylose, with small quantities of sucrose, fructose and glucose. It is also a good source of essential vitamins and minerals such as vitamin C, thiamine, riboflavin and niacin. The leaves, especially those of the sweet cultivars, also have up to 25% protein and is edible (Mombo et al., 2017; Montagnac et al., 2009).

Cassava can grow under marginal conditions of degraded soils, where other crops might fail, hence it serves as a food-security crop. Because of its drought tolerance, its production has not been affected by increasing temperatures due to climate change. The mature root can also be stored in the ground for up to 3 years before it starts thickening, so farmers do not need to spend money on storage facility and it therefore serves as food bank in lean times (Lebot, 2009). Lancaster et al. (1982) reported that severe famine and carbohydrate deficiency rarely occur in places where cassava is commonly grown, because being relatively inexpensive it readily fills the human nutrition gap; at least for the daily carbohydrate requirements as supported by Uarrota et al. (2019).

According to Obisesan (2013) cassava is one of the most important food crops in Nigeria, with the country being the largest world producer with an annual aggregate of over 34 million tonnes, despite production being largely in the hands of small-scale farmers. Nigerian farmers' affinity for its production can be attributed to cassava's ability to grow on degraded or marginal lands, making its cultivation suitable for the tropics (Pradyawong et al., 2018), as well as its minimal demand for agrochemicals compared to the requirements of other crops with the same output. There has also been cassava multiplication programmes initiated in the past in Nigeria. Cassava being available year-round because it can be stored in the ground for up to 2-3 years makes it perfectly fit for the small scale farmers of Nigeria who use it as a source of food security and income (Anikwe & Ikenganyia, 2018).

Processing cassava into *garri, lafun* and *fufu*, which are human foods throughout Nigeria, further increases its production, as these derivatives have longer shelf life than the fresh tubers (Taiwo, 2006). Most cassava varieties, especially the bitter ones (usually with green petiole), are not safe for human consumption in their raw form because of their toxic levels of cyanogenic glucoside. There are a few sweet varieties that can be consumed raw or boiled, which are mostly those with a red petiole. The toxicity of cassava is reduced considerably by processing it into a dry form, which involves peeling, washing, fermentation and drying into more stable products like *garri* and *lafun* (Falade & Akingbala, 2010).

Cultural practices in cassava production include land clearing with hand hoes, using stems as planting material, planting on a ridge, mound or flat, hand weeding or no weeding, intercropping with other crops, storing in the ground and processing immediately after harvesting (Ande et al., 2008; Buthelezi & Ngobeni, 2015). A typical cassava farm in Nigeria is shown in Figure 2.2 after the other crops have been harvested off the mounds and the cassava plants are well established.

Figure 2.2

Picture of a cassava farm

Source: Olaniyan B. S. 2021

2.1.2 Yam

Yam is a general name of a plant species of the genus *Dioscorea* in the Dioscoreaceae family, it is known as *isu* by the Yorùbás, *ji* by the Ibos and *doya* by the Hausas. Yams are produced by both annual and perennial vines, in the form of edible large tubers. They are widely grown in Africa, Americas, the Caribbean, South Pacific and Asia (Verter & Bečvářová, 2015). There are about 600 species in the genus of which 7 species are major food sources for humans. The species *Dioscorea rotundata* and *D. cayenensis* are indigenous to West Africa where they account for most of the global production output, with Nigeria being the world's largest producer (Akoroda, 1993).

Adisa et al. (2015) places yam second on the scale of important West African root crops, after cassava. This may be due to yam being a traditional food crop with a major cultural role, as opposed to the many industrial uses of cassava. It holds a special place particularly in Nigeria, where it is present at all occasions either as food or a gift. For the Yorùbás and Ibos of Nigeria, yams are part of the bride price presented during traditional weddings (Okeke et al., 2008). The New yam festival is celebrated at harvest time to give thanks to God and the ancestors for a bountiful harvest; the practice serves as a deterrent to harvesting the crops before they are fully matured because severe sanctions are placed on whoever sells or eats yam before the festival. The date varies across the ethnic groups but generally falls at the beginning of harvest, which could be between July and October in the southern part of Nigeria (Coursey & Coursey, 1971; Obidiegwu & Akpabio, 2017).

Yams thrive in a fertile soil that drains easily, as the growing tubers need space to enlarge in the soil and avoid so forming abnormal shapes, which reduces their marketability (Ike & Inoni, 2006). The plants do not do well in high temperatures, so, for optimum growth, a mulch is used to regulate the temperature in the mound and keep it cool. Lal and Hahn (1973) reported from their study that mulching reduced the soil temperature, improved the time of emergence and increased the tuber size and eventually the yield of yam. Ayanlade et al. (2009) noted that high humidity, flooding and drought can predispose the yam plant to infections and diseases. Consequently, for optimal yield, yam planting must be timed so as to avoid too much of either rain or drought.

Cultural practices in yam production include making mounds, mulching, staking, weeding, harvesting with sticks or wooden implements to reduce damage to tubers, scraping off the soil and storing tubers in the soil, an underground pit or in barns. Yams are also peeled, dried and milled into yam flour for *àmàlà* and, more recently, into *poundo yam* for those wish to avoid the stress of pounding (Opara, 2003). A representation of some of these practices is shown in Figure 2.3.

Figure 2.3

Yams growing in mounds with millet stalk serving as stakes for the vine

Source: Olaniyan B. S. 2021

2.1.3 Sweet Potato

Sweet potato (*Ipomoea batatas*), known as *òdùnkún* by the Yorùbás, *ji nwanu* by the Ibos and *dankalin turawa* by the Hausas (the three major tribes in Nigeria) belongs to the family Convolvulaceae. Sweet potato is an important food worldwide, especially since the development of the Vitamin A variety, which is meant to bridge the nutrient gap in the poor man's diet. Also because it it usually matures in 3 months, which is earlier than other root and tuber crops, it is farmed a least twice a year, so it is available all year round.

Sweet potato is primarily a human food, although the leaves and root can also serve as animal feed. In technologically advanced countries it is processed into chips, flour, and baby food, among others, but in Nigeria it is usually eaten boiled or fried. Some tribes boil and pound as they do yam, but few people have knowledge of this process. It is also used by the indigenous people to treat diseases such as mouth tumour, asthma, whitlow, catarrh (Matthew Olaniyi Adewumi & Fatimoh Adebayo, 2008; Olotu et al., 2017; Tewe et al., 2003). Nigeria is among the highest producers of sweet potato in Africa (Olagunju et al., 2013) although the crop is underexploited there with its full potential is yet to be maximized (Kassali, 2011).

Sweet potato is a hardy drought tolerant crop that can grow on marginal lands. It requires minimal input during cultivation and because it covers the ground it prevents soil erosion where water run-off may be a problem. In Nigeria, it is grown mostly as a secondary crop, except in Offa local government area of Kwara state where it is held in high esteem as a cash crop. In many parts of Nigeria it has some cultural importance and the harvest of yams may be celebrated with a feast equivalent to the New yam festival (Fawole, 2007; Unya, 2021).

Adeyonu et al. (2019) reported shortage of labour, insect infestation and poor access to improved varieties as the major constraints to sweet potato production in Kwara state. It is a good food security crop with low input and production costs compared to the output, so that smallholder farmers get good returns for their labour. There is the added nutritional benefit of beta-carotene, which helps the human body produce Vitamin A, so that the nutrient requirements for children, pregnant women and nursing mothers are met by consuming sweet potato regularly (Odebode et al., 2008).

The cultural practices in sweet potato production include planting on mounds or ridges, intercropping it with other crops, because the sweet potato vines serve as a cover crop to suppress weeds, as shown in Figure 2.4. Weeding of the plot is not necessary once the plant is well established as it suppresses the weeds itself. Being highly perishable, sweet potatoes are not stored for long and are sold off fresh.

Figure 2.4

Sweet potato planted on mounds

Source: Olaniyan B. S. 2021

2.1.4 Cocoyam

Cocoyam (*Colocasia esculenta*- taro and *Xanthosoma* spp-tannia) belongs to the Araceae family. It is known as *kókò* by the Yorùbá s, *ede* by the Ibos and *gwaza* by the Hausas. Cocoyam is most commonly consumed in the southern and middle areas of Nigeria. It has higher nutritional content of protein, vitamins, minerals and digestible starch than either yam or cassava. Besides its ceremonial use among the Yorùbá people of Nigeria during the naming ceremony to pray for a comfortable life for the new born, in Ethiopia its traditional uses include treatment for depression, hepatitis, and relief of pain. (Abdulrahman et al., 2015; Kadiri et al., 2014; Wada et al., 2017).

Across Nigeria cocoyam is mostly produced by small scale farmers as a secondary crop alongside other crops. It is often regarded as a female crop because women are more involved in its production (Knipscheer & Wilson, 1981). The crop is highly underutilized despite its high productivity and better storage ability than the other crops. There has also been less research on it than for yam, cassava and sweet potato. One reason for the deficit suggested by Baruwa and Oke (2012) could be the lack of information about the nutritive value of cocoyam and its versatility as a food among potential consumers. Its use as food will be discussed in section 2.2. On the other hand Abdulrahman et al. (2015) submitted that cocoyam is not a priority crop because of its lack of value as a food or industrial material for more advanced countries so that it does not earn foreign exchange. Therefore production in Africa is largely for local consumption in Africa, while Pacific countries earn foreign exchange from the crop (Akwee et al., 2015). Like most varieties of cassava, cocoyam is toxic when raw because of the presence of oxalates that may cause swelling of lips, mouth and throat and possible skin irritation but the effects are eliminated by peeling and cooking. This anti-nutritional factor may also be responsible for its low production (Owusu-Darko et al., 2014).

Cocoyam is reputed to tolerate soils with low fertility, and drought once the crop is well established after 20 weeks of growth; however, it is prone to pests and diseases. It can be planted on either well drained upland soil or in flooded lowland soil. The versatility of cocoyam is most evident in its propagation because it can be planted using the suckers, the corms and cormels, or the whole tuber. As all the parts of the plants are edible, this versatility can lead to tension between what to eat and what to plant. Its year-round available means it is well-adapted to the intercropping systems adopted by most farm families in Nigeria and it is an alternative source of food for these families during lean periods (Ogunniyi, 2008; Ubalua et al., 2016).

Cultural practices of cocoyam production include minimal tillage, especially in lowland planting, intercropping with tree or other crops, harvesting when needed and immediate processing. Production constraints that reduce the cultivation of cocoyam include early deterioration of planting materials, competition between use for food or propagation, priority being given to other root and tuber crops, lack of storage facilities, low financial returns and lack of information about its nutritional value (Nkeme et al., 2021). A picture of cocoyam planted behind makeshift bathroom to ensure constant supply of water is shown in Figure 2.5.

Figure 2.5

Picture of a cocoyam plant in flooded area

Source: Olaniyan B. S. 2021

2.2 Indigenous Products and Uses of Root and Tuber Crops

Root and tubers are used by the rural farmers and urban dwellers primarily for food and as a source of income. Because of their high perishability they are processed into more stable forms using indigenous technologies. Processing may be as simple as peeling, cutting, blanching and sun drying or be more complicated as in the processing cassava to *garri*. The ultimate aim of processing is preservation of the harvest, value addition and increased income. The root and tuber crops under study will be discussed separately as the processing and uses of each crop differs.

2.2.1 Indigenous product and uses of cassava

Cassava is a highly perishable crop as the roots begin to deteriorate a few days after harvesting. Thus it is processed immediately after harvesting into more stable forms using simple technologies, such as fermentation, that are readily available locally. Fermentation helps to breakdown the hydrogen cyanide in the bitter varieties of cassava (Cock, 1982; Echebiri & Edaba, 2008; Etejere & Bhat, 1985; Falade & Akingbala, 2010; Iwuoha & Eke, 1996; Kolawole et al., 2010; Taiwo, 2006).

Falade and Akingbala (2010) have listed various products from cassava, which include the following:

a. *Garri* is prepared by peeling the cassava, grating it, bagging it, which is then placed under a jack press or heavy stones for some days, which leads to fermentation. The product is then sifted and roasted on cast iron pans. The longer the cassava stays in the press the more it becomes fermented and soured, which results in different products. *Ijebu garri* is sourer because it stays longest in the pressing stage and is preferred for drinking. The *ibo garri* has palm oil added to it which keeps it from burning during roasting and gives it a yellow colour (Panda & Ray, 2016). The finished product can be taken directly, soaked in water along with sugar, groundnuts, fish, beans, coconut or any other desired option. It can also be eaten by adding boiled water to make *èbà,* which is then eaten with a soup of one's choice. *Garri* is popular in all societal strata across the country.
b. *Láfún* is fermented cassava flour obtained by soaking the cassava roots. These are peeled either before or after soaking to ferment and soften the roots, which are then sun-dried and ground into flour, which is then stored for future use. The flour is stirred into hot water to form a semi-solid paste, which is then eaten with a soup of one's choice. High quality cassava flour is made when the roots are boiled after peeling, which are then sundried and ground to flour, without any fermentation (Afolabi et al., 2015).
c. *Fùfú or akpu* (as it is known amongst the Ibos) is produced by different processed across the country. In the southeast, the roots are washed, cut at both ends and soaked in water for 3-5 days to allow them to ferment, they are then peeled and sieved, put in raffia or cotton bags, squeezed and left overnight to remove excess water. The resultant starch is then rolled into large balls, wrapped in banana leaves, partially cooked and then pounded in a mortar. It is then further sectioned into smaller balls, wrapped again in leaves and thoroughly cooked. In the southwest, the Yorùbás process cassava into *fùfú* by peeling the roots, cutting them into small pieces which are soaked in water for 3-5 days, during which fermentation takes place. The softened roots are then mashed in clean water, sieved to

remove the fibre and allowed to settle. The sediment is then put in a pot and stirred over a fire until it forms a semi-solid dough, which is then eaten with the chosen soup.

d. Cassava starch may be derived as a by-product during the processing of *garri* or as a standalone product. The cassava roots are peeled, washed, grated, put in bags and placed between four planks tied firmly with ropes. The gratings are then left for 3-4 days, with the ropes being tightened regularly to extract the starch solution, which is allowed to sediment and the water carefully poured out to collect the residue.

e. *Abacha* is prepared by washing the cassava, peeling and boiling them in water for 1 hour. The roots are then cut into thin longitudinal slices and soaked in water for 1-2 days, after which the slices are washed thoroughly with fresh cold water then eaten with coconut or any other accompaniment. At the end of the process, the cassava has a bland taste.

2.2.2 Indigenous product and uses of yam

Amongst indigenous peoples, yam is used mostly as food for humans and the peels are fed to animals. Yams are usually stored until needed to prepare various dishes, boiled, fried or as pounded yam. That is except amongst the Yorùbás, where it is processed into *èlùbó* which is then prepared as *àmàlà*. The processes involved in the preparation of each is discussed briefly. Yam is also an important part of celebrations, especially traditional weddings amongst the Ibo, Yorùbá and Tiv peoples of Nigeria, where it is part of the bride price a man presents to his potential in-laws when asking for a lady's hand in marriage. It is also a major feature of the New yam festivals held across the country to signal the beginning of harvest and give thanks to God and the ancestors for a good harvest. Usually new yam is neither sold nor eaten until the festival has been performed, during which the chief priest declares the yam fit for consumption and the king is symbolically the first to eat it (Onipede, 2017).

a. Pounded yam is touted as the king of foods in Yorùbá folklore and is eaten across Nigeria. It is prepared by peeling the yams, boiling them without adding salt after which they are pounded using a traditional mortar and pestle. A pounding machine has been invented, although most people still use the mortar and pestle despite its being a laborious task, see Figure 2.6. The resultant dough is eaten with a variety of soups.

Figure 2.6

Picture of a traditional mortar and pestle

Source: Olaniyan B. S. (2021)

b. Fried yam is known as *dùndún* in Yorùbá language; the word also being applicable to fried cocoyam and sweet potato. It is prepared by peeling, cutting, washing the yams, and frying them in oil.
c. *Èlùbó* is yam flour, which is prepared by peeling yams, cutting them if the tubers are large, parboiling and then sun drying them to produce *gbodo*. The *gbodo* is then pounded in a wooden mortar to break it into smaller pieces (this part can also be mechanized) which are then milled into yam flour called *èlùbó*. The flour is stirred in boiling water to make a semi-solid dough known as *àmàlà*, which is usually eaten with a soup called *ewédú* made from the leaves of jute mallow (*Corchorus olitorius*), although any soup may be chosen.
d. *Àsáró* is a general name for porridge made by the Yorùbás (like its counterpart *dùndún*); which can be made with yam, cocoyam, sweet potato or plantain. The yams are peeled, cut into cubes and boiled with salt, condiments, pepper, oil, fish or crayfish. It is then mashed slightly and served. Different modes of preparation pertain across the country.

e. *Ìkokor*é is a dish peculiar to the Ijebus, a subgroup within the Yorùbá tribe. It is prepared using water yam. The process entails peeling the yam and grating it using an aluminium grater nailed to a plank, the fine mesh of the grater ensures that the resultant batter is smooth. The gratings are then mixed with condiments and small balls are scooped into boiling water that has pepper in it. It is allowed to cook for some minutes then boiled or dried fish is added with oil and the mix is allowed to simmer. Another dish made using the same process is *òjòjò*, in which the gratings batter is mixed with salt, seasoning, onions and pepper (optional), the mix then being fried in oil (Amusa et al., 2003; Babajide et al., 2007; Coursey, 1984; Ferraro et al., 2016; Ike & Inoni, 2006; Ray & Sivakumar, 2009).

2.2.3 Indigenous product and uses of sweet potato

In most parts of Nigeria sweet potato is seldom processed. It is either boiled or fried as *dùndún*. Sometimes it is cooked as *àsárò* but amongst the people of Offa, a town in Kwara state, Nigeria it is prepared in the same way as pounded yam and processed into flour for *àmàlà*, using the same process mentioned in Section 2.2.2. Cold water may also be used in processing sweet potato to flour. This involves peeling the tubers, soaking them in water for 3-5days until they are soft, after which they are sun dried for 1-2 weeks (Fetuga et al., 2013).

2.2.4 Indigenous products and uses of cocoyam

As was stated in Section 2.1.4, cocoyam is highly underutilized; thus its processing is not as extensive as with the other crops. Agbelemoge (2013) reported that people in southwest Nigeria used cocoyam in the following ways:

a. Pounded cocoyam which is prepared by peeling the cocoyam, boiling it and mashing it in mortar and pestle.
b. *Dùndún* (fried cocoyam) which involves peeling the cocoyam, adding some salt and frying them in oil.
c. *Àsárò* (cocoyam porridge) is prepared by peeling the cocoyam, boiling it and adding some pepper, onions, condiments, crayfish or fish, and eating the mix with sauce and oil.
d. Cocoyam flour which is obtained by peeling the cocoyam, slicing it, blanching the slices in hot water and sun drying them, followed by milling them into flour (Mbanali et al., 2018).

e. *Èbìrìpò* is made by the Ijebus when the cocoyam is grated, mixed with condiments and boiled in leaves. A similar dish is known as *ekpangnkukwo* amongst the Efiks.
f. Cocoyam leaves are used to wrap food for sale and may be cooked as a soup. They are sliced, boiled and cooked with other ingredients like fish, meat, salt, oil or seasoning cubes. The leaves are also dried and used as soup thickener (Osahon & Ekwe, 2020). Beyond Nigeria, in Ghana, Boakye et al. (2018) highlighted the other uses of cocoyam. *Fufu* results from peeling, boiling and pounded cocoyam into dough. Fried crisps or chips are made by peeling, slicing and frying the cocyam in oil. *Ogoo* is prepared by roasting the cocoyam, peeling it and mashing it with other ingredients. *Eto* involves peeling, boiling and mashing the cocoyam with other ingredients. It is used as soup thickener when the cocoyams are peeled, boiled, pounded and added to the soup while it is still on fire - as is also done in the southeastern part of Nigeria. The leaves are also boiled or steamed and mashed with other ingredients and served as sauce. The similarities in use of cocoyam across Nigeria and Ghana may be attributed to the similarities in their culture and the underutilization of cocoyam in both countries.

2.3 Indigenous Knowledge in root and tuber production

Having discussed the indigenous uses of root and tuber crops, this section will elucidate the indigenous knowledge (IK) employed in root and tuber farming in Nigeria. Exploring the IK involved in root and tuber production first requires interrogation of the term ‘indigenous knowledge’ so as to properly delineate the type of knowledge being assessed in the processes involved during root and tuber production.

2.3.1 Indigenous knowledge

Indigenous knowledge is a body of knowledge native to a particular people and developed around their existence in a particular geographical location (Tella, 2007). This knowledge is acquired from their day-to- day experiences, and the trial and error method of solving problems arising in their interactions with their environment (Rankoana, 2017).

Dei (1993) defined indigenous knowledge as the common-sense knowledge and ideas of local peoples derived from their everyday experiences of living, which form part of their culture and are usually passed down the generations. This includes their cultural traditions, values, belief systems and worldviews that may differ from Western scientific knowledge. Indigenous knowledge was further explained by Ryser (2011a) as being the knowledge that a local community accumulates over generations of living in a particular location. This often refers to a broad expression of knowledge peculiar to a people(s) with historical ideas and practices being associated with a particular location. Camacho et al. (2016) posited that this knowledge is not limited to technical know-how, skills, innovations, practices, processes, learning and teaching, but also includes knowledge that is associated with biodiversity, traditional lifestyles, natural resources and the supernatural.

Most of this indigenous knowledge exists only in oral form; it is passed down through the generations, learned from elders through shared practice and trial and error experimentation. During the colonial period, African tribal practices that stem from traditional knowledge systems, for example herbal medicine, were largely ignored, under-valued or replaced by Western practices. There might have been some justification for the substitution where treatments were found to be ineffective, or remedies poisonous, so their misuse often led to illness or even death. Nevertheless the replacement of IK by Western knowledge has led to a severe cultural disruption of the African' way of life (Lalonde, 1991b). Besides the effect of colonization some of this knowledge has been lost due the death of the 'custodians' so there is an urgent need to document the indigenous knowledge that still survives. Warren et al. (1995) argued that recording indigenous knowledge and making it available to the global community would soon be regarded as important contributions to global knowledge. This is one of the gaps this study intends to fill by documenting and making available the IK employed by root and tuber farmers in coping with climate change.

2.3.2. Indigenous knowledge in root and tuber production

This refers to all cultural practices involved in root and tuber production that emanates from the indigenous people's way of doing things, which have been passed down through the ages. Studies have shown that IK is applied in all stages of root and tuber production, from the decisions about where to plant, how the land is cleared, selecting the seeds, how the planting is done, taking care of the growing plants, harvesting, storage, processing and marketing. Each of this is discussed briefly in this section.

a. Choosing a site for root and tuber production:In making decisions on where to plant, Neina (2021) submitted that farmers consider the nutrient uptake of the crop; for example for yam they would choose a land rich in organic matter. In addition, they practice shifting cultivation, so that they alternate the period of use of a piece of land for farming with long periods of lying fallow, allowing it to regain its fertility. While this practice is advantageous when fertile land for farming is available, as far back as the 70s, Kio (1972) argued that it is a laborious process and not sustainable given the human population to land ratio of Nigeria, which means there is competition for land use between agriculture and other purposes so the fallow period becomes shorter and shorter. Thus the farmers make use of some indices for determining the fertility of land, which Luka and Yahaya (2012) highlighted as being the presence of earthworms, green vegetation, dark loamy soil with a loose texture. When these indicators are present on a land it is deemed to be fertile and fit for root and tuber farming.
b. Preparing the land for cultivation: Root and tuber crops grow better in light textured and loose soil hence the farmers have to till the land by clearing all vegetation using traditional cutlass and hoes to make mounds for planting their seeds. This is done to loosen the soil and incorporate the plant residue into the soil where it serves as manure. In addition, slashing and burning of existing vegetation is believed to increase the soil fertility (Howeler et al., 1993). Agbede (2006) reported from his study of tillage practices for yams that planting on mounds and ridges increased the yield of root and tuber crops as the tillage practice improved nutrient availability to the crops. Nweke et al. (1991) also reported on their study concerning production costs of yams that the mound size had a more pronounced effect on the yield of yam than did fertilizer. They also noted regional differences in the mound sizes; in the Guinea savannah the mounds were about 50 cm high and 55 cm wide while in the forest zone the mounds were larger, being 90 cm high and 220 cm wide.
c. Selecting the planting materials: The quality of the planting material has considerable effect on the yield, so farmers select the materials to retain for the next planting season carefully from each harvest. In the case of yam, small tubers are reserved as seeds along with larger yams that are cut into smaller pieces. For cassava, healthy stems are used as planting materials. Sweet potato is planted using vines while cocoyam can be planted using any of the suckers, corms and cormels. In rare cases when competition for product usage was high the farmers might resort to buying seeds from fellow farmers. Seeds to be planted are also first

treated with herbs or wood ash to prevent insect infestation (Amanze et al., 2011; Bamigboye, 2016; Mignouna et al., 2015; Sesay et al., 2013).

d. Planting procedure: One crucial aspect that determines the success of the farming season for root and tuber crops is the time of planting. Over the years, indigenous people have mastered the art of timing their farming activities to ensure maximum yield. Previous studies have shown that timely planting of root and tuber crops to be just before the start of the rainy season helps in the growth of yam, because it significantly reduces the dormancy period. Although cassava is known to be drought tolerant, it still needs rain at the root initiation stage. Proper timing also helps reduce the severity of some diseases and improves the efficiency of mulching on the soil. The advent of climate change has led to irregularity in the onset of rains so farmers try to predict the imminent onset of rain using local observations such as the temperature or flowering of certain trees before they plant (Adipala et al., 1998; Daryanto et al., 2016b; Egesi et al., 2007; Olasantan, 1999).

e. Taking care of growing plants: After planting, the growing crops have to be tended for proper growth. Activities for weed management to reduce competition for available soil nutrients might be manual weeding using a hoe, or intercropping with cover crops. Another activity is mulching, which entails placing grass or leaves on the mound to helps to conserve moisture in the mound, regulate the soil temperature and incorporate crop residue which, in the long term, breaks down to manure. For yams, stakes are placed on the mounds to support the trailing vines. In addition actions are also taken to prevent pests and theft by setting traps and placing scarecrows on the farms (Adeniyan et al., 2008; Ennin et al., 2014; Nedunchezhiyan et al., 2014; Odjugo, 2008; Weerarathne et al., 2017).

f. Harvesting and storage: Harvesting with simple implements like wooden sticks and sickles is done with utmost care taken to minimize bruises on the tubers because they could provide an entry point for pathogens that cause rot (Kusi et al., 2013). When harvesting yams, the farmers carefully loosen the soil around the tuber before lifting and detaching it from the vine. For cassava the plant is slashed down to a stump, and this used to uproot the whole plant in a bid to cause minimal damage to the harvest. To preserve the tubers, the soil is scrapped off them with sticks, but not washed because damp would predispose the tubers to infestation. The harvested yam tubers are dusted with wood ash before storage. Farmers practice in-ground yam storage by digging a pit in which sticks are set as pallets on which traditional sponge is placed before arranging the yams, then some of the excavated soil is used to cover the pit. Cassava is left in the soil to continue growing as it deteriorates much faster than other crops once harvested. Hence immediately after harvesting it is processed into more stable products like *garri* and flour. Sweet potato and cocoyam are also used or sold immediately after harvesting (Afek & Kays, 2004; Akinbo, 2019; Osunde, 2008; Uchechukwu-Agua et al., 2015).

g. Processing and marketing: To preserve the harvest and increase income, the rural farmer process damaged yam tubers and cassava into dried products, which increase their shelf life and attract more money. These are then sold at the farm gate or cyclical markets, to wholesalers, retailers and consumers. The processing is done using available resources with little mechanization, as was explained in section 2.2 (Onyenwoke & Simonyan, 2014; Parmar et al., 2018).

2.4 Interface of root and tuber crops with Climate Change

Agricultural systems are expected to be adversely affected by climate change where the impact would affect crop production, availability of water, input supplies, value-addition and other components (Adesiji et al., 2012). Ayanlade et al. (2018) emphasized that rural farmers' understanding of climate change is crucial to designing policies and strategies that address the threats, risks and effects posed by climate change to the agricultural sector. This understanding is especially fundamental in Africa because agriculture on the continent is primarily rain-fed and changes in climate have a profound impact on the agricultural sector and by extension other sectors.

Developing countries, which already have to deal with social, economic and environmental issues, now must add weather extremes such the increasing incidence of droughts and floods to the mix. Parry et al. (2007a) reported that and drier conditions have reduced the length of the growing season with detrimental effects on crops as supported by Bathiany et al. (2018). According to Wiggins and Wiggins (2006), climate change effects also include irregularity in rainfall patterns, rising temperatures and drought, increased incidence of floods, landslides and severe cyclones which result in agricultural lands being submerged by water. Thus, agricultural production will be in a dire circumstance unless it evolves to meet the rising challenges (Hasnat et al., 2018).

Nyikahadzoi et al. (2017) proposed that root and tuber crop production may be a solution as the crops, especially sweet potato and cassava, can grow on marginal lands and are drought tolerant so they can withstand the stress where other crops will fail. Accordingly, they recommended a shift towards root and tuber production in the drought prone areas of southern Africa. Anju et al. (2014) noted that root and tuber crops have the ability to grow, irrespective of whether the conditions are favourable or not. They explained that the crops simply stop growing during unfavourable conditions like drought, floods and heat stress and then resume growth when the tide changes, which reduces the chance of crop failure. Therefore, root and tuber crops are promoted as a cheap alternative to cereals in Kerala, India. Enete et al. (2011) submitted that crop diversification using drought tolerant crops and varieties may cushion the effect of climate change and recommended cassava as being the most adaptable crop for climate variations because of its hardiness. Along these lines, in their study on awareness and adaptation to climate change among yam based farmers, Oluwatayo and Ojo (2016) reported that yam farmers in Oyo state, Nigeria, noticed a change in rainfall pattern, and the duration of rainfall with an adverse effect on the yield of yam. This view is supported by Angba et al. (2020), who submitted that rising temperatures occasioned by climate change have an adverse effect of declining yam production. Because the incidence of pest and diseases of yam increases with rising temperatures, they suggested development of pest and disease tolerant varieties of yam.

The potentially deleterious effects of climate change have necessitated actions in mitigation and adapting to it. Hence, an overview of current adaptation measures is discussed in the next section.

2.5 Mitigation and Adaptation to Climate Change

There are two areas of responses to climate change namely mitigation and adaptation. Mitigation focuses on reducing our impact on the causes of climate change, which Uyigue and Ogbeibu (2007) pointed out differs from adaptation, which tackles the adaptive effects the phenomenon has on humans, animals, flora and the planet as a whole.

Mitigation, on the one hand, involves a critical assessment of all human or other activities that contribute to the increases in the atmospheric temperature. Actions like the use of fossil fuels or household appliances and products that contain chlorofluorocarbons lead to the emission of greenhouse gases which in the stratosphere react with and break down the ozone layer, leading to an increase in temperature and global warming. Stern (2008) reported that the cost of preventing climate change is significantly lower than the cost of addressing damages caused by it. Since the causes of climate change are partly linked to human activities, the need arises to identify such and modify where necessary in order to adapt to climate change. Fawzy et al. (2020) highlighted the main mitigation strategies to be the use of technologies that reduce emission of carbon into the atmosphere, such as switching to renewable energy, capturing carbon dioxide from the atmosphere, storing, utilization and managing solar and terrestrial radiation; but these strategies are largely still in the theoretical phase.

Adaptation, on the other hand, is coping with the changes that have already occurred or will occur, with the aim of minimizing the deleterious effect of the phenomenon and exploring the benefits inherent in climate change (Klein et al., 2005). Smit and Pilifosova (2003b) defined adaptation as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. These adjustments may be in the form of changes in processes, practices, or structures to mitigate potential damages or to benefit from opportunities associated with climate change. It is a form of response to climate change that seeks to redress the vulnerability of social and biological systems to the impact of climate change (Bassett & Fogelman, 2013). Climate change adaptation is especially expedient in developing countries because it is predicted that they will bear the brunt of the effects of climate change so there is a consequent need to enhance their adaptive capacity by identifying local vulnerabilities (Smit & Pilifosova, 2003b). For this study, adaptation will be adopted as the response to climate change. It is judged to be more pertinent than mitigation for farmers because the resources needed can be sourced locally within their environment, so it is the more suitable approach for the farmers.

Adaptation processes vary according to the system in which they occur, the person(s) undertaking them, the climatic stimuli that prompted them, their timing, functions, forms, and effects. Hence the capacity and potential for adaptation (called adaptive capacity) will not be equally distributed across different regions and populations, with developing countries having less capacity to adapt (V Kumar, 2014). Most developing economies depend directly on natural resources; the use of which has led to degradation with simultaneous increase in populations that are concentrated in ecologically fragile and remote areas (Barbier, 2013). Local farmers have proffered solutions to changes in the weather arising from findings that Rhoades and Bebbington (1995) identified as being from experiments borne out of curiosity for problem-solving and adaptation. This idea is supported by Kolawole (2006), who reported that small scale farmers have employed various methods of soil conservation in the hope of improving agricultural production and subsequently their livelihood. However, the emergence of westernization, as a by-product of colonization, led to distortion in the way of life of indigenous people. Indigenous knowledge systems were completely abolished or relegated to the background with the few representations of such knowledge being through the lens of western culture (Semali & Asino, 2013). This gave rise to the preference for western technologies, especially in the areas of soil conservation and crop protection. The local approaches were discarded in favour of newer technologies, which were perhaps seen as being more efficient. But these technologies have proven to be unsustainably expensive to sustain and are usually not culturally adaptable to the local environment, which may be coupled with little or no support from the Government. Consequently, there is a return to indigenous knowledge (Kolawole, 2006). To sustain their production and livelihoods indigenous farmers have been responding to climate change in their own ways, an overview of such responses is explored in the next section.

2.6 Indigenous Responses to Climate Change

Studies have shown that around the world indigenous peoples have become aware through their relationship with the environment of changes in the weather over time and are doing all they can to protect their source of livelihood in agriculture by using available resources in a sustainable manner (Asrat & Simane, 2018; Prusty & Tripathy, 2015; Speranza et al., 2010). Sekelemani et al. (2020) reported that farmers in Botswana indicated increasing temperatures, erratic rainfall pattern and variation in rainfall duration as their perceptions of climate change. The corresponding adaptive measures identified include growing drought tolerant crops, changing planting dates and techniques, using soil and water conservation methods; all using indigenous knowledge.

Adesoji (2016) also explored the indigenous farming systems of arable farmers in face of climate change and identified crop rotation, shifting cultivation, cover cropping, mulching, multiple cropping, planting different varieties and changing planting dates as adaptive strategies employed by the farmers to mitigate the effects of climate change. This is supported by Nyong and Bassey (2019) in their analysis of 'climate smart' agricultural practices of yam farmers in Akwa-Ibom state, Nigeria. They listed multiple cropping, crop diversification, mulching, cover cropping, making of mounds, making ridges across the farm to prevent soil erosion, change in planting and harvesting dates and use of IK to forecast weather before planting (because public weather forecasts are usually too sophisticated for them to decipher and not location specific), as the climate change adaptation practices of the farmers. They argued that these were routine practices of the farmers that required no technology, hence they were frequently used by the farmers in responding to climate change. These findings give a good representation of perceptions and adaptation to climate change across sub-Saharan Africa.

Denton et al. (2008) reported that capacity building is inherent in people and achieved through process of ‘learning by doing’ where skills and knowledge of all participants are improved. The process involves the direct application of proffered adaptation solutions so it makes indigenous knowledge a good avenue for developing adaptation strategies. Making this knowledge available would provide a resource that policy makers, educators and the drivers of climate change adaptation could use so that implementation is built into the research. Such links between researchers, decision makers and communities would help ensure that the research is driven by the needs of its users, rather than the research organizations.

Previous studies have identified indigenous strategies for adaptation to climate change across several states in Nigeria and other parts of the world, with respect to environmental conservation, coping strategies of farmers in producing different crops like rice and yam, farming systems, flood prevention and management, awareness and vulnerability to climate change, and weather forecasting (Ajetomobi et al., 2011; Ajibade & Shokemi, 2003; Wahab & Ojolowo, 2012). However, there has been little documentation of the exact practices and procedures for the aforementioned examples. This study addressed such a deficit by documenting the IK used in Nigeria in adapting to climate change at different stages of root and tuber crop production and has highlighted the procedures, materials and outcomes of such interventions.

Other researchers have also looked at the potential of cassava, yam, cocoyam or sweet potato as food security crops by, amongst other aspects of root and tuber production, analysing the constraints in production, weed and disease management, and effect of tillage on yield (Adegbite et al., 2006; Adeniyan et al., 2008; Agbede, 2006; Kamalkumaran et al., 2020). Most of these studies mentioned IK briefly rather than placing it as the main crux of root and tuber production. So they differ from the current study, which focuses on the role of IK in agricultural practices at every stage of root and tuber production and how it has sustained production by rural smallholder farmers over the years.

There is a dearth of studies that look critically at the role that indigenous knowledge plays in the collective issues of growing the major root and tuber crops in Nigeria and the farmers' responses to climate change, rather than simply looking at each crop individually. Hence this study provided a holistic view of the IK employed across the crops and documented the variations in IK practices, both in production and adapting to climate change with resultant outcomes, against a background of agricultural science practices. This is a bid to make the identified IK available and preserve it for inclusion in agricultural education curricula, mainstream climate change adaptation programmes; thereby contributing to knowledge.

2.7 Summary

A conceptual literature review in this chapter showed the links between IK, climate change and root and tuber production. The important role that root and tuber crops play in making Nigeria food secure was explained and reinforced the need for production to be sustained and improved, despite climate change. It was shown that in crop production the farmers deploy their IK, so the continued use of IK alongside relevant intervention involving conventional knowledge is advised. It was evident that there has been insufficient documentation of the IK used in root and tuber farmer, in previous studies IK has been mentioned in relation to specific root and tuber crops. But its collective role across the major root and tuber crops has not been explored. These research gaps inform the purpose of the study. The theoretical framework of the study is discussed in the next chapter.

CHAPTER THREE: THEORETICAL FRAMEWORK

3.0 Introduction

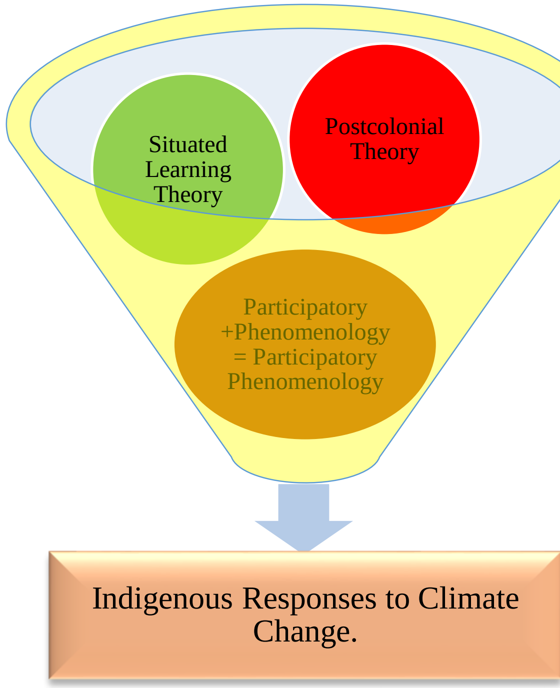
In the previous chapter the literature related to the key concepts of the study, namely indigenous knowledge, climate change, and root and tuber production, was reviewed and the links between them were shown. The research gaps in the literature were also identified, which informed the following three research questions:

1. **What are Nigerian root and tuber farmers' experiences of climate change?**
2. **How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?**
3. **Why do Nigerian root and tuber farmers respond to climate change the way they do?**

This chapter describes the theoretical framework for this study. The chapter unpacks the term indigenous knowledge in looking critically at its subjugation by western knowledge (WK) in terms of climate change adaptation through the lens of post-colonialism. Then the appropriateness of situated learning theory for eliciting and documenting IK is also discussed. The merging of phenomenology and participatory research methods into participatory phenomenology, as used in the study, are also explained. Figure 3.1 gives a representation of the theoretical framework of the study.

Figure 3.1

Representation of the interplay of theories underpinning the study



Source: Researcher

3.1 Unpacking Indigenous Knowledge

Indigenous knowledge (IK) is the way of knowing for a people in a particular location; it is a compendium of how they view themselves and relate with the natural world, which informs their use of natural resources, their cultural beliefs, history, general well-being and problem solving strategies (Semali & Kincheloe, 2002). Abah et al. (2015) stated that IK is all encompassing as it relates to all areas of life, both physical and spiritual, for the indigenous people. It is at the centre of all decisions made by the people concerning how they navigate life daily. They employ it in areas, including what to eat, what to wear, how they treat sicknesses, how to interpret the weather. This knowledge has been passed down through the ages, both practically and orally in the forms of songs, stories, proverbs etc. As a definition, Sillitoe (2006) states: “Indigenous knowledge (IK) is any understanding rooted in local culture. It includes all knowledge held more or less collectively by a population that informs interpretation of things”. Ryser (2011a) describes IK as being a specific body of knowledge belonging to a specific people located in a particular place and it involves their understanding or possession of information, facts, ideas, truth or principles. As such, indigenous knowledge forms the essence of the people people and cannot be detached from them.

According to Aikenhead and Ogawa (2007), indigenous ways are communicated through oral tradition which involves listening to stories and songs, observing dances and participating in all ceremonies where IK is passed down across generations. So this communication is embedded in almost all manifestations of daily living and is derived from the people's relationship with nature, such as the knowledge of which plants are good for food or herbal medicine. Akullo et al. (2007) suggested that IK is stored in people's memories and activities which has preserved the IK over the years, allowing its expression in their language, cultural values and agricultural practices, amongst other elements of life. It takes centre stage in the decision making processes. Dei (2000) reiterated that IK is learnt by experience and transmitted orally only if the receiver is perceived to be able to handle it responsibly and so making meaning of the experiences of IK is mediated by the individual involved.

Oniang'o et al. (2004) argued that IK is very important to people living in rural areas as sometimes among diminishing resources, it may be the only resource available. Thus, it is the basis upon which most local decisions are made. They further stated that if an intended programme or project builds on existing IK or project it elicits participation by the indigenous people; its familiarity gives them a sense of belonging meaning that such efforts are then sustained through communal relations that engender long term collective development. Such participation would prevent the dilemma identified by Doebel (2000) wherein indigenous societies are threatened by modernization and development which erode their natural resources and their world as they know it.

Owusu-Ansah and Mji (2013) took another view: that indigenous knowledge has its limitations, such as the continued use of practices and beliefs that are impervious to necessary changes. Practices which people deem sacrosanct and not to be tampered with are frequently deeply rooted in spirituality and, thus, not open to interference from economic, environmental or social forces. An example cited by Tanyanyiwa and Chikwanha (2011) was the conservation of some tree species amongst different tribes in Zimbabwe, which was based on their perceived usefulness and totems attached to them. The people had been taught to not consume their totem, while they might wantonly destroy those species of with a different status.

Oguamanam (2016) (pp.15−16) enumerated differences between indigenous and western knowledge, which is presented in Table 3.1. This difference in worldviews between IK and WK sometimes creates tension in a bid to establish superiority of one over the other, which is evident particularly in the climate change adaptation efforts discussed in the next section.

Table 3.1

Differences between Indigenous and Western Knowledge

1. The transmission of indigenous knowledge is mostly orally based, that is, through folklores and legend, or through imitation and demonstrations.	Western science transmits knowledge through writing.
2. Indigenous knowledge is gained by observing and participating in simulations, real-life experiences and trial and error.	Western knowledge is taught and imbibed in abstraction.
3. Indigenous knowledge is founded on the spiritual; the notion that the world and its components have life force and are infused with spirit, and this includes both the animate and inanimate objects such as fire and trees.	Western knowledge severs the animate from the inanimate and treats all as physical entities.
4. Indigenous knowledge views the world as interrelated; it does not necessarily subordinate all other life forms to mankind as they are all interrelated and interdependent parts of one ecosystem.	Western science views mankind as superior to nature and "authorized" to exploit it maximally.
5. Indigenous knowledge is integrative and holistic in nature, rooted in a culture of kinship between the natural and supernatural.	Western science is "reductionist and fragmentary, reducing and delineating boundaries to the extent that every relationship is treated as a distinct whole."
6. Indigenous knowledge values intuition, emphasizes emotional involvement and subjective certainty in perception.	Western science thrives on logic and analysis, abstracted from the observer, and the replication of measurement to determine results.
Indigenous knowledge is based on a long period of close interactions with the natural environment and phenomena.	Western knowledge thrives on the mathematical and quantitative.

Source: Adapted from Oguamanam (2016)

3.2 Hegemony of Western Knowledge in Climate Change Adaptation

Hitherto, climate change adaptation programmes have been largely influenced by western knowledge, which subverted indigenous knowledge as it was seen as illogical and unsystematic and so unsuited to addressing a complex issue like climate change (Demeritt, 2001; Kolawole, 2012). As Cobern and Loving (2001) puts it, science is taught all over the world as being superior to indigenous knowledge; hence, it must hold sway in all discussions of knowledgeable proportions. Speranza et al. (2010) mentioned that scepticism about IK has limited its use in practice as a science. When it is evaluated using the same criteria as western science, IK is put at a disadvantage because it differs across different indigenous groups, so a ‘one size fits all’ evaluation is not suitable in this paradigm.

Schipper (2006) noted that at the time of their paper most responses to climate change had been geared towards reducing the emission of greenhouse gases, which is essentially mitigation. Most countries had relegated adaptation to the background and it had not been a pertinent issue in determining policy. Instead, as adaptation was perceived to be a mere indicator of how a country could tolerate the effect of climate change, and as such it was deemed to be in the purview of the indigenous people. Furthermore, Kates (1997), in his review of the second volume of the Intergovernmental Panel on Climate Change (IPCC) report, remarked that although adaptation was mentioned in the title it had not been given due attention in the report; a mere 32 pages of the 728 pages of substantive text had been dedicated to adaptation, so that the impact of climate change and mitigation took centre stage. He elaborated that although the scientists had a plethora of human and natural adaptation studies to draw from, which had been included in the appendix, the scientists’ favoured those works that were rooted in the industrialized world while neglecting the developing world where indigenous people might not have the capacity to prevent or adapt to climate change.

Obermeister (2017) argued that although the IPCC report acknowledged the resourcefulness of IK in adaptation measures and called for its integration in existing practices, there was little evidence that it has been integrated in the assessment process. The various working groups had disregarded the contribution of IK because they had employed scientific methods in their assessment and so exercised considerable epistemic and political control despite advocating for collaboration between the various knowledge systems. This paradox in the recommendations of

IPCC and the activities of the working groups reveals the hegemony of scientific knowledge over other forms of knowledge, with any attempt to challenge the former creating resistance. Thus a dualistic view was suggested, this view is supported by Agrawal (1995) and Biermann (2001).

Nyantakyi-Frimpong (2013) suggested that the tension between indigenous knowledge and western knowledge needed to be addressed. With each knowledge system having its limitations and creating issues when employed separately in terms of climate change adaptation, there needed to be a good balance between the two to achieve a good blend of the strengths of the two knowledge systems (Agrawal, 2002; Nyong et al., 2007).

In Zimbabwe the use of indigenous methods of weather forecasting was advocated by Muguti and Maposa (2012a) because scientific methods did not always give accurate estimates and so have been shown to be flawed, so it is evident that IK and scientific methods can be complementary in weather prediction. Nkuba et al. (2019) also reported that farmers in Uganda make use of indigenous forecasting as the scientific forecast records only the onset and cessation of rain without considering whether the amount of rainfall would be sufficient for plant growth. The weather forecast only predicts probability of rain falling, not the amount of rainfall, neither does it consider the peculiarities of farmers' specific localities. So according to the farmers, scientific data could not be trusted when making the best decisions for their plants or animals. As a result they use their local knowledge to forecast the weather and plant when rain is due. Similarly, Kolawole et al. (2014) submitted that seasonal forecasts released by government departments do not give timely information that is relevant to the farmers. The farmers may not get access to such forecast and such reports are also usually not in a language that the farmers understand; hence the forecasts do not give famers enough indication of what changes in weather conditions to expect to enable them to prepare appropriately for their crops.

3.3 Interaction between Western Knowledge and Indigenous Knowledge in Climate Change Adaptation

To adapt effectively to climate change (CC), a collaborative effort between scientists and indigenous people has been proposed by many scholars. Kettle et al. (2014) made a case for the blending of scientific and indigenous knowledge in climate change adaptation, as scientists usually generalize the impact of climate change across a region, whereas indigenous people are only conversant with conditions in their locale. Makwara (2019) suggested that indigenous knowledge systems (IKS) can be integrated into scientific weather forecasting to give more accurate and specific forecasts that are useful to local people in planning their farming activities. Such IK can be validated against scientific knowledge over time to reach a consensus of its applicability to accurate weather forecasting. This came up in his study of the functionality of IKS in weather forecasts in Zimbabwe, where he discovered that the seasonal forecast issued by the meteorological agency was handled with scepticism by the farmers, who considered it unusable, hence they resort to using their local indicators such as foliage pattern of some trees, behaviour of some animals and the timing and intensity of cold and dry seasons.

Adeoti et al. (2016) argued for a dynamic approach in a collaborative effort between scientists and indigenous people to sufficiently reduce vulnerability to CC at both national and local levels. They further noted that adaptation by the indigenous people is dependent on the customs and local institutions of the people, hence there would be a varied approach amongst people in different locations within the same country, which must be taken into account when merging scientific and indigenous methods in a response to climate change. They identified constraints farmers face in adapting to climate change in Kwara state, Nigeria, which included lack of information on weather related matters, financial constraints, and shortage of land and labour, so recommended increased awareness on the effects of CC, access to affordable credit, and development of improved crop varieties and irrigation techniques that are better suited to the area as being some means to adapt to CC. All these are within the scope of scientific knowledge. Ayinde et al. (2018) made similar recommendations, based on their study of maize farmers' vulnerability to climate change in Kwara state where their respondents had little or no management strategies to combat CC thus they were very vulnerable to its debilitating effect. The authors proposed that policies should emphasize access to small-scale irrigation systems, adequate information dissemination and access to drought tolerant varieties of maize.

A joint effort by both needs to put in place to combat climate change, as suggested by Madzivhandila et al. (2021) in preference to putting the blame of exacerbating climate change on developed countries with counter blames being made on developing countries. Whatever the debate about which part of the world contributes more to the emission of greenhouse gases, the effects of climate change are felt all across the world. Hence, the need to collectively strategize and implement actions tailored to mitigate and adapt to it. An interplay between, on the one hand, the technical know-how of the developed countries with their the scientific knowledge system and, on the other hand, the efficient use of resources by developing countries according to their indigenous knowledge system could provide a potential panacea for climate change (Madzivhandila, 2014).

The documentation and inclusion of IK into mitigation and adaptation strategies would, as argued by Dimelu et al. (2014), improve the capacity of agricultural extension professionals to disseminate these strategies, because their message would then resonate with the farmers who would see that most of the adaptive practices in agriculture emanate from indigenous knowledge. They identified that this could be achieved by co-learning; that is, a situation where the extension agents teach farmers new skills and innovation while themselves learning the indigenous methods. The blended knowledge then leads to a robust repertoire of skills and techniques that would effectively reduce the effects of climate change for all (Ifeanyi-Obi et al., 2012a; Mugwisi, 2017).

When integrating IK with scientific knowledge, Mistry and Berardi (2016) cautioned that its distinctiveness and epistemology should be respectfully acknowledged, rather than trying to make IK more scientific or validating it using scientific methods. The aim should be to engage with the communities affected by climate change, to get their perspective on the issue and learn about their adapting strategies, then to seek relevant scientific knowledge. This route would not only result in a wider range of adaptation options from which the people could choose but also lead to greater acceptability of scientific knowledge by indigenous people as the adaptation options would have some familiar concepts to which the people could easily relate, rather than their knowledge being relegated in the process. Overall, such a strategy would lead to a more robust engagement with such adaptation strategies. However, if the application of IK in climate change adaptation were subjected to scientific scrutiny and made to adhere to scientific structures, IK would lose its ability to deal with complexity, as it would have to change modus operandi (Agrawal, 2014; Kolawole, 2012; Olukoshi, 2006).

A side-by-side approach in the integration process has been advocated by Alexander et al. (2011), as indigenous knowledge can provide complementary information about climate change in areas where there are no historical scientific records. They noted that the presence of indigenous narratives in areas where there have been no prior studies of climate change impact suggests that those narratives can expand knowledge; thus more such narratives should be sought. Also, these indigenous narratives give a multidimensional picture of the impact of climate change by giving it a human face; that is, showing how it affects the quality of life of the people rather than simply being the data and figures of its scientific counterpart. Viewing climate change through the lens of indigenous knowledge gives a deeper understanding of the impact of climate change on livelihoods, culture and general living standards, beyond the statistical analyses of scientists (Archer et al., 2008; Ceci, 1978).

The neglect of IK in developing adaptation strategies hampers the efforts put in place to combat CC because without the thorough understanding of the extent of vulnerability, the community values, and infrastructure of an area, the scientific adaptation strategies may not be accepted or even be unsuitable for the locality. Correspondingly, a lack of scientific expertise and ignoring the large-scale trends of climate change impact and how these might affect indigenous people may hinder the progress of indigenous adaptation. It is thus essential to work hand-in-hand to achieve the common goal of survival.

3.4 Postcolonial Theory

This study leaned on postcolonial theory, which deals with the criticism of the way literature in the Western world distorts the experience and realities of the colonized people, ascribing the term 'inferior' to them while the colonizers are termed 'superior'. According to Mapara (2009), postcolonial theory deals with how texts were written in former colonized countries and how the colonizers view such texts. He further noted that postcolonial theory is about the two sides of the divide announcing their identities and rewriting their histories that were lost during the conquests. The formerly colonized do this by highlighting their past achievements that the colonizers had conveniently left out historical records, while emphasizing their knowledge and belief systems that had survived the onslaught of colonization. This announcement is achieved by studying indigenous knowledge systems and integrating their principles into education.

Rukundwa and Van Aarde (2007) stated that: "From an optimistic point of view postcolonial theory is a means of defiance by which any exploitative and discriminative practices, regardless of time and space, can be challenged. By contrast the pessimistic view regards postcolonial theory as ambiguous, ironic and superstitious”. The argument is that in spite of countries having gained independence from their colonizers, imperialism and colonialism are still very much in effect today in the form of neo-colonialism, which is essentially the interference by industrialized nations in the political and economic affairs of post-independent nations; this reflects in how these nations are viewed by their industrialized counterparts (Roy, 2016; Sparke, 2007).

The theory is based on the concepts of otherness and resistance. Frank Fanon and Edward Said are reputed to be the main proponents of postcolonial theory. Fanon (1967) identified that the black man behaves differently when he is with his fellow black man to how he is with a white man; this division of self was attributed to the colonizers having relegated the black man to an evolutionary level between the apes and man, so the black man, in trying to prove otherwise, tends to behave like the white man in order to be approved. Fanon argued that no matter how good his mastery of the language and mannerisms of the white man, the black man would always be referred to as ‘the other race’. This attitude is what he tried to change with his life works.

In his work *Orientalism* Said (1979), explained that the terms ‘the Orient’ and ‘the Occident’ are terms imposed on the people of Asia by the colonial powers of Europe, which reflect a style of thought based upon ontological and epistemological distinctions made between the two. Such terms depict the views of the colonizers as being superior and those not belonging to that group being ‘the other’, which must be conquered and subjugated. In an effort to expatiate on his previous work, Said (1985) remarked that Orientalism was an attempt by unrepresented or misrepresented people to speak up and represent themselves in circles to which they had hitherto been denied access, thereby producing resources for a new kind of knowledge, rather than being defensive of their race or interests.

Homi Bhabha (1988), in his work *The commitment to theory*, criticized the language of theoretical discourse with its emphasis on the hegemonic role of the West as the world power. He noted that all the ‘-isms’ of academic language are tailored to perpetuate the notion of ‘the other’, thereby reinforcing the power-knowledge equation of the West. Bhabha (1988) proposed hybridity, which gives room for a new entity that differs from the antagonism and negation hitherto at play. He noted that negotiation helps to articulate contradictory elements in discourse, without losing the essence of each element; this is done to make sure theory is separated from politics (Bhabha, 1983).

This post-colonial theory stance informed the manner in which this study was carried out with a view to leave all the politics of knowledge out of the discourse but present the findings as a viable addition to the knowledge forms available to all organizations responsible for climate change adaptation or to draw from in formulating policies.

In the words of Gayatri Spivak, in her work, *Can the subaltern speak*, the postcolonial intellectuals come to an understanding that their privilege is their loss, as they have to represent their realities in a way that their colonizers would understand, thus undermining the reason for their struggle. They are torn between their identity as subaltern and the embodiment of what the resistance is all about. So they must carry all the other categories embedded in 'the other' in the realization that to confront the colonizers is not to represent the colonized but to learn to represent themselves and provide unmediated access to correct representation that would achieve the desired aim of giving the subaltern a voice (Spivak, 1988). This study attempts to give such a voice to the root and tuber farmers in their experience of climate change, in a language that is easily understood by all that may come across it.

Muguti and Maposa (2012b) posited that colonialism tagged everything African as being fetish. So the colonialist view that whatever was good for the centre (Westerners) was also good for the periphery (Africans), lead to the aim of killing the Bantu in the black man and indoctrinating him in the ways of the white man. Hence these authors attempted to re-claim the enduring vitality of African indigenous methods of weather forecasting in accordance within the stance of postcolonial theory, which adopts the centre-to-centre hypothesis rather than one of 'centre-periphery'. They made explicit the indigenous ways of forecasting weather in Zimbabwe that had withstood the onslaught of colonialism and were still relevant. Other authors also posited that these indigenous practices were based on African's past empirical experiences, and they informed their view of the cosmos as a whole (Ashcroft et al., 2006). In a similar fashion, the present study has documented the indigenous knowledge embedded in root and tuber production methods that are used by the farmers as they adapt to climate change, which have been passed down the generations, undergoing some modifications through the ages.

Mapara (2009) argued that imperialism was not just about military conquests but a denigration of all practices deemed heathen and primitive. It was not entirely successful as evidenced by some indigenous knowledge systems that have survived the onslaught and are still in use today. He opined that IKS are not just a way of displaying the knowledge and belief systems of the formerly colonized, but indicate resistance to the myth of ‘Western superiority’. Rodney (1973) noted that IK is about removing the label of ‘the other’, and indigenous people reclaiming their history and having a proper representation of ‘us’ using their own lenses

This study has documented and presented the indigenous knowledge of root and tuber farmers, in terms of both production and adaptation to climate change, without making an attempt to attach extraneous meanings to it or to explain it in terms of scientific knowledge. Such action would be tantamount to seeking validation for the IK under study, instead of its being a separate knowledge system worthy of a place in the academy. One aim of the study was to produce a compendium of indigenous practices, without ambiguities, that would correct any erroneous information about such practices. The researcher also believes that language is fundamental for representing the views of a particular group of people, so the adaptation strategies were documented in the Yoruba language, which is one of the major languages spoken in the study area. But in order to reach a wider audience, considerable effort was put into translating the responses into English, without losing the intrinsic essence of such words. However, in situations where there was no suitable English word that could succinctly fit the concept, the response was recorded in original language and an English explanation given in parenthesis.

3.5 Situated Learning Theory

Since indigenous knowledge is learnt by doing, this study also drew on situated learning theory (SLT) as proposed by Jean Lave and Etienne Wenger (Lave & Wenger, 1991).. Their description of learning in a community of practice fits IK perfectly. The theory describes a learning space as being where knowledge is acquired and applied. So learning is essentially creating meaning from activities of daily living, as learners will eventually participate amongst practitioners. Thus, they should learn within the sociocultural context of their community if they are to gain mastery of such skills. The theory advocates proper socialization of learners by interaction with masters in the field, artefacts and identities, among others, as they acquire the intended skills in their apprenticeship. These writers view students as apprentices, with teachers and computers as masters, in a cognitive learning process that actively engages the students without their becoming mechanical copiers of the things taught and so avoiding rote learning (Lave & Wenger, 1991).

Situated learning theory views learning as learning by doing that happens *in situ*, which emphasizes the interdependency of the learner, community, the activity, in the assigning of meaning, learning and knowing. The theory claims that such learning happens when people are engaged in activities arising within their social and cultural context (Lave, 1991), p. 67). Lave (1991) recommended a "decentralized view of the meaning of learning, where learning is recognized as a social phenomenon embedded in the experienced, lived-in world, through legitimate peripheral participation in ongoing social practice". Where the identity of a person and the process of acquiring a skill are interwoven, it leads to full participation in the learning process, with the student being taught interpersonal skills useful for daily living. For instance, as he or she could be learning arithmetic in the grocery store as well as in the classroom.

As Cobb and Bowers (1999) put it, SLT emphasizes context, which would specifically refer to the social settings in which learning occurs; this may be the classroom or while selling oranges on the streets to generate an income, provided the student is engaging in mathematical reasoning within their own social circumstances. They further noted the identity assigned by the learners to themselves in each social context would have a direct influence on the transfer of knowledge. Beach (1995) also conducted a research where students who also work as shop keeping apprentices had not related the arithmetical reasoning they used as being common for the two contexts, because they had compartmentalized their identities. By contrast, the shopkeepers themselves had related their arithmetical reasoning used in both contexts because they saw themselves as shopkeepers, irrespective of whether they were in their adult education classes or in their shops

Learning indigenous knowledge takes place everywhere that an activity takes place, as reiterated by Barnhardt and Oscar Kawagley (2005). These authors noted that Western science and education thrive on compartmentalized knowledge that is taught away from where it can be applied, which does not guarantee a student is able to apply the knowledge in dealing with life issues. By contrast, indigenous people acquire knowledge through their interaction with the real world. Akena (2012) stated that in indigenous knowledge, individual units are as important as the whole; the lessons learnt are put to use in real situations that test the person's knowledge to ensure he or she could survive in their environment, thus preserving lives over the years.

Lauer and Matera (2016) argued that a practice-based approach helped their work in the Solomon Islands as they gained deeper understanding of the local marine system and disaster response, which had been overlooked by the conventional way of knowing. Situated learning provided them with a conceptual space in which to learn the nuances embedded in the ecological knowledge of the people, so helping them to bridge the divide between IK and WK because both types were both seen as practices. Conceptualizing local knowledge as active, dynamic and a heterogeneous assemblage of practices helped their research to explore how the Solomon Islanders perceived the effect of a tsunami. They concluded that viewing "IK as a complex, multidimensional process will encourage more inclusive and effective disaster management policies that are sensitive to the peculiarities of the Indigenous people and improve their resilience to disaster situations" (p.45). Viewing knowledge as situated practices helps to assess the contexts in which it was produced and applied, which implies that a study of the daily practice and actual usage of the knowledge is needed in exploring IK (Aswani, 1998; Lauer & Aswani, 2009).

Donaldson et al. (2020) posited that situated learning provides a means whereby the students connect their learning with real life situations by experiencing such in appropriate contexts. The students, therefore, have the opportunity to practice the skills learnt and improve on them as they engage with experts in the field and get feedback from all available quarters. This helps specially to simplify complex topics, as they are applied in relevant context. Learning is then a lived process of participating in actual activities so experiences are gained and learning imbibed with corresponding mastery of such skill being attained, rather than a mechanical accumulation of facts and concepts (Apple et al., 2014; Riggs, 2005).

Fox (1997) highlighted the tenets of situated learning theory (SLT) as follows:

- SLT is a single encompassing theoretical entity that views the mind, lived world, relations among person, activity and situation as they are given in social practice.
- SLT attributes the students' failure to learn as reflecting a defect in the system and social practices of the educational professionals.

- SLT encourages learning to take place away from conventional settings like the classroom but should be done in everyday settings known as communities of practice.
- SLT sees the mind in action in the everyday world as the person creates knowledge and learns concurrently, while interacting with all aspects of the lived world rather than being a vessel to be filled up with knowledge.
- SLT views the learning process as being dependent on the context in which it takes place coupled with the social interactions that occur as it proceeds.
- SLT seeks to remove the dichotomy between professional and everyday knowledge; emphasizing that neither is superior to the other.

This study took all these tenets of SLT into account, paying particular attention to the notion that no knowledge should be overlooked, and the site of instruction should not determine the importance of any educational activity. The divide between formal and informal education was also removed as all forms of education are valid and useful, irrespective of the medium of instruction, location or tutor. It should be noted that learning outside of a controlled space like the classroom can be tasking, cumbersome and prone to interruptions due to ambient noise and other factors being beyond one's control.

The documentation and learning of IK practices in root and tuber production was done on the farms with the farmers eagerly showing the city girl researcher the ropes. Learning in the field context also clarified much of what I had learned in school; it simplified the concepts because being hands-on with the farmers gave a deeper understanding of the academic terms learnt in school, and I could deduce the science embedded in indigenous knowledge and relate it to my own experience of climate change.

3.7 Indigenizing Methodology

Indigenizing methodology, also known as decolonizing methodology, is an attempt to ensure that research in the indigenous paradigm is carried out in culturally appropriate ways; in this case, taking into account the African values and belief system especially those of the Yoruba people that constitute the majority of the respondents. Chilisa et al. (2015) noted that decolonization entails a deviation from the blind use of Western standards and values when appraising programmes in Africa. Decolonizing methodology, therefore, empowers indigenous people by carrying out research using their own models, theories, methodologies, which have emanated from their local culture, worldview and philosophy (Chinn, 2007). This requires that, to effectively carry out the inquiry, the researcher must have insider knowledge of the participants' culture.

Louis (2007) argued that in carrying out research in the indigenous paradigm, indigenous methodologies must be employed, and the four unwavering principles shown in Table 3.2 must be observed. These principles have guided the study, so the researcher took all of these into consideration when selecting the methodologies for the study, in order to ensure reliability of the data generated.

Table 3.2

Principles of Indigenous methodologies

1. Relational accountability: This essentially means that all parts of the research from conception to final report are related and the researcher must take into account the relationship; nurturing and maintaining it while being accountable to all his relations, just as the indigenous people depend on their relationship with everyone and everything around them in their daily living. 2. Respectful representation: This essentially involves the researcher presenting the research, people, phenomena and themselves in a way that portrays respect for others. In other words, the researcher must take care not to superimpose his or her own ideas, but rather listen carefully to participants' ideas and views and presenting them in a manner acceptable by all. 3. Reciprocal appropriation: This behoves researchers to carry out their study in a way that benefits all involved. 4. Rights and regulations: This ensures that the people are not subjects of research, but instead, the study is done in collaboration with them right from inception to conclusion. Also, the intellectual property rights reside with the indigenous people, so they have control over the reporting and publication, which must be approved by them.

Source: (Louis, 2007)

Indigenous education in Africa is a relational experience, hence the methodology for exploring IK must be one that fits suitably into that pre-existing mould. As Fafunwa (2018) puts it: "education in old Africa was an integrated experience, combining physical training with character building and manual activity with intellectual training". So traditionally, any individual who possessed good character alongside a specific skill was adjudged to be a well-educated member of the society, commonly referred to as *Omolúàbí.* As education was viewed as a means to the end of preparing the individual for adulthood and induction into the society, it was carried out by individuals actively participating in the daily activities as they learned the ropes (Adebisi, 2016). In accordance with that idea, this research adapted the principles of two methodologies for data generation, to ensure that fieldwork was culturally responsive. The methodologies were phenomenology and participatory research, which are discussed in the following sections.

3.8 Phenomenology

In his analysis of phenomenology, Alase (2017) refers to the premises of Husserl, who sought to understand the lived experiences of people and how they assigned meaning to such experiences. He identified two approaches of phenomenology that are commonly used in research as hermeneutical and transcendental (descriptive) phenomenology. He then goes on to van Manen's explanation of hermeneutical phenomenology as being the art of studying peoples' lived experiences and their interpretation of the life they lived and experienced, while showing that Moustakas focused more on describing the lived experiences and separating the researcher's experiences from those of the participants known as bracketing. Teherani et al. (2015) indicated that the purpose of phenomenology was "to describe the essence of a phenomenon by exploring it from the perspective of those who experienced it so as to understand the meaning participants ascribe to the phenomenon". Accordingly, this study made use of focus group discussions and interviews to explore the root and tuber farmers' experiences of climate change and elicit how they perceived the phenomenon, their understanding of it and how they were responding to climate change.

Neubauer et al. (2019) said that phenomenology can be defined as a research approach which aims to describe a phenomenon by looking at it from the perspective of those who experienced it. The goal is to articulate what and how it was experienced. Phenomenology is deeply rooted in the conception of the details of the experiences using the lens of the people involved. Aspers (2009) submitted that the core idea of phenomenology is that one begins analysis of a phenomena in the mental realm and not in the objective world. It is about what the mind is perceiving or directed towards. Phenomenology does not start with any presuppositions; instead it gradually establishes a position as the study proceeds. Aspers further stated that meaning and understanding are intertwined, so understanding a phenomenon requires attaching it to something familiar. Hence the approach of phenomenology is about giving a holistic meaning to a process as one tries to understand a phenomenon, which may go on in cycles as one relates the part to the whole (Hydén & Bülow, 2003).

Conroy (2003) noted that for a phenomenological study to succinctly capture the essence of the phenomenon one must steer the participants from ‘knowing that’ to ‘knowing how’, by probing their stories to be able to identify when a shift in thinking occurred to them; in other words identifying when the participant moved from just observing the phenomenon to making sense of the situation. This may involve delving into other narratives, not necessarily related to the study, that are mentioned only in passing, with the notion that indigenous people connect the dots between occurrences and so understanding how they have perceived one event can give an insight into their understanding of the current issue being studied. In such a way the research is steered away from simply describing the phenomenon to interpreting it (Seidman, 2006).

The assumptions underlying phenomenology, as enumerated by Boss et al. (1996), are given in Table 3.3.

Table 3.3

Assumptions of phenomenology

1. Knowledge and meaning attached to such are socially constructed and evolve over time, thus they are incomplete. 2. People assign different meanings to objects, events, or situations even if experienced at the same time. 3. Common, everyday knowledge about the world is epistemologically important to the study at hand. 4. Language and meaning of everyday life are significant; thus they should be given attention in a study. 5. As researchers, we are not separate from the phenomena we study. 6. Knowledge is shared and held by researchers and participants alike. 7. Bias is inherent in all research and must be declared at the beginning of the study, even if it is not negative.

Source: (Boss et al., 1996)

The assumptions in Table 3.3 may not be fully applicable in practice because of extraneous variables beyond the researcher(s) control, as fieldwork depends on the availability of the participants and their willingness to share their experiences. Also, one might research a phenomenon that they have never experienced, so the assumptions are not sacrosanct. The researcher took all these into account during the study and articulated her bias of being a novice in the field of indigenous knowledge.

Petty et al. (2012) submitted that phenomenology is focused on understanding the unique lived experiences of people by exploring the meaning they ascribe to a phenomenon. Interpreting and analysing the data helps the researcher define the essence of the phenomenon and its meaning to those involved, which is only possible when the researcher sets aside their own opinions of the event under study to enable them to understand at a deeper level what the phenomenon is all about. This possibility of separating oneself from the research imputes some level of objectivity to the study. Also, the language with which the research is reported is very important as we make meaning of the world using language (Bevan, 2014).

Creswell and Poth (2016, pp. 57-58) noted that phenomenology aims to describe what a group of people have in common when going through a certain experience. As such it differs from the narrative approach, which deals with individuals experiencing a certain issue. Phenomenology aggregates the participants' understanding of the experience into a common theme known as the essence of the phenomenon, which describes succinctly how they perceived the phenomenon. This is done by collecting data from people who have gone through the identified phenomenon usually through interviews and then synthesizing a description of the experience applicable to all the participants. This description must include what they experienced and how they experienced it; thereby giving a rounded picture of the phenomenon (Schiemann, 2014). The researcher must ensure that they refrain from preconceived frameworks in describing the issue at hand, instead they must remain true to facts gathered in the study. The researcher has identified climate change as being a problematic issue worldwide, and roots and tubers being promoted as food for the future. Accordingly, there is a need to explore such farmers' experiences and responses to the phenomenon of climate change.

Grossoehme (2014) noted that phenomenology is a good choice when one seeks to study what an experience means to a particular group of people, but cautions that the findings may not be generalizable, because the main aim of phenomenology is to give an accurate presentation of the phenomenon being studied, without necessarily considering the applicability of the findings in a wider context. Since the goal of phenomenology is to document the participants' lived experiences in terms of a richly detailed story, as well as meaning they have attached to the event, the sample size needs to be kept small by using purposive sampling, which is predetermined before the actual study. Elkatawneh (2016) advised that for the purpose of analysis, the researcher should immerse themselves into the data by interacting with both the recordings and their transcriptions many times, assigning codes to the data, categorizing the codes, inferring meanings of the categories and combining them into thematic statements that describe the experience under study. The processes carried out by the researcher in analysing the data for the current study aligned with this summary.

Williams (2007) identified that the method of collecting data in a phenomenological study is through lengthy interviews of between 1-2 hours to enable the researcher to elicit a thick description of the experience and interpret it in such a way as to understand the participants' perceptions and meanings attached to the event. Such data are then organized in a way that clusters of meanings emerge, which then form the themes by which the participants' experiences and perceptions are commonly described in helping the readers understand the essence of the experience this is supported by (Creswell, 2007).

The use of phenomenology to explore people's lived experiences seemed to be a good theoretical fit for exploring the farmers' responses to CC using IK, but in practice, it was not a best fit. Accordingly, I blended phenomenology with a culturally responsive methodology of participatory research, as discussed in the next section.

3.9 Participatory Research Methodology

Hall (1992) submitted that the term 'participatory research (PR)' was coined in Tanzania in the early 1970s as an attempt to shift the daily lived experience of the people from the margins of epistemology to the centre. Participatory research practice put the less powerful participants at the centre of the knowledge creation process as the government of Tanzania tried to experiment with its peoples' creativity in move the country forward from relying on the western world. He reminisced that as the original group relocated they took the ideology of PR to their various locations for further practice then discovered it existed in some forms in the western world, but not as they practiced it (Hall, 1992, pp.15-16). This added to the debate of who owns what knowledge or methodology. In this regard, Kurt Lewin has been credited with having articulated the concerns that underpin PR. So although Hall agrees that the term 'participatory research' is new, the ideological concerns have a long history in social science (Chambers, 1992).

According to Cargo and Mercer (2008), PR is a form of inquiry done in collaboration with the participants with the aim of either effecting change or for educational purposes. PR combines the researcher's knowledge of theory and methodology with the participants' wealth of real-life knowledge and experiences, to form a formidable research partnership. The traditional research dynamics are altered in PR as the participants move from being subjects of research to active players in the study. They work closely with the researcher to produce knowledge offering solutions within their purview to enrich the study (Best et al., 2003). At the core of PR are mutual respect and trust, which enable the co-actors of the research to express their views and opinions freely without fear or prejudice, which leads to capacity building, empowerment and ownership. By thus involving the non-academic participants in how resources for the study are disbursed there is room for them to engage with opportunities that arise from the study and so better their status (Cargo et al., 2003; Kelly, 2005). Accountability and sustainability ensure that all involved in the process are accountable to one another and their funders for how the goals of the research are to be achieved. The aspects discussed above differentiate PR from other forms of research.

PR involves the participants from inception to conclusion, as Denton et al. (2008) emphasize, so that the researcher learns 'by doing' alongside the participants. This occurs as the participants would, for instance elucidate their understanding of the climate related impacts they have experienced and the resources they have at their disposal in responding to climate change. This builds capacity of all involved as skills and knowledge are furthered mutually as the process ensues (Hoffmann et al., 2007). During this study, the researcher was extensively exposed to the indigenous practices involved in root and tuber farming and climate change adaptation, so her knowledge increased; at the same time the farmers expressed their joy in passing on knowledge to the younger generation, so that it would be preserved for posterity.

Wallerstein and Duran (2017) noted that the core of PR is *participation* and the question of where the power lies needs to be addressed for there to be proper participation by all involved. This calls for an evaluation of the participatory process to determine the authenticity and fluidity of the relationship between the academics and the community members. Authenticity of the participatory process needs to be protected by ensuring that the power differences are identified and demystified, with the academic consciously doing away with the pose of the knowledgeable one and connecting with the community as a co-creator of knowledge in the study. The issues of who represents the community and the university, who owns the data generated and what is to be done with it, also need to be addressed at the outset of the study to ensure all players are equally familiar with the aims of the research and have equal footing in the execution of plans (Huberman, 1990; Mercer et al., 2008). For this study the researcher ensured that the aforementioned was taken care of by ensuring that the farmers understood that she had not come to lecture them but learn how they responded to climate change using their indigenous knowledge and to produce a report that would serve as a compendium of IK in that locality. Besides preserving indigenous knowledge, which has been known to be lost with the death of custodians such a compendium could also be promoted for inclusion in curriculum and adaptation strategies.

Maguire (1987) stated that PR not only recognises many forms of knowledge but also insists on an alternative position in knowledge creation. The researcher should take the position of transforming reality *with* the participants instead of *for* them. In addition, the intent should not be just to describe and interpret their reality but, if possible, to also change them. As PR encourages self-determination, emancipation and transformation as the goals of research. Dudgeon et al. (2017) further noted that PR possess a component that helps people develop their skills of collecting, analysing and using information, which strengthens their beliefs in their own abilities. More importantly the people involved in the production of knowledge also have a say in how it is applied in their everyday lives.

Macaulay et al. (1999) espoused that PR tries to negotiate a balance between developing knowledge that can be generalized and adding value to the community where the research is carried out. The research process is enhanced by inculcating the knowledge and expertise of the community members into the whole process, in a collaborative manner that pitches the community and researchers as equal partners in the process. PR is enriched by shared leadership, power and decision making, from conception to conclusion, with the partners agreeing on the roles and responsibility of each other in the process and being accountable to meet the desired outcomes, in bringing their unique strengths to bear on the study at hand (Israel et al., 1998).

Cochran et al. (2008) noted that although PR had made good progress among indigenous communities, there was still the possibility of resistance by some indigenous peoples because research had sometimes been known to advance the course of colonialism, hence they were wary of partnering with researchers. Thus, researchers must be sure to employ culturally sensitive methods that take into account the customs, needs and standards of the indigenous people, to elicit responsiveness by the community. This entails assuring them that they are neither objects to be researched nor problems to be solved with the help of outside experts, but instead they are regarded as co-producers of knowledge. This helps to ensure that the correct methods are used for the study, which would have a resultant effect on the validity and reliability of the study (Huberman, 1990; Lasker et al., 2001).

Pain and Francis (2003), p. 45) submitted that the essence of participatory research lies not so much in the techniques used, but rather lies in the extent of participation by the community during and after the research, which reflects how invested they are in the whole process. Narayan and Mundial (1996) considered that the PR approach did not start as a methodology but was, instead, a process through which communities could work towards change; this was the essence to which the researcher should stay true. For this study, the researcher ensured that the participation of the root and tuber farmers was not taken for granted; they were very pleased to be part of the study and were surprised when they were served refreshment at the end of each session. This city girl knowing the right thing to do was what they termed *omo to bá mowó wè yio bá àgbà jeun*. After the field work, I continued to keep in touch with them through the extension agents. They freely indicated what could or could not be included in the report, bearing in mind the knowledge they were not interested in sharing, and the norms of the communities involved were also adhered to.

Couto (1987), p. 84) highlighted the characteristics of participatory research as being:

a. The conception and the formulation of the problem under study is initiated by the community.
b. The aim of the research is to use the data gathered for political or social change.

c. The community members are in charge of defining the problem, the gathering of data and deciding what to do with the data gathered.
d. The local people and researchers are equals in the research process, with teaching and learning happening both ways.

This study did not perfectly fit into this mould, nevertheless most of the characteristics were incorporated into the adapted methodology, termed participatory phenomenology, which is discussed in the next subsection.

3.10 Participatory Phenomenology

The merging of phenomenology and participatory research to form participatory phenomenology (PP) is not an original idea; instead it has been used by previous authors, especially in the field of medicine, to assess peoples' perception of their illnesses, mental conditions and practice. Participatory phenomenology is an attempt to merge two methodologies to arrive at a methodology that is culturally relevant to the participants of the study and will elicit rich responses from them, without being too clinical or rigid (Frauenberger et al., 2010; Kaivo-oja, 2017). It is a blending the best of both ideas to create a methodology that was judged to be a best fit for gathering participants' perceptions and lived experiences of climate change as well as working with them as they showed how they responded to the phenomenon using their indigenous knowledge. Phenomenology was employed in the former while participatory research methodology was applied to the latter.

Previous authors have used this blend of methodologies, For instance Bragin et al. (2021) used it to study the psychosocial wellbeing of Afghans as they walked together with the participants to relive their experiences of the war, to discern how it had affected them pychologically, their perception of wellbeing and how they were working towards it. They found that the participants viewed others as having a good life because they have peace of mind, which they aspire to. It was concluded that social workers and psychological counsellors needed to understand the psychological wellbeing of their clients in order to help them, so would need to tailor their work towards that end (Davidson et al., 2001).

In other research, Bush et al. (2019) merged phenomenology and participatory research to understand the lived experiences of people living with Parkinson's disease and their caregivers in a rural setting. They noted that, although focus group discussion does not fit into phenomenology as methodology, it was commonly employed to understand the lived experiences of individuals concerning a phenomenon. It was useful in eliciting reflections amongst the participants in the group that gave insights into the working of their inner minds and how they cope with the disease, thereby revealing an overall theme for their study findings. They suggested that using an interpretive phenomenological lens and analysis methods could authenticate the findings from participatory research. They also submitted that a natural synergy exists between the two methodologies as phenomenology is about using the experiences to construct shared meaning, which is made in a shared context, and PR asserts that the social context is where meanings are constructed so one can only access a community's experience and understanding of a phenomenon from the community itself. Hahn (2015) suggests that navigating between the two methodologies can be quite cumbersome and confusing for a novice researcher so one needs to delineate which aspects of each is to be deployed in practice while being flexible to identify teachable moments on the field~~.~~

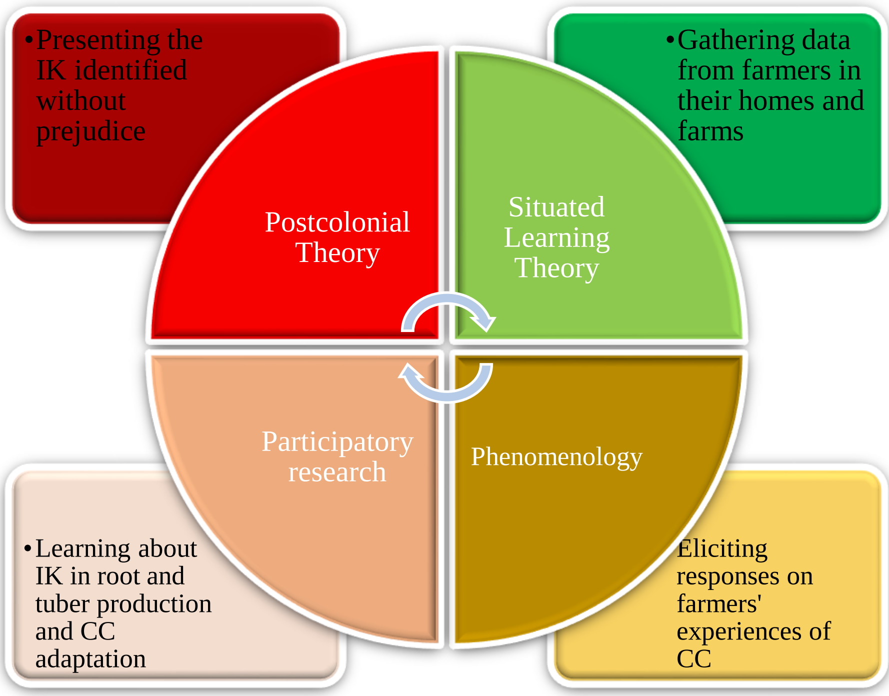
The merging of phenomenology and participatory research into participatory phenomenology in this study helped to, not only access the root and tuber farmers lived experiences of climate change, but it also provided a deeper understanding of their decision-making processes when responding to the phenomenon. The use of focus group discussions gave a panoramic view of the different communities' experiences of climate change and helped to identify key informants who were custodians of some specific IK employed in root and tuber farming and in responding to climate change. The interviews revealed detailed descriptions of the IK in root and tuber production and adaptation to climate change. Participant observation enabled the researcher to experience the application of IK in root and tuber farming as she worked alongside the farmers on the farms and was shown the processes.

3.11 Summary

This chapter has given a detailed explanation of the theoretical leanings of the study. Postcolonial theory was the philosophical basis for this study while situated learning theory underpinned the study of IK *in situ* and so grounds the study in the indigenous knowledge paradigm. Figure 3.2 is a represention of how the theories were used in the study. An *exposé* on the nature of IK, the subjugation of IK by western knowledge systems with the resultant agitation by post colonialists for their voices to be heard were also given. The merging of phenomenology and participatory research, referred to as participatory phenomenology, was also explained. A detailed description of how it would be used in this study is given in Chapter 4.

Figure 3.2

Use of theories during the study



Source: Researcher

CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

4.0 Introduction

This chapter gives a detailed explanation of the processes involved in fulfilling the objectives of the study. The research design and methodology, along with justification for decisions taken as needed during the course of the research, are also discussed in-depth.

The study sought to understand the role that indigenous knowledge played in root and tuber farmers' responses to climate change. To understand their responses, it was necessary to know their experiences of climate change, the perceived effects of climate change on their crops, the measures they took to alleviate these effects together with an in-depth analysis to determine whether the origin of such measures was indigenous or scientific, and the resultant effects of these measures on their farming activities. The study sought to answer three questions, specifically:

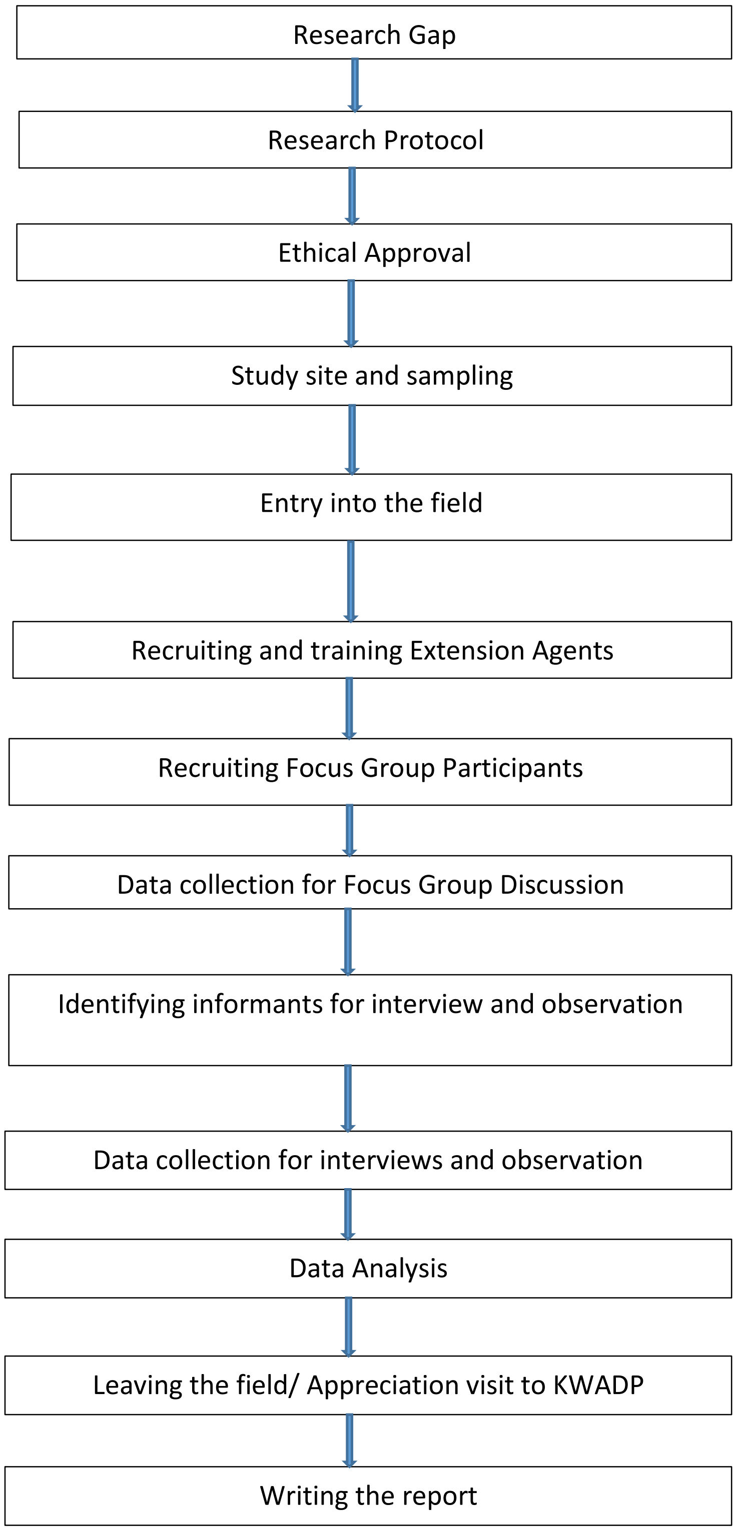
1. What are Nigerian root and tuber farmers' experiences of climate change?
2. How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?
3. Why do Nigerian root and tuber farmers respond to climate change in the way that they do?

A pictorial representation of the processes the researcher undertook in carrying out this study is given in Figure 4.1.

Answering the research questions, a first step entailed a study of the climate data for Kwara State over 28 years, to establish if meteorologists had documented changes in the weather pattern. This would provide scientific proof that the phenomenon of climate change really existed and so ensure the veracity of the farmers' experience of it. The 28 years signified the time over which the Department of Planning, Monitoring and Evaluation of Kwara Agricultural Development Programme had taken weather readings to help the department in planning agricultural interventions for farmers. This covered the years 1991 to 2018; my field work was conducted in 2019 and the data for that year would only available at the beginning of the following year (see Appendix K).

Figure 4.1

Processes the researcher undertook during the study



Source: Researcher

An interview was conducted with the Director of Extension Services of KWADP to obtain the field report of farmers' complaints about the changing weather pattern and the extension advice or activities tailored towards such which had been offered. He explained that they had given the farmers improved varieties for grains, but for root and tuber the only action that had been taken concerned a cassava doubling technique and training on yam mini-sett; neither of these had been adopted by the farmers. Yam mini-sett technology is the practice of cutting yam tubers into smaller pieces of about 2 cm thickness and weighing about 25 g, with the cuticle intact on the back, which are then used to produce seed yam, see Figure 4.2. This contrasts with the local farming practice of using a whole tuber. The aim of yam mini-sett technology is to address the issue of scarcity of seed yam (Madukwe, 1995). To understand why the farmers had resisted the change and retained their indigenous methods, I had to be immersed in the process to get the farmers' perspective on the issue at hand. Accordingly, a qualitative research design was employed in the study.

Figure 4.2

The researcher's attempt at producing yam mini-sett

Source: Researcher

4.1 Research Design

According to Kothari (2004), research design is the outline of what, where, when, how much and by what means a research study would be carried out. It includes a template for collecting, measuring and analysing data; carefully setting down what the researcher would do from conceiving the idea for the study, through to data analysis and reporting the findings. For this study, research design refers to the plan of work for data collection. Novikov and Novikov (2019) suggest that a researcher designs a system to obtain the knowledge that he or she is interested in, so the design phase is an aggregation of several stages through which such a goal is achieved. For this study the design stages were:

a. Research paradigm
b. Research strategy
c. Methodology
d. Selecting the study sites
e. Study population and sampling
f. Negotiating entry into the field
g. Data generation methods
h. Ethical considerations

These stages are discussed in the remainder of the chapter.

4.2 Research Paradigm

Wilson (2001) submitted that a paradigm is "a set of beliefs about the world and about gaining knowledge that goes together to guide one's actions as to how one is going to go about doing the research". Furthermore, Kovach (2010) opined that the paradigm influences the methods chosen, how one goes about using the methods, how the data are gathered, analysed and interpreted.

The study is situated in the interpretive paradigm, which according to Chilisa (2011), means that it sought to understand and describe human nature without imposing external values. The paradigm is based on the assumptions of there being multiple social constructs of realities and values that are integral to social life, with no one value being wrong, only different. This idea is supported by Cohen et al. (2013), who stated that the interpretive paradigm is concerned with understanding the subjective world of human experience and deriving meaning from shared experience. Lapan et al. (2012) also posited that interpretive researchers base their work on the assumption that people derive their meanings from interacting with the world around them; thus, there is no single reality apart from human perceptions. Since each person is unique as are their realities, they cannot be grouped together to explain a phenomenon, the interpretive researcher must attempt to understand the phenomena under study according to the value that the study participants assign to them. Since this study was about the role of indigenous knowledge in root and tuber farmers' responses to climate change, indigenous research methodologies should be employed in the process. According to Brayboy et al. (2012), the first thing a research must seek to do is foster relationships between themselves, the community and the topic of inquiry. This is because the indigenous research methodology is rooted in relationships, so the researcher must be trustworthy and held accountable. This supports Wilson (2001), who stated that a researcher is answerable to all his participants; not making any judgments nor looking for validity and reliability. Instead, he fulfils his relationship with the world around him, presenting all involved in the study in a manner that uphold their uniqueness, aptly capturing their opinions without bias from his own ideas and accepting the people's decisions on how to use the knowledge they shared with him; all the time being humble, generous and patient in the process (Louis, 2007).

Since this study was about the role that indigenous knowledge plays in root and tuber farmers' responses to climate change, it needed to be fluid concerning the interpretive and indigenous research paradigms, especially in the choice of methodology and the eventual field work. Ezeanya-Esiobu (2019) noted that the common denominator in all the interpretations of IK is that it is an alternative to mainstream knowledge and it represents knowledge pertinent to a particular people, which explains their worldview and responses to situations as they arise. Indigenous scholars agree that the manner in which indigenous people create knowledge differs from that of non-indigenous people. The indigenous people's interactions with and experiences of their environment, animals, plants, people, culture and even the supernatural inform the knowledge generated. It is usually peculiar to a particular location although there may be similarities across localities. IK is developed as the people make efforts to know their environment and survive, despite all manners of problems they encounter in their daily living (Abah et al., 2015; Ezeanya-Esiobu, 2019; Rigney, 1999).

4.3 Research Approach

This study employed a qualitative approach to answer the research questions posed as I sought to understand how root and tuber farmers make sense of climate change and respond to it using their indigenous knowledge. To carry out the research effectively I had to be embedded in the farming process and interact with the farmers in their locations while learning from them. Such actions fall under the purview of the qualitative research approach as I had to work together with the participants to identify and document the indigenous knowledge across the whole process. I needed data on the lived experiences of the root and tuber farmers on climate change in order to do this I had to view the phenomenon from their perspective, using the lens through which they view the world around them. This required my being involved in the farming process and interacting with the farmers as they applied their indigenous knowledge, all the time consciously bracketing my opinion and notions about the world around me, so they did not mix. ***Hence, a qualitative design deeply rooted in phenomenology was employed*** as the researcher sought to describe the farmers' experiences and responses to climate change in the way they perceived it and not from a theoretical standpoint or by imposing on them my own opinion and bias. Teherani et al. (2015) posited that qualitative research is a systematic inquiry into social phenomena in their natural settings with the researcher being the major data collection instrument in examining why events occur, what happened in the events, and the meaning participants attached to the events. Qualitative research employs the methods of observation, documentation, analysis and interpretation of the phenomenon being studied in such a way as to describe and understand it without trying to predict or control the phenomenon (MacDonald, 2012). Accordingly, it was judged to be appropriate for this study.

4.4 Methodology

This study employed a ***participatory research methodology*** **(PR)** as being a culturally responsive method because the study was about exploring indigenous knowledge and so it was essential to ensure cultural compliance in the process. Moreover, this was closer to a collaborative participation, as espoused by Cornwall and Jewkes (1995), as the farmers and the researcher worked together on a study that was designed, initiated and managed by the researcher. Participatory methodology was used in this study because of its flexibility and adaptability, both of which are needed when exploring indigenous knowledge and perceptions (Chambers, 1992).

According to Narayan and Mundial (1996), participatory research is a process of systematic problem solving where information needs are defined, analysed and reported with proper follow–up actions taken to fulfil a clearly defined purposes. Cargo and Mercer (2008) reported that participatory research is broadly defined as a system of inquiry done collaboratively with the people affected by the phenomenon being studied for purposes of education and taking action or effecting change. For the purposes of this study participatory research will be known as PR. The beauty of PR lies in the coming together of the researcher's epistemology, ontology and axiology and the non-academic participant's real-world knowledge and experiences to form a mutually beneficial partnership between the 'town and gown', with each party deploying all the resources at their disposal to solve a problem that they view from different angles and accomplish objectives they may not be able to do alone (Lasker et al., 2001).

The philosophical underpinnings of PR are that of the notion of multiple shared realities and people needing to have a say in matters of their own development by being part of identifying the issues and proffering solutions to them. They then essentially hold the power and control in ensuring sustainable development (MacDonald, 2012). The idea of PR originated from Kurt Lewin, who believed that research should seek to solve practical problems by planning, acting and investigating the outcomes of the research. He was opposed to the view of positivists that research should be done objectively without taking into consideration the way the participants make meaning of the world around them (Wallerstein & Duran, 2017). The school of thought arising from his work insists that the role played by the researcher and the participants must be reciprocal with neither being left behind, as they share ideas and take decisions concerning the research. Later proponents of this school of thought like Paulo Freire proposed a transformation of communities from being object of study to participants in the inquiry and that truth should be viewed both objectively and subjectively to form a concrete reality. They posited that people should take responsibility for their own development rather than the intellectuals being the proponents of change, they should act as catalyst and provide support (Hall, 1992; Rahman, 1985; Rowan, 2001).

Macaulay et al. (1999) identified collaboration, education, and action as being key elements of participatory research. The researcher, along with the extension agents, worked together with members of the various communities to document the indigenous knowledge involved in root and tuber farming; in the process becoming educated about cultural practices they had not been conversant with and producing a compendium of indigenous knowledge the farmers make use of when responding to issues occasioned by climate change.

One of the factors that distinguishes participatory research is the fluidity of methods employed in different contexts; in other words, adapting conventional methods to suit the ways of the people participating in the research. The process is expanded to allow use of local methods like storytelling, learning under the tree, on-farm demonstration, which are essentially ‘learning by doing’ (Cornwall & Jewkes, 1995). This study drew upon the principle of African traditional education in seeking out indigenous knowledge embedded in root and tuber production, as espoused by Adeyemi and Adeyinka (2003) who submitted that the older generation inherit knowledge and culture from their progenitors, adapt it to their situation and pass it on to the next generation for further use down the line, with modifications as the need arose. This process was identified as educating the next generation. The researcher belongs to the incoming generation receiving the knowledge, documenting it for use and modification to current circumstances, hence actively switching roles between town and gown.

Storytelling is a qualitative research method, in which the participants describe their answers orally rather than on questionnaires (Drawson et al., 2017), also featured in the study as the participants wove their experiences of climate change into stories. Wright et al. (2012) indicated that storytelling was the ideal method for integrating non-human elements (e.g., animals, water, wind) into data collection and analysis. Storytelling was also useful in the dissemination of knowledge uncovered in the data collection and analysis phases. It was also an integral part of the whole process.

The researcher ensured that the ***methods were culturally responsive*** as she took into account the culture of the population to be sampled by acknowledging the local histories, traditions and indigenous systems that inform them (Chilisa, 2011). This required having a *culturally competent* individual doing the field research and, in this context, the researcher is an indigenous insider/outsider. The customs of the participants were adhered to by her being accompanied by a male extension agent, complying with expected dress code of the Muslim communities, and the research being carried out in the local language of Yòrùbá or Baruba. The researcher is conversant with Yòrùbá language, while the extension agent that covered Kaiama and Baruten was conversant with Baruba language.

Cochran et al. (2008) noted that collaboration between researchers and communities must have a clear-cut delineation of the expected benefits of the research and who would have access to what. The participants and the researcher both agreed that the indigenous knowledge employed in responding to climate change needed to be documented and preserved for posterity's sake. This called for flexibility in adapting to the schedule and practices of the farmers and reflecting on the whole process as events unfolded which sometimes did not fit into the pre-planned scheme. In this regard, the researcher had to break down preconceived boundaries, which later turned out to be ice-breakers, and ensured openness as the researcher was seen as one of them by the participants (Pain & Francis, 2003).

4.5 Selecting the study sites

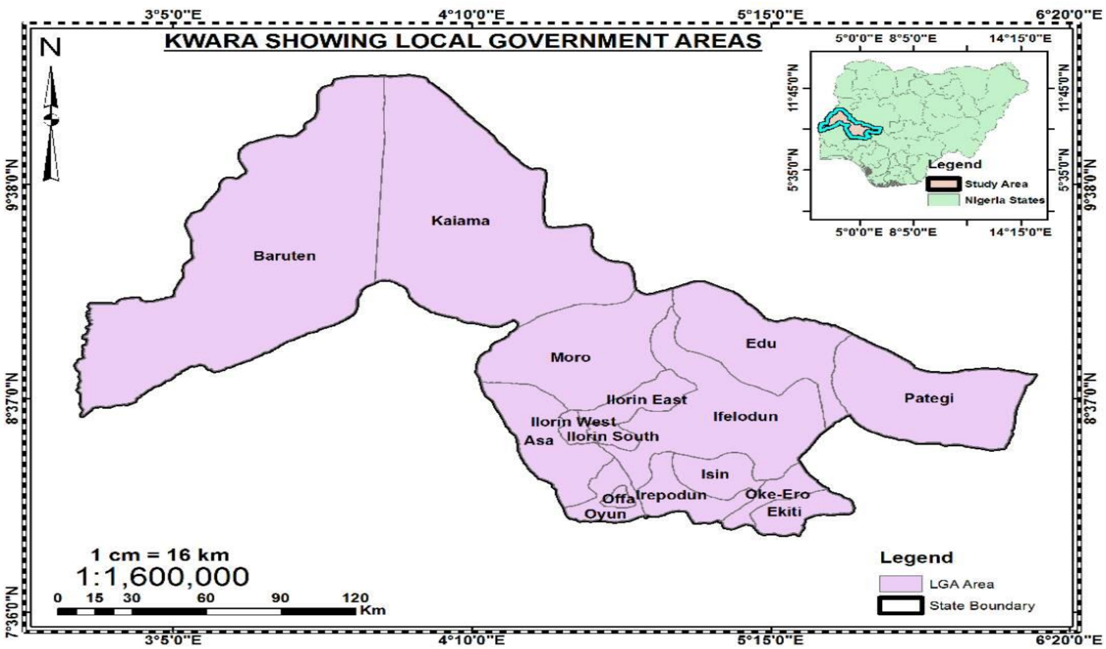
The study was carried out in Kwara State, Nigeria. Kwara State is composed of 16 local government areas (LGAs), which were formed according to geo-political distributions. The population of the study area is made up of the Yòrùbá and other ethnic groups. The state is an agrarian society and has a very vibrant Agricultural Development Programme overseeing the activities of farmers.

Kwara state was purposively selected because root and tuber crops are some of the major crops grown there (Matthew Olaniyi Adewumi & Fatimoh Adebayo, 2008). Also, the researcher has some roots there; having been schooled there and having already worked with the Kwara Agricultural Development Programme (KWADP). This organization falls under the Ministry of Agriculture and has a mandate to oversee agricultural activities in the state by liaising with research institutions and the university to introduce innovations to the farmers, through a system of the training and visits carried out by extension agents. KWADP also serves as an intermediary between the farmers and the industrial sector, ensuring that famers get adequate compensation for their produce. This was necessary as the farmers had, in the past, been exploited by big companies who paid them a pittance for their produce, for the small compensation of being spared the stress and cost of harvesting the crops. For instance, one company had paid a farmer 50000 naira for a hectare of tomatoes on the understanding that they would harvest it themselves, whereas if he had harvested the tomatoes himself and sold them on the open market, the man would have made about ten times that amount. So now, to get to the farmers one has to be approved by KWADP and the extension agent for that area must present you to them before they give you an audience. In effect, KWADP is the gatekeeper for this study.

KWADP has divided the state into four agricultural zones, namely:

Zone A: Baruten and Kaiama local government areas.
Zone B: Edu and Patigi local government areas.
Zone C: Asa, Ilorin-East, Ilorin-South, Ilorin-West and Moro local government areas.
Zone D: Ekiti, Ifelodun, Irepodun, Offa, Oyun, Isin and Oke-Ero local government areas.
A map showing these local government areas in Kwara state is given in Figure 4.3.

Figure 4.3
Map of Kwara state showing the local government areas



Source: Researcher

After consultation with the Director of Extension Services in KWADP, Zones A, C and D were selected as being areas with an abundance of root and tuber farmers who continue to use indigenous knowledge in farming, Zone B is known for cereals, rice and fish farming so it was excluded from the study. Selecting specific villages where the study would be carried out was guided the extension agents as they knew which farmers would be willing to participate in the study and the villages where the farmers continue to use their indigenous knowledge in farming activities.

4.6 Study population and sampling

For every study there must be a population from which a sample is drawn, as time, financial and other constraints would preclude carrying out the research with the whole study population. So research tends to involve some form of sampling; either probability or non-probability sampling. Probability sampling is done when one intends to generalize the findings of the study while non-probability sampling is done if the intention of the study is not to generalize the findings (Acharya et al., 2013; Henry, 2009). The study population for a research project could be individuals, cities, or hospitals. But all require well-defined criteria such as age, size, dimensions etc. For this study, the population consisted of all KWADP contact root-tuber farmers in Zones A, C and D.

According to Martínez-Mesa et al. (2016), p.327), sampling is defined as "the process through which individuals or sampling units are selected from the sample frame". Ishak et al. (2014) noted that for qualitative research the focus is usually on how the small sample, units or the phenomenon is to be studied, rather than the detailed procedure for drawing a representative sample, as is the case of quantitative research. They posited that, for a qualitative researcher, the purpose of sampling is to get specific cases or actions that give a deeper understanding of the phenomenon under study. Hence the general use of non-probability sampling for qualitative research. Etikan et al. (2016) mentioned that purposive sampling, which is also known as judgmental sampling, involves choosing a study participant solely because of the qualities they possess. The researcher looks out for people who have the ability and are willing to share their knowledge about a predetermined inquiry and can succinctly articulate such knowledge to the researcher. The onus for selection therefore lies with the researcher as he/she has a specific purpose to fulfil through the study. Accordingly, criteria are drawn for choice of participants/cases that would help in fulfilling such a purpose, with the need to identify such individuals and focus on how they can best achieve success for the study.

This study employed purposive sampling at every stage in the selection process. As described, the local government areas were chosen for the study because of their high numbers of root and tuber farmers there and the villages were chosen because they had been identified as using indigenous knowledge in root and tuber production. The criteria used for selecting farmers within these villages were that they be at least 40 years of age and have been resident in that village for at least 30 years. This as recommended by Falaki et al. (2013b), who posited that the age range and years of residence in that locality suggests that participants would be old enough to discern changes in the weather pattern over the years. Accordingly, 10 farmers were selected for focus group discussions known as *Ìjíròrò egbé* in each village, the focus group discussion enabled me to interact with the farmers as a group where I got a panoramic view of IKS in that locality. In addition, I could elicit information that would be useful later in personal interviews. From the focus group discussion, one farmer per village was identified, who had portrayed a high knowledge and/or usage of indigenous knowledge in their farming activities was further identified for an in-depth interview and observation. The process of sampling is presented in the Table 4.1.

Table 4.1

Sampling procedure

Population	**Sampled**
4 Zones (A, B, C, D)	A, C, D (density of root-tuber farmers in the area)
16 Local Government Areas (LGAs)	5 LGAs with at least one village in each LGA (the usage of IKS)
10 farmers in each village, aged 40 and above who have lived in the village for at least 30 years	Focus Group Discussion Participants (these respondents were assumed to be able to recall temperature and rainfall patterns in their communities and be repositories of indigenous knowledge (Falaki et al. (2013a))
1 farmer identified during focus group discussion was selected from the 10 FGD participants per village	In-depth interviews and observations of a total of 6 participants across the villages.

Source: Olaniyan B. S. (2021)

4.7 Negotiating entry into the field

Entry into the field marks the beginning of fieldwork and the manner of entry will largely determine the richness of the data generated during the study. Devers and Frankel (2000) submitted that having identified the potential study sites, researchers usually have to seek access into the field from gatekeepers. These gatekeepers have some form of control over the participants of interest to the research and their consent needs to be sought before proceeding with the study. Failure to do this might hinder the effectiveness of the research as the gatekeepers may frustrate the efforts of the researcher. Furthermore, Chughtai and Myers (2017) noted that once access is gained it needs to be maintained by building and sustaining relationships during the process. This promotes acceptance by the participants as the researcher becomes a familiar feature in their lives during the fieldwork.

Negotiating entry into the field for this study started at the proposal writing stage when the Director of Extension Services (DES) at KWADP was contacted to familiarize him with the proposed research and seek his advice on the intended participants and ADP's interface with indigenous knowledge in Kwara state. After getting the necessary approvals from the university ethics committee, a discussion ensued with the DES at KWADP head office, briefing him of the progress of the study and seeking an introduction to the extension agents and the identified farmers. Enquiries were made about their root and tuber expansion programme, which sought to address the challenges faced by root and tuber farmers, such as poor product prices, poor processing and storage technology, limited product utilization and limited marketing opportunities. The findings were that the programme was targeted at post-production rather than production and most of the farmers did not use the technology provided because of a lack of electricity supply.

The DES confirmed that the farmers' production methods depend solely on their indigenous knowledge in root and tuber production and he advised the researcher to join the training that KWADP was about to start for some farmers selected from all the zones and their extension agents, to get to know them, because being officially introduced to them by the authorities was needed to ensure acceptance on arrival in the field. The training was on sustainable land management, and it was tailored towards teaching the farmers to use the available land so as to retain soil fertility and boost production over successive years and to discourage them from abandoning existing farm sites and clearing bush or forest in search of fresh arable land; a practice that contributes to deforestation and, subsequently, climate change. Attendance at the training and participation in the practical sessions gave me the visibility needed and, later, when the fieldwork eventually started, the farmers kept referring to having seen me at the headquarters. The seminar was also time of reunion with the ADP staff, where I became newly acquainted with some field staff whom I had not known previously.

A pre-field meeting was held with the extension agents to map out the strategy and logistics for the focus groups and eventually interviews and participant observations. The six villages Yeregi, Iludun Oro, Aigoro, Alapa, Gaa Ogbe and Kaiama were selected and the extension agents booked appointments with their contact farmers to hold the focus group discussions. In Kaiama, a training session was carried out with the assistance of the extension agent, this involved conducting a personal interview with one of the farmers who had attended the seminar and a demonstration focus group. This action was based on advice that the roads were very bad and getting there for a 'city' person like me would be risky. The DES and the extension agent indicated clearly that they were sure than on my return I would need to be admitted to hospital. So, the extension agent was delegated to carry out the data collection. He was shown the methods and given a data storage device, which he returned some weeks later when he came for accreditation at the headquarters. We also had some follow up sessions by phone while he was in the field gathering the data.

4.8 Data generation

Data generation is a natural outflow of the process after sampling and negotiating entry. It is expected that for the research to be complete, data must be generated as evidence for the findings concerning the phenomenon that was studied. For a qualitative study, data are usually in oral or written form, or as intangible deductions from observations. As reported by Lopez and Whitehead (2013), p. 127): "whatever can be observed or communicated are considered to be potential or actual data". Data provide proof of the phenomenon under study; they are the basis on which the findings of the study are based. Data are used to give a thorough description of how the researcher arrived at his conclusions. They indicate the evidence by which the findings are legitimized (Polkinghorne, 2005),

Data were generated through focus group discussion in the various villages to elicit the farmers' general knowledge of climate change and identify key informants for personal interviews and observations. The key informants selected from the groups were those who showed a good knowledge of indigenous practices involved in root and tuber farming, actively employed IK in addressing issues arising from climate change and were willing to participate further in the study.

The researcher appealed to the extension agents (EAs) to also observe the process and take notes to complement with the audio recordings, to ensure no information was left out. So after each session the researcher conferred with them to harmonize the sets of data. The EA also helped with translating some terms into English and identifying some plants and varieties mentioned by the farmers.

Data collected were tailored towards answering the research questions in order to reach reasonable conclusions. The data were analysed in context to prevent researcher bias and allow the voice of the participants to be projected by using direct quotes from the interviews. It is pertinent to note that the researcher adopted the role of an insider-outsider in the research. The farmers were led to understand that although the researcher is a Yòrùbá woman, she was raised in the city and thus not cognizant of the indigenous knowledge being studied, meaning that she should be regarded as a student in their 'classroom', which endeared the researcher to the farmers. They were evidently glad to see someone from the younger generation who was eager to learn the ways of the elders.

4.8.1 Focus group discussions

Focus group discussion is a qualitative research method used to gather semi-structured data from purposively selected participants on a topic. It has the particular advantage of encouraging interaction among the participants so the researcher can discern innuendos and body language, which may give more insight into the issue at hand (Wong, 2008). This also helps the researcher to become familiar with participants perceptions and values regarding the issue at hand (Nyumba et al., 2018). Boddy (2005) defined focus group discussion as "a group of people brought together to participate in the discussion of an area of interest". For this study the focus group discussion will be known as *ìjíròrò egbé*. Folch-Lyon and Trost (1981) opined that focus group discussions should include six to twelve people who talk about topics germane to the investigation under the guidance of a moderator. The participants should be chosen from a predetermined target group whose views are of utmost importance to the study and more than one group session should be conducted to ensure adequate coverage of the subject matter. As described earlier, participants were root and tuber farmers who had resided in the village for close to 30 years and were sufficiently cognizant of the weather pattern over the years to succinctly elucidate a change over the years.

The numbers in each discussion group ranged from 5 to 12, due to the ongoing farming activities in the season and the ability of the contact farmer to rally his counterparts for the meeting. This range is in line with Lunt and Livingstone (1996), who proposed that for the group to be less contentious six to ten members works best. Mishra (2016) suggested, similarly, that the optimum number for a focus group is six to eight, without the researchers, although as few as three could be suitable and there was no upper limit, suggesting including as many participants that were available. The downside of lower numbers is the smaller the scope of the discussion, while larger numbers might not be as easy to control and so increase the tendency towards chaos. For this research, six group sessions were held for this study in six villages with the target group of root and tuber farmers.

It is noteworthy that there was only one female participant and she was there as the contact farmer for that village although she was not a root or tuber farmer. Nevertheless, her presence in the meeting was crucial; we had to wait for her before commencing the meeting. On enquiry, the researcher was told that root and tuber production was a male-dominated system and the female folk are more involved in the post-harvest processing although they may help in harvesting if need be.

The extension agent opened the meeting to introduce the researcher, as a way of affirmation. She then acted as moderator for the sessions as shown in Figure 4.4. Gibbs (1997) identified that the role of the moderator is critical to the success of any focus group discussion. The onus lies on such a person to introduce the study, calm any frayed nerves and ensure that the discussion stays on track with minimal digression, while also making sure that people participate by asking leading questions and trying to ensure that no single person monopolizes the discussion. The researcher combined the role of moderator with that of co-participant as she was learning from the elders and frequently had to respectfully steer the discussion back on track by seeking elaboration on some concepts relevant to the study. The group dynamics was maintained by directing questions to the members of the group who might silent most of the time, to ensure everyone shared their knowledge (Wong, 2008).

Figure 4.4

Researcher moderating a focus group discussion session

Source: Olaniyan B. S. (2021, permission granted)

At each session, the study was introduced and participants were assured of their anonymity and, most importantly, that this was not a government intervention but rather a study to document indigenous knowledge in root and tuber farming with the dual aims of getting a Ph.D. and keeping the knowledge for posterity. The researcher tried to stay as neutral as was possible while asking questions and seeking elaboration as the learning proceeded, as suggested by McLafferty (2004).

Cameron (2005) posited that interaction between the respondents is a major factor that distinguishes focus groups from one-on-one interviews. The group dynamic is energized by people contributing to others' responses; either in agreement or with differing opinions. The participants are thus exposed to different points of views on the same issue and some may reconsider their initial ideas and perceptions as a result of the group session. In this study, the moderator (researcher) tried to give room for dissenting opinions by labelling them as additional knowledge and affirming that there was no right or wrong answer because people are exposed to indigenous knowledge from various sources resulting from cross-fertilization of knowledge through urbanization.

Doody et al. (2013) suggested that focus groups should last between one and two hours, though the complexity of the topic at hand and the number of questions to be discussed should largely determine the duration. Extended time is necessary to allow broader introspection into the topic and to gather rich data. For this study the average duration for the focus group discussions were one and half hours.

4.8.2 Key Informant Interviews

Key informant interviews for this study were conducted face-to-face along with on-farm demonstrations of cultural practices such as the use of millet stalk as stakes for the yam trellis, multi-cropping of yam, cassava, okra, leafy vegetables and maize on the same heap.

Kumar (1989) described key informant interviews as interviewing a particular group of people who may provide the needed information and insights on the issue being investigated. He further noted that the interviews involve only a few respondents, who are selected because they have the information needed by the researcher. The interviews are qualitative in nature, are an informal form of interaction between the interviewer and interviewee, with the researcher eliciting information through their good rapport with the interviewee, while taking notes that are used for analysis.

Lokot (2021) opined that key informants are often termed such because they are presumed to hold expert knowledge on the issue at hand; so they are considered more special than others in the community and they may occupy positions of power. She further noted that key informants are thus termed because of their position in culture, rich store information on the research topic and relationship to the researcher.

Taylor and Blake (2015) noted that interviews among key informants had the advantage of generating rich data in an inexpensive manner, with the flexibility of the process allowing room for adjustment as it unfolds, and awareness of the topic is increased along with deepening relationships. The flip side of the coin is that the informants tend to introduce their bias and opinions and other qualified informants in the community may have been overlooked due to their lack of visibility.

The key informants for this study had been identified during the focus group discussions. They were not necessarily the most vocal amongst the group, but their responses during the group session inferred that they had in-depth knowledge of the indigenous ways in root and tuber production, or at least showed a 'special insight' that others did not possess. Some key informants where actually identified by the other participants as being the 'lead farmer' with very good annual output in root and tuber production and practising some indigenous ways that were known only to such people. For this study, key informant interview would be known as *ìfòròjomitoroòrò,* the Yoruba term for interviews.

4.7.3 Participant Observations

Laurier (2010) posited that participant observation is about spending time by living or working with people, so as to understand them and be close to the phenomenon being studied, and therefore to be able to succinctly communicate the people's perception about the phenomenon. Kawulich (2005) opined that participant observation helps researchers to learn about the way of life of the people under study in their natural setting, by observing and participating in those activities. It is the researcher learning by been exposed to the day-to-day routine of the participants as they engage with the phenomenon being researched.

Participant observation involves three stages, which are: the researcher gains entry into the intended community, he lives or work amongst the people to get a deep understanding of their views on life and the phenomenon, then he goes back to his original life and writes about his perceptions of and findings about what had been encountered in the field, which is essentially his trying to make sense of the time spent in the field (Cook, 2005). Most of the villages in the study where a few kilometres from Ilorin, the capital of Kwara state where the researcher was based, so she left home early in the morning to travel to the villages and returned home at the end of the day's work.

Becker and Geer (1957) submitted that data gathered through participant observation gives more information about the event or phenomenon than any other method, thus it provides a yardstick by which to judge whether data gathered in other ways are complete, and to inform us about any information left by other data collection methods.

For this study, the extension agents introduced me to the farmers during the focus group sessions and after identifying the key informant for each village, we approached them and discussed getting to know them further and the intention to 'shadow' them on their farms to learn more from them. They agreed but were sceptical about whether a city woman would survive the long trek to the farm so they organized an 'alùpùpù' (motorcycle) to transport her there with the extension agent. On the farms, the farmers showed me the tubers at varying stages of growth and the cultural practices carried out at each stage such as staking, weeding, capping and mulching. It was a profound experience to be learning at the elders' feet. For this study participant observation is known as *àkíyèsí alabaṣe*.

4.8.4 Data generation instruments

Focus group discussion guide, semi-structured interview schedule, the researcher and extension agents were the data generation instruments for the study.

4.8.4.1 Focus group discussion guide

The focus group discussion guide was essentially a list of questions to be asked during the focus group sessions, which would be used to elicit information from the community represented by the selected participants on their experiences of climate change. The guide included, amongst other questions, soem about the changes that they had observed in the weather pattern over the previous 30 years and what their opinions were on the likely cause of CC. These questions had been developed by the researcher after brainstorming with fellow students who were also researching IK and were familiar with the context of the study area, taking care to ensure the questions were properly worded and viable to elicit rich responses see Appendix H (Stalmeijer et al., 2014). Section 4.8.4.5 shows how the instrument was piloted, after which some questions were modified as they seemed cumbersome

4.8.4.2 Interview Schedule

Kallio et al. (2016) defined an interview schedule as "a list of questions which direct conversation towards the research topic during the interview". The interview schedule was used during face-to-face interviews with participants who had been identified during focus group discussion as having in-depth or unique indigenous knowledge, and were using such in their root and tuber production.

The schedule was used to find out the IK employed in farming in each village. Questions covered topics such as how they determined when and what to plant, the indigenous responses to the effects of climate change, for example an increase in pests and diseases, delayed rainfall etc. see Appendix I. The instrument was piloted as described in Section 4.8.4.5 leading to some questions being removed because they were repetitive. The focus group discussion guide and semi-structured interview schedule were developed by the researcher, checked by the supervisor, other PhD. students and a science educator.

4.8.4.3 Researcher as instrument

The researcher and EAs were the data generation instruments for the participant observations. Cohen et al. (2018) stated that researchers are the key instruments in a qualitative study as they collect data by interviewing, observing and interpreting the data so gathered. Our role was unstructured as the aim was to learn from the farmers without imposing our scientific knowledge, bias or opinions on the process. This reflects what Taylor-Powell and Steele (1996) described as direct observation. The observations were made in the natural settings of the village and the farm, as recommended by (Morgan & Harmon, 2001). Also efforts were made to ensure that the researcher and EA were in good shape physically, emotionally and mentally, by taking adequate rest between the journeys, providing good food and transportation to forestall distractions during observation. Such care is recommended by Poggenpoel and Myburgh (2003) because the researcher may be a threat to trustworthiness if proper attention is not paid to details of emotional stability, preparedness and generally dotting the 'i's and crossing the 't's. The researcher and extension agents, who doubled as research assistants, observed the process and activities of the farmers during the study.

A pilot study was then conducted in Uganda to test the instruments and methods, leading to some adjustments.

4.8.4.5 Pilot Studies

It was necessary to conduct a pilot study to give an idea of data to be collected during the full study and expose any inadequacies in the instruments. In this research it possibly showed transferability of the study because it was conducted in Uganda, which has a different weather pattern to the study area. Such transferability would emphasize the claim that climate change is a universal phenomenon (Hassan et al., 2006). Furthermore, Lancaster et al. (2004) recommended conducting a pilot study as it helps in calculating the sample size, checks the integrity of the study protocol, tests the data collection forms or questionnaires, tests randomization procedures, determines recruitment and consent rate, shows the acceptability of intervention if the study intended to do that and helps in the selection of the most appropriate outcome of the study (pp. 308-309). The pilot study for this research was conducted in Central Uganda at Nabutiti a suburb of Kampala and Bukerere, which is a village on the outskirts of Kampala. Two female farmers participated in the pilot study, one had access to extension services and practice a blend of scientific and indigenous knowledge forms while the other woman stuck with her indigenous practices. This helped to test the research instruments and also gave insight into the transferability of the study as Uganda and Nigeria have differing ecosystems and weather patterns, but root and tuber crops are grown extensively in both countries.

4.9 Ethical considerations

Klopper (2008), p.71) opined that "ethical considerations refers to the protection of the participants' rights, obtaining informed consent and the institutional review process (ethical approval)". The researcher had to navigate between the conventional ethics of conducting research and the indigenous ethics of holding meetings with elders and learning from them during data generation. For the UKZN institutional review aspect, once the proposal had been defended and accepted, an application was submitted to the Humanities and Social Sciences Research Ethics Committee. Permission to proceed was given before proceeding with the fieldwork. A copy of the ethical clearance is attached in the Appendix M.

As for the field work, the principles of respect for elders embedded in the Yòrùbá culture were useful guidelines and adhered to during the data generation process. This was particularly relevant as a female working amongst adult males. As noted by Avoseh (2013): "most social interactions, especially at the levels of negotiations and adjudications, require intellectual abilities manifest in the very best use of the spoken word". Accordingly, proverbs were used by the researcher to explain the study in a way that portray such abilities. Nevertheless, this required paying obeisance to the elders every time a proverb was used, because it is expected that when a younger person makes use of a proverb he or she should say *tó o sé bi òwe* as an act of saying you couldn't help but use a proverb. As the Yòrùbá saying goes, *òwe lẹṣin òrò, tí òrò bá sonù, òwe la fíí n wa,* which literarily means 'proverbs serve as a horse for words to ride on; and when words are lost, proverbs are used to search and find them'. Then the elders would reply *wà á pà mîì,* which is a way of saying you would live long to say another one. If a younger person employs the use of a proverb among elders without following these protocols he or she is said to lack a proper upbringing and uncultured (Avoseh, 2013).

Another ethical consideration to be navigated was the religious divide of being a Christian woman amidst Muslim men, who ordinarily would prefer the woman to be quiet and properly covered. Accordingly, in such villages the male extension agent took the lead in moderating the sessions, with support or clarification being provided by me, as needed. Furthermore, extra effort was made to dress in a way that would be acceptable in such settings. The effort put into not offending the men's sensibilities, by seeing the world through their lens, paid off as we established a rapport that transcended the research milieu and allowed free flow of information. The researcher was termed *'omo òdò àgbà';* essentially meaning 'a child that lived with the elders and learnt life lessons from them' thus being fit for socialization in the indigenous context.

The concept of *àgbá jowó la fí n sòyà, àjèjì owó kan kò gbé erù dórí,* which is loosely translated as 'we beat the chest with our five fingers and one hand cannot lift luggage up to the head' was also at play during the field work in that the participants believed it was their traditional duty to ensure that the next generation would be well educated about their culture. Essentially, it connotes the importance the Yorùbás put on the 'collective' in their general way of life. It is the responsibility of every adult in the community to raise a child into the total man, known as *omolúàbí,* or 'one who is well cultured, socialized and endeavours to be humane in all his dealings' (Busari et al., 2017). According to Akinwale (2013), *omolúàbí "*means a child that in endowed with all the best gifts of mankind, like commitment, patience, love, respect and truth", and this is achieved by the community as a whole. As the popular saying goes *ojú mérin ló n bímo, igba ojú ló n wo,* which translates as 'two people give birth to a child but the community raises it', hence the farmers deemed it fit to educate the 'child' on their indigenous farming practices.

Orb et al. (2001) noted that any worthwhile study should abide by the principle of respect for people by informing them about the study, indicating their right to decide on participation or otherwise and their choice at any stage of the process of withdrawing or continuing with the study. For this study, informed consent was applied at every stage. Although KWADP provided access and the extension agents introduced me to the farmers, the general aim of the study was explained to the farmers and their consent sought to participate in the study. They were also informed that they were free to withdraw from the study at any point if they no longer felt comfortable with the process.

The participants' names were not included in the study to ensure anonymity and protection; thus pseudonyms have been applied to identify individual responses where necessary. This is in accordance with Roberts (2015), who stated that for a research to be ethical it has to weigh the benefits expected from the study against the potential harm to the participants. Trying to maintain this balance puts a burden on the researcher to ensure the safety of the participants while pursuing the aim of the study and taking care not to lose sight of either factor throughout the study. After introducing the study and going through the focus group discussion, the key informants were identified and approached about further participation, then the choice to participate was presented, which they accepted. The informed consent form was signed at the end of the whole process of personal interviews and observation because signing before getting to know the researcher and the study put a formal restraint as the process is then viewed as a government program. Some asked why they had to sign this, and it was explained that it was to show their assent to participating in the study and then they gladly signed the form. The participants had no issues with the fieldwork being recorded using my phones as they had been assured that the recording would be handled with utmost care and be accessible to only the researcher and her supervisor. The recordings have been kept safe in a file until the end of the study when it will be disposed of in a careful manner.

4.10 The Field Experience

This section is a reflection on the activities involved before, during and after the field work to ensure a smooth flow for the research process.

4.10.1 Initial meeting with farmers at KWADP

In the meeting with the DES of KWADP, as mentioned in Section 4.6, he advised me to join the seminar-cum-training on sustainable land management that had been for farmers in conjunction with soil scientists from the Institute of Agriculture, Research and Training, Ibadan, Oyo State. He also mentioned that the participants would be from all the zones of KWADP, and would include the Zonal Managers, Zonal Extension Officers and Extension Agents. These officials would then use their training and visit days (T&V) in their respective fields to train other farmers who had not been included in the training.

In the 2-day training seminar the farmers were told how their indigenous practices had helped sustain the land and were encouraged to switch to the use of organic fertilizers in lieu of the inorganic ones they were used to. The farmers were then trained on the production of organic fertilizers, with practical sessions held on the second day. During the practical session the farmers mentioned that they had been using the components of the organic fertilizers on their farms but not in the form the scientists were showing them, and also pointed out some other plants they used. The scientists had combined neem leaves, cassava leaves, plant residues, cow-dung and poultry droppings with sawdust. The plant materials are cut into small pieces and piled together in a spot, the animal dungs are kept in another spot, then the two mixed in a ratio of 1 portion of plant residue to 2 portions of animal dung. These were then mixed together with water and covered with a tarpaulin. After four weeks they were to be mixed again, further water added, and then covered again for another 4 weeks. By the end of 8 weeks the materials would have broken down and reduced to half the original size, showing that the fertilizer was ready for use on the farm. The fertilizer was to be broadcast on the farm before ploughing then the land planted 2 weeks later. The farmers mentioned that they used poultry droppings separately and incorporated neem, cassava and mango leaves and crop residues into the soil when clearing the land in preparation for another farming season. The scientists mentioned that they had gathered their knowledge from science and extensive work with local farmers in different parts of Nigeria when they were carrying out soil analysis across the nation, and the formulation they brought was the one that would enhance the soil with the minerals they identified was lacking in the soils of Kwara State. The lead scientist noted that they blended indigenous knowledge of plants with their scientific knowledge to foster acceptance by the local farmers and ensure access to organic fertilizers, which should replace the expensive ones sold in the markets. This would foster the aim of having the land protected for future generations.

After the soil scientists left, the DES then introduced me to the farmers as a researcher working on climate change (CC) who would be coming to meet them in their villages to find out indigenous knowledge of CC. The DES implored them to accept me as their child and gave me the opportunity to address them. I took the stage and greeted them in the local way, *àgbè arokobódúndé o*, which means 'may you be healthy to till the land always' to which they replied *ase o* (amen) then switched to the farmers' slogan NO FARMER! NO NATION (Igboin, 2012). The study was introduced to the farmers as exploring the indigenous knowledge employed by root and tuber farmers in responding to climate change and he again emphasised that essentially I had come to learn from them, not the other way round. They welcomed me and promised to give me audience whenever I arrived at their villages if those eventually fell within my selected sites. Some even advocated for having a group interview immediately, as they were not sure we might meet again. We obliged and the data collected served as a triangulation tool because the IK mentioned intersected with that obtained at the eventual study sites.

4.10.2 Meeting with Zonal Managers, Zonal Extension Officers and Extension Agents

After the general meeting above, another meeting was convened by the director to introduce me officially to the Zonal Managers of the preselected zones, who assented to the research and handed me over to the Zonal Extension Officers (ZEOs) as they would work directly with the Extension Agents. The ZEOs then asked for specific details of the study to help decide which of the EAs would be best suited to the job. They then called the EAs and gave them instructions on how to go about the project, identifying the best villages and farmers to contact and how to present the study. They emphasized that the farmers should be informed that this person has come to learn from them, unlike the conventional research they were used to. The EAs had already mentioned that the farmers were tired of being the subjects of research, which Blair (2015) and Goodman et al. (2018) have termed "being researched to death". In particular, they stressed that no questionnaires would be used, so the EAs were relieved that they would not have to administer these, but wondered what the process would be like. I responded by explaining that data would be collected using audio recorders and field notes. We then exchanged contacts and they asked to be allowed some days to get in touch with the contact farmers in the villages that had been identified as IK usage being prevalent and set up an appointment for *ìjíròrò egbé.* The director then implored them to take good care of me and ensure my safety and give me maximum support to ensure the success of the field work, because I was one of them, who had worked with the organization during the compulsory National Youth Service Corps year and stayed in touch with them. So, we departed with the undertaking to make more detailed arrangements by phone.

4.10.3 Focus group discussions (**Ì*jíròrò egbé***)

After making the appointments the EAs notified me that they had picked villages not far from Ilorin, the capital of Kwara state, so we could commute easily and called on me to prepare a timetable for the journeys. Each day started by travelling to the villages to arrive around midday when the farmers took a break from farming activities and to rest from the heat of the sun, after which they would return to the farm to finish the day's work by sundown. By prior arrangement the farmers were usually waiting for us at a central place like the town hall, under the tree or at the home of the village head.

On arrival, general greetings are done with the researcher kneeling, being a female, and the extension agent prostrating, as a male, to greet the elders. Then introductions are done, both of the people present and the purpose of the gathering. Once permission had been granted, the researcher explained the aim of the study and sought their consent, which they gave after asking if they had to fill questionnaires, we could answer that in the negative and explained we would do audio recording and take notes. They were intrigued that this was a different sort of study and were happy that they would be able to share their experiences and impart knowledge to someone from *ilé ìwé gíga* (university), who would then preserve the knowledge for posterity and make it available in a usable form for the younger generation, policy makers and anyone who might be interested in what the farmers had to share.

The general flow of the meetings took the form of the researcher asking a question and the 'younger ones' deferring to the elders, who then gave them go-ahead to speak first then would buttress the point. This is because of the saying *erin kì n fon kí omo rè fon* meaning 'the baby elephant doesn't trumpet while the elephant trumpets'. This saying in essence emphasizes the respect for elders that is embedded in the Yorùbá culture, where the younger members do not speak before the elders except when given permission to do so. It is pertinent to note that the age of those present ranged from 40 to 80 years, but even for 40-year-olds as long as there were older people present, protocol must be followed. So, the younger ones repeated what they had been taught by the older ones and the elders filled in the gaps, while buttressing the point. The elders also supplied the indigenous names of some plants and animals as opposed to the common names that the younger ones knew, what they termed Yòrùbá *ìjìnlè.* The elders further gave clarity on the changes in weather pattern from their younger days, which showed clearly that CC is indeed an issue, and they indicated the farming practices they had had to modify to cater for this phenomenon.

At the end of each meeting, the participants were shown appreciation for their time and the knowledge shared, and a summary of the day's meeting was given, so they could identify any gaps and corrections to be made. The EA gave a vote of thanks and a representative of the community also commended the efforts put into documenting indigenous knowledge. Then the sessions ended with prayers, in either the Christian or Islamic way depending on the prevailing religion of the village. Refreshments for the participants was monetized because of the logistical effort of carrying them from the city in public transport, and they chose to either buy things in the village or share the money. It would have been culturally unacceptable to have brought the people together without entertaining them thus. In turn, they also apologized for not having a gift of yams to give me because the harvest was not due and the new yam festival had not yet been held.

4.10.4 Personal interviews (key informants) and observations

Following ì*jíròrò egbé,* individual farmers were contacted and invited to continue with the study. These farmers had been identified, sometimes by the group members, as possessing unique or extensive IK which they used in root and tuber production, or that their farm had outstanding output. When we approached them to seek their consent for *ìfòròjomitoroòrò* and observations they gladly obliged. The recruitment process usually took the form of the following conversation.

Researcher: Baba you mentioned something about a particular plant as pesticide during the meeting, we will like to know more about that and see how you take care of the heaps on the farm.

Baba: You these children of nowadays, you are so inquisitive. It's okay I will show you since you're eager to learn. Most educated youths don't bother with farm work because it is tasking and you get dirty doing it.

To which, the researcher and EA would smile respectfully and fix a date for the interview.

On the appointed days we would arrive at the village early in the morning to find the farmer waiting for us, having arranged transport in the form of *alùpùpù* (motorcycle) to convey the researcher as they joked that the distance from village to the farm was too much for a city girl. Truthfully the ride would have been at least 20 minutes by bicycle so I was grateful for their thoughtfulness. They would take me round the farm showing me the heaps and the crops at different stages of growth, demonstrating the use of IK and explaining the resultant effects then we would retire to the farm hut, called *ahéré*, to seek clarification on things seen on the farm and to discuss at length the local indicators of the weather, and how they predicted the weather in order to plan the farming season. On one occasion the farmer looked at the sky that appeared very clear to me and the temperature reading on my phone was 32^0C, and said if we did not want to get soaked we needed to be on our way within the next two hours because there was going to be a heavy downpour. The EA told me not to discount the comment, and as we were already rounding off for the day, we thanked the farmer and left within the hour, but we could not get transport at that time. Exactly two hours after he told us it was going to rain, the clouds changed and it was indeed a heavy downpour; we were really drenched by the rain that day. A representation of how the clouds changed within an hour of waiting for transportation is shown in Figure 4.5.

Figure 4.5

Picture of how the clouds changed within one hour

Source: Olaniyan B. S. (2021)

4.11 Handling Data

Data were generated in the forms of audio recordings, field notes and photographs. The audio recordings were done using two phones, one serving as a backup. The pictures were also taken using one of my phones and that of the EA. On getting home each day, the recordings were transferred to my laptop from my regular phone while the one on my backup phone was kept intact. This proved to be a smart choice and a saving grace when my laptop was stolen. The data on the backup phone therefore remained intact and some missing pictures were obtained from the EAs. The data from Kaiama was also recovered because the EA had used his phone for recording, and had then transferred it to his laptop, from which he had initially copied it onto a USB drive for me. I sent him a message was sent explaining what happened which he thankfully received just before he was about to delete it from his system and so he could send me another copy. The retrieved data were immediately uploaded to my Google drive, and also copied onto a flash drive that was dedicated for that purpose, and I started transcription and continued analysing the data. The transcribed data were then sent to my supervisor for initial perusal and comments.

The transcription was done by both me and a Yòrùbá language specialist to ensure proper translation and that correct terms were used. The language specialist also filled in the gaps in my own translation and ensured the correct intonation marks were ascribed to each word. She also helped in finding the English names of some of the plants, trees and animals mentioned by the farmers during the study.

The initial transcriptions of the data were sent to the EAs, who in turn discussed them with the contact farmers so they can give feedback on the data, to be assured that their views had been properly captured. The final compilation of the IK used by root and tuber farmers to respond to CC will be presented to each community after the completion of the thesis.

4.12 Data Analysis

Making sense of the data started during the fieldwork, as I had to reflect on what had been said during *ìjíròrò egbé,* concerning what was practiced on the farm and perhaps ask for further clarification. For instance, some of the unfamiliar terms necessitating asking the farmers for the common name or the meaning, or I was shown some of the local indicators for predicting the weather such as *igi odán, igi osè*, and I needed the English names to document of all the trees and birds mentioned.

After transcribing the data, significant statements were identified, and recurring ones were categorized into themes for further analysis. I also used *ATLAS.ti* software to code the data and then carried out an inductive thematic analysis of the farmers' responses, so they were grouped as categories emerged, giving a graphical view of how the different categories linked together in answer to each of the research questions. The diagrammatic representation is presented in the next chapter.

My supervisor also looked at the data and the analysis to ensure they synchronized properly and that the categories are a true representation of the data. A test and measurement specialist, who is also a Yòrùbá man, examined the data and the subsequent analysis to ensure conformity, proper coding of the data and correctness of the identified themes. A science educator, also a Yòrùbá man, compared the audio data with the transcribed version and identified gaps which were then rectified. One of the EAs also checked through the audio recording and transcribed data to ensure the transcription was properly done.

4.13 Reflecting on the field experience

The fieldwork opened my eyes to a world that existed outside my cocoon of city life. The many journeys to and from the villages were times to thoroughly enjoy nature although the time so spent seemed too fleeting. The connections made with the extension agents as we shared life stories on these journeys were enlightening, we crossed the divide of gender, social status and religion and were simply researchers-cum-scientists with the common goal of establishing good rapport with the farmers while getting them to accept the study and own it. Their many suggestions such as how to frame the questions, what to expect in the village, or who needed to approve the study in each village were helpful and prepared my mind for the eventual meetings. On one occasion my head scarf was left behind while rushing out of the house and when I mentioned it to the extension agent he allayed my fears that the community leader was a Christian and would have no issue with my head being uncovered, so all went well. The EAs frequently mapped out our journeys in a manner that reduced transport costs and was more comfortable; they kept mentioning that a student should do more with less money. They took particularly good care of me and were also challenged to undertake further studies themselves.

Another issue that came up was the language barrier. My fluency in Yòrùbá language was put to test in the field; many times the extension agents and/or the participants came to the rescue when I was at a loss for the correct word. Sometimes the 'right' Yòrùbá word was used but it meant a different thing in their dialect, so they would laugh and tell me theirs. It was both fun and enlightening as I was schooled in my language over and over. As the study progressed I had to dig deep into the recesses of my language repertoire accumulated over the years, particularly the use of proverbs in communication to articulate the essence of my study to the participants. Once the right words in the right context could be found the study continued smoothly and the farmers commended me that for a city girl, my use of their language was impressive.

The openness and warmth of the farmers is another high point of the study. They welcomed me with open arms, cracked jokes to make me feel at home and made suggestions on how the focus group discussion or interviews should go. They made arrangements for transport to the various farms to prevent my exhaustion before the day's job had started. One man actually put himself between me and a Fulani herdsman who had accosted us on the farm; all the while diffusing the tension with jokes that all the man's cattle could not pay for my bride price. He kept watching out for further threats while we waited on the farm for the other farmers to join us. There were many such acts of kindness, like making sure my recorder was functioning properly and asking if the phones needed to be charged before leaving for the farms. All touched me greatly.

The study enabled me to see the act of humaneness known as *omolúàbí* in reality as it was displayed on both sides that is by the research team and the farmers. The mutual respect for each other made for free flow of communication and the process went smoothly. This study reinforced my belief in the richness of the Yoruba culture and exposed me to it in a greater dimension than any of my previous experiences.

4.14 Summary

This chapter gave a detailed explanation of the research methodology employed during the study. The research took a qualitative approach in exploring the farmers' use of indigenous knowledge in their farming process and response to climate change. The study was done in collaboration with the participants using participatory methods of focus group discussion (*ìjíròrò egbé*), interviews (*ìfòròjomitoroòrò*), participants' observations (*àkíyèsí alabaṣe*) and storytelling (*ìtàn síso*).

This was done while making decisions that are ethically acceptable both to the university institutional review and the socio-cultural beliefs of the participants. The researcher also had to switch roles many times between being part of academia and being a student at the feet of the elders. The findings are presented in the next chapter.

CHAPTER 5: FARMERS' EXPERIENCES OF CLIMATE CHANGE

5.0 Introduction

The research methodology for this study, as discussed in Chapter 4, was participatory phenomenology using the specific methods of focus group discussion (*ìjíròrò egbé*), interviews (*ìfòròjomitoroòrò)* and observations (*àkíyèsí alabase*) with storytelling (*ìtàn síso*) being the overarching theme. It gave rise to a myriad of data that had to be categorized, delineated as indigenous or scientific, and themes identified to succinctly answer the research questions which are:

1. What are Nigerian root and tuber farmers' experiences of climate change?
2. How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?
3. Why do Nigerian root and tuber farmers respond to climate change in the way that they do?

The findings are presented in this chapter with an in-depth analysis of the farmers' perceptions of the occurrence of climate change through comparisons between the weather pattern now and over the previous 30 years. The use of the participatory research methods of focus group discussion (*ìjíròrò egbé*), interviews (*ìfòròjomitoroòrò),* and observations (*àkíyèsí*) with storytelling (*ìtàn síso*) being an overarching theme, as explained in the previous chapter, helped elicit a broad spectrum of data which I tried to make sense of from the standpoint of an insider-outsider of an under-represented group, the Yòrùbá people. I focused specifically on the Yòrùbá in Nigeria, with their rich heritage of indigenous knowledge, although the Yòrùbá people are now found all over the world. The methods not only allowed documentation of the knowledge gathered but also confirmed the source of the knowledge being the farmers who were able to distinguish between what had been handed down to them by their forebears and the scientific knowledge brought by the extension agents. They also mentioned that while some of those techniques brought by the scientists had been tested by them they had, nevertheless, found that their own way produced a better yield, so they had discontinued the modern techniques.

5.1 Overview of the Data Analysis

Data were collected from six villages, so the findings are presented for each village along with a brief description of each village. The data were used to highlight the variations among the experiences of climate change as espoused by the farmers. Direct quotes have been used when necessary and pictorial representations of the grouped categories are also provided. The same pattern was followed for all three research questions. A systematic representation of the whole data analysis process is shown in Table 5.1.

Table 5.1

Synopsis of Data Analysis

Research Question	Instruments	Method	Analysis
1. What are Nigerian root and tuber farmers' experiences of climate change?	Audio Recordings	Focus group discussion Storytelling	Narrative Data Analysis: Horizontalization-identifying significant statements or quotes Textual description Structural description-illuminates the context
2. How do Nigerian root and tuber farmers' use indigenous knowledge to respond to climate change?	Interview Schedule Field notes	Interview and Observation	Categorization Thematic
3. Why do Nigerian root and tuber farmers' respond to climate change the way they do?	Interview Schedule Field notes	Interview and Observation	Categorization Thematic
4. What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change?	Data collected from Q1-3 above were analysed to answer this question		Analysis and synthesis of all data into holistic representations from categories above.

Source: Olaniyan B. S. (2021)

In trying to make sense of the data a conscious effort was made to bracket my ideas and opinions and **present the data as it was, without putting in my own interpretation,** so as to let voices of the indigenous people ring out through the process, in a postcolonial manner, as they told their stories. I was essentially a *bricoleur*, constructing meaning from the data at hand. Also the data were subjected to several stages of external scrutiny for validity. Firstly, my supervisor went through the transcripts and gave useful suggestions on the coding; then a Yoruba language expert also checked for correspondence between the audio data and the transcribed data to ensure no meaning had been lost during translation; next, a test and measurement expert also checked the data and the eventual codes and themes for correlation, and finally one of the extension agents went through the transcripts to ensure the field work had been properly documented. All the gaps identified by the aforementioned people where noted and rectified (Carstensen, 2011; Gobbi, 2005; Johnson, 2012; Kincheloe, 2011).

I familiarized myself with the data by transcribing the audio recordings and reading through the transcripts many times and listening to the audio for clarity in cases where gaps appeared in the data. For RQ 1, horizontalization was done. This is a qualitative data analysis process where each piece of the data was considered important and thus analysed. Significant statements that kept re-occurring and so represented how the participants perceived CC were identified and grouped into clusters of meanings to arrive at the themes that described their experiences of CC, thus giving a textural description. All of this came from repeatedly sifting through the data to identify the recurring words and statements. An attempt was also made to describe the setting or context of the villages, which would influence how the villagers perceive CC and inform their decision. This is called structural description (Creswell & Poth, 2016). A brief description of each village is given before presenting the relevant experiences of CC.

5.2 Brief Description of Aigoro Village

The small village of Aigoro in Moro local government area of Kwara state is an agrarian community about 24 kilometres from Ilorin, the capital of the state. It was eerily quiet that Thursday afternoon as I entered the village alongside the KWADP extension agent who was in charge of extension services in the area. On enquiry I was told the farmers were on their various farms tending to their crops as it was getting close to the yam harvest season. The extension agent allayed my fears that this might be an abortive trip; reassuring me that they have been informed about the research and my target group of root and tuber farmers, those who were 40 or more years old and had lived long enough in that village to be cognizant of the changes in weather pattern over time, were waiting for us in the town hall.

In this village, yam, cassava and sweet potato are planted alongside other crops like maize, millet okra, and leafy vegetables. Most of the houses had a little garden nearby called *'oko etílé',* mainly for vegetables and other crops intended for household consumption. Domestic animals, such as goats, chickens and in some cases sheep, could be seen roaming about the village. They provide meat and an additional source of income to the village families. Most of the houses had corrugated iron roofs with wooden doors and windows. However, the town hall stood out with its brightly coloured metal roofing and aluminium windows, as it was used by the villagers as the venue for hosting visitors and ceremonies. Nevertheless, electricity was out and the hall with its long wooden benches, characteristic of the average village in Nigeria, was dark, so we had to sit outside for fresh air and illumination.

Figure 5.1

Cross section of participants, EA and researcher in front of the town hall

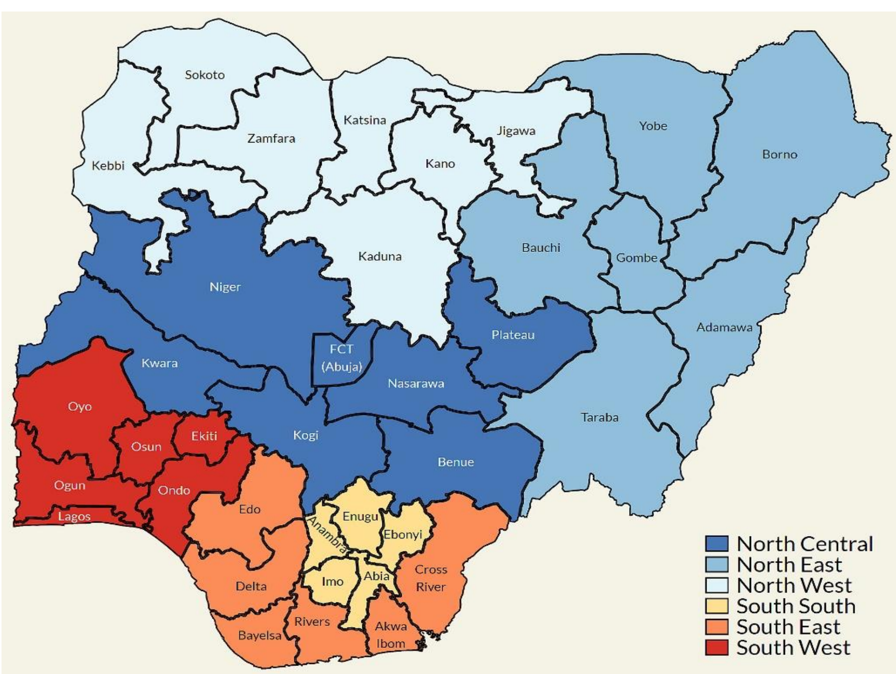
Source: Olaniyan B. S. (2021, permission granted)

The inhabitants of the village are mostly Yoruba, a tribe situated in south-western part of Nigeria including Kwara state (shown in Figure 5.2) with a few Fulani herdsmen who had migrated southward from the northern part of the country in search of pasture for their animals. The Fulani are a tribe whose origins are unknown but are believed to have migrated to what is now known as

Nigeria and settled there. They established a caliphate after the jihad wars led by Usman Dan Fodio against the native dwellers of that area that is the Hausas, Kanuris etc. The Fulani are nomads who breed animals such as cattle, goats and sheep and undertake seasonal north-south migration in search of pasture and water for their animals (Ajibefun, 2018; Lannbrecht, 1976). Some of the Fulani women could be seen hawking milk curds (*wàrà*) along the road while their men grazed their cattle. This grazing has recently been a source of tension in the country, as hostile herdsmen have reportedly killed farmers who resisted their movement into their farmlands. There have been reports of rape, attacks on the farmers, looting the farms by either uprooting the tubers for the cattle to eat, or pillaging the tubers stored on the farms (Adeoye, 2017; Bamidele, 2018; Fasona & Omojola, 2005). The farmers confirmed that there had been a greater influx of herdsmen from the north, in search of fresh grass for their animals, because deforestation occasioned by climate change and human activity of felling trees had taken their toll in the north. The village head (*Mógàjí*) had to call a meeting of all concerned and set rules of engagement in the community to curtail violence.

Figure 5.2

Map of Nigeria showing the geopolitical zones.



Source: Wagai et al. (2021)

5.3 Farmers' Experiences of Climate Change in Aigoro Village

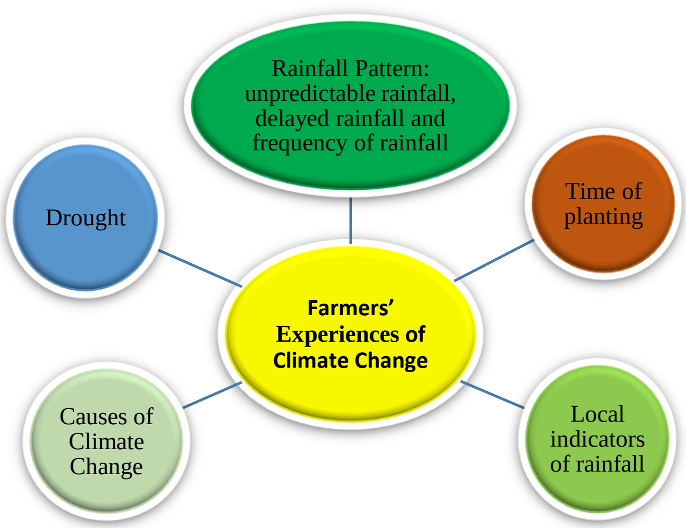
The causes and effects of climate change were discussed at length in Chapter 2. In seeking out the role of IK in root and tuber farmers' responses to CC, the study entailed knowing the farmers' views about CC. Are they aware of the phenomenon? If yes, how did they become aware? What are their perceptions of CC? What are the notable changes observed over the years? The farmers' response to such questions are examined in this section and form the basis for answering RQ 1.

This section is structured around the pictogram presented in Figure 5.3 below. The farmers' responses were categorized and are discussed according to the themes that formed their experiences of climate change, as follows.

a. Rainfall pattern (unpredictable rainfall, delayed rainfall, frequency of rainfall)
b. Drought
c. Time of planting
d. Local indicators of rainfall
e. Cause of climate change

Figure 5.3

Categories of farmers' experiences of Climate Change in Aigoro Village



Source: Olaniyan B. S. (2021)

5.3.1 Rainfall pattern

The farmers identified that the rainfall pattern had changed over the years, with the rains now arriving later than usual and their length has also changed. They noted that in the old days, rain fell in three cycles per year, from February till December, but nowadays the rains may not start until April and may stop earlier, so the crops suffer for this. An excerpt from the focus group discussion (*ìjíròrò egbé*) gives an exact representation of their views.

Researcher: What did the rainfall pattern look like some 20 years ago and how is it now?

Alfa A: When we were much younger and rain falls, it falls in three ways. It was in the beginning of the year, middle and at the end of the year. There is nothing like that again now, God do as he pleases. If we say that the rainfall is small before it stops falling, it may stop in the tenth month (October), I'm talking about recent times, but it wasn't so before rain falls all the time then and farmers don't have any problem.

Alfa T: The period that he is talking about, rainfall begins from the second month of the year (February) till the third month (March) and around this period the farmers will plant a crop called bàrà (melon). Then the rain will fall from that February till December. Even when we plant millet, the rain will still fall on it, but now everything has changed. There are times that farmers would have calculated when the rain will start falling and when it will stop and then the rain will just suddenly stop falling halfway, which is why farmers start planting immediately the rain starts falling.

This finding is supported by Uyigue and Ogbeibu (2007), who reported that there had been a change in the rainfall pattern of Nigeria. Previously, farmers could predict the rainfall and know the best time to plant but the change in the pattern resulted in many farmers making losses due to delayed rainfall and wrong timing of their planting.

The change in the rainfall pattern has multiple implications for the farmers in the form of changes in its predictability of timing, frequency and duration. The farmers explained that before the advent of CC, the seasonal calendar was regular and their fathers knew exactly when the rain would start and end, which helped them make decisions about their farming activities. Unpredictable rainfall is a situation where the farmers are not sure when the rains would start or end within the year. The timing of the rainy season is delayed and the frequency of rainfall was now haphazard. Since agriculture in Nigeria is rain-fed, that is farmers depend solely on rain to water their crops, any delay or change in the amount, duration and time of rain has an adverse effect on farm productivity. Ayanwuyi et al. (2010) submitted that the farmers sampled in their survey on perceptions of CC identified delayed rainfall, and unusual heavy rainfall, amidst other indicators, as determinants of CC in their area. Their survey was conducted in Ogbomosho agricultural zone of Oyo state, which shares a boundary with Kwara state, so they share similar rainfall patterns.

5.3.2 Drought

The farmers identified drought as another way CC had expressed itself. Drought, which they called *ògbelẹ̀*, indicated times when there was no rainfall. They also identified a pattern of drought every 3 years, as follows.

Alfa K: There are times that farmers would have calculated when the rain will start falling and when it will stop and then the rain will just suddenly stop falling halfway, which is why farmers start planting immediately the rain starts falling. The more reason why food was expensive about three years ago,

Interviewer: Was three years ago the only time that you've experienced drought here?

Alfa K: No, but that was the most recent one. It doesn't happen all the time. It happens every three years. That was what was observed by our fathers.

This observation corroborates Ayanlade et al. (2017), who submitted that farmers in southwest Nigeria indicted that drought and dry spell are recent occurrences due to CC. When farmers' perceptions were compared to meteorological data, they found the perceptions to be accurate. Hence, they concluded that the farmers had good knowledge of their environment.

5.3.3 Time of planting

The farmers mentioned that there had been a change in the time of planting because of CC, although they highlighted that this has greatest effect on crops that grow above the soil, like maize, millet and beans, which need the most water. Cassava is drought tolerant and once yam is planted and mulched (placing grass on the heap) moisture is conserved so the crop would continue to grow, though it might not be as big as when there is abundant rainfall. The farmers have resorted to planting more drought tolerant varieties at the normal time of planting, then waiting for the rains before planting the varieties of yam that need more water. This is in agreement with Adesoji (2016), who reported that planting at different dates was the adaptation strategy most frequently used by crop farmers in Nigeria to CC.

Alfa S: We have up to four varieties or more. What happen is that the local yams that we were taught how to plant by our forefather's years back, the heaps for these varieties of yams are made by the month of September or October. Some farmers may make round heaps while some will make their heaps on a straight line. After making the heaps, there is something we called èbùjò, it is believed that when the heaps are made and the mist causes the soil to shrink together no matter how hot the sun is, it won't affect the yam that is in the soil.

Nweke et al. (1991) noted that the shrinkage of the mounds is due to the physical properties of the soil that lead to it forming clods during dry season when the soil moisture is reduced.

When asked what is done during delayed rainfall, the farmers had this to say:

Interviewer: Has it ever happen before that you are expecting the rain to fall in April and the heaps have been made already but then the rain refuse to fall?

Alfa A: Yes, it has happened before

*Interviewer: What was done that year***?**

Alfa D: When the rain is expected to fall and it was delayed, it may begin to fall by June and it won't stop till December.

Interviewer: So, you don't plant any crops till you see the rain?

Alfa T: Yes, we don't plant until the rain starts falling.

The uncertainty in the weather pattern that led to change in planting dates has made the farmers adept in reading the weather signs using their indigenous knowledge of their environment to predict the weather, their knowledge of how trees change with season and the behaviour of some animals helps them predict the weather and so enable them to time their farming activities properly. This is discussed in the next subsection.

5.3.4 Local indicators of rainfall

To help them plan the farming season efficiently the farmers need to predict the weather; they use local indicators that have been passed down from their forefathers. These indicators are essentially part of natural resources around them, such as trees, birds, the direction and even sound of the wind, and the way they perceive the temperature.

Interviewer: Yesterday, I was telling someone that if rain wants to fall, I use to smell it. Is there any local way of knowing when rain will fall?

Alfa K: In the dry season, when the shea butter (òrí) leaves starts blooming, it is a sign that rain will soon start falling. Another way of knowing is when ficus thonningii leaves (igi Ọdán) starts falling off, it means rain will soon start falling.

Agricultural Extension officer: Like in our own area now, we also look at the direction of the rain.

Alfa F: Yes, when the wind starts blowing towards the direction of the sun in the afternoon. This is a good sign that rain will soon start falling.

The findings above corroborate Ajibade and Shokemi (2003), who reported that rural people in Asa local government area of Kwara state use cloud cover, sightings of some plants and animals, odour of the environment as well as air and temperature intensity to forecast rainfall. These abilities of the farmers to infer from their environment the weather pattern was also reported by Kolawole et al. (2014), who said that local farmers in the Okavango delta predicted the weather by various means like smelling the environment, listening to chirping of birds, sounds from insects, migration of some animals, behaviour of some plants, and cloud gatherings, amongst others. And in this research we see the same thing being done in Kwara state, Nigeria. Heads of rural households in Okavango Delta also noted that "one does not need a sophisticated tool to predict the weather" (Kolawole et al., 2016, p.138). Nkuba et al. (2019) submitted that there is need to involve farmers in forecasting the weather.

5.3.5. Causes of climate change

The farmers in this village were unanimous in their response that change in the rainfall pattern, a fall out of climate change, had been caused by God and there is nothing any man could do about it.

Alfa A: For rain it is God that changed it not humans. When we were much younger and rain falls, it falls in three ways. It was in the beginning of the year, middle and at the end of the year. There is nothing like that again now, God does as he desires.

Interviewer: So rain stops by October. And all through December to March there will be no rainfall?

Alfa T: Yes, but the work of God can't be predicted, there are times that millet would have been planted with the hope that there would be no rain and then the rain will start falling, though it may not be much, and the millet will have to be sundried again.

This is in consonant with Ayanwuyi et al. (2010), who posited that farmers perceive climate as having a strong spiritual, emotional and physical dimension so they approach the issues arising from climate change from the same perspective.

5.4 Brief description of Alapa village

Alapa is a small village in Asa local government area of Kwara state. It is situated about 26 km from Ilorin, the state capital city. The village is on the highway that leads out of Kwara state to Saki in Oyo state, and which passes through the village with the market on the right side of the highway as you travel from/to Ilorin and the mosque on the other side. The highway makes the village easily accessible, with resultant effect of economic development. There are houses on both sides of the highway, and non-farm activities take place along the corridor, for example a grocery store, mechanical workshop, vulcanizing machine for tires etc. This means that there was a lot of human and vehicular movement in the village.

The asphalt paved main road into the village provided easy access to the farms and market. The houses were a mixture of ancient mud houses and modern cement block buildings, but the rural setting was intact. The location for the focus group discussion (*ìjíròrò egbé*) was a communal storage facility for root and tuber crops, which was close to the market. This place was a customary meeting place after Jumat prayers on Fridays, when the farmers would congregate as a group. Some processed yam tubers, called *èlùbó,* were in storage to be sold at the market on the next day.

The major root and tuber crops for in this village are yam and cassava, grown alongside maize, millet, beans and leafy vegetables. The village is renowned for their yam production, which they supply to neighbouring villages, towns and travellers on the highway. The villagers have issues with grazing cattle wandering onto their farms but with no resident Fulani herdsmen there were few clashes between farmers and herdsmen.

The village is predominantly a Muslim community, but the farmers allowed the researcher to sit and be photographed with them. I had made sure that my dress was acceptably long that my head was covered when they prayed, see Figure 5.4. The women in the community are primarily involved in the processing of root and tuber crops rather than with production, which is labour intensive and deemed to be a man's job.

Figure 5.4

Focus group discussants and participants at the storage unit

Source: Olaniyan B. S. (2021, permission granted)

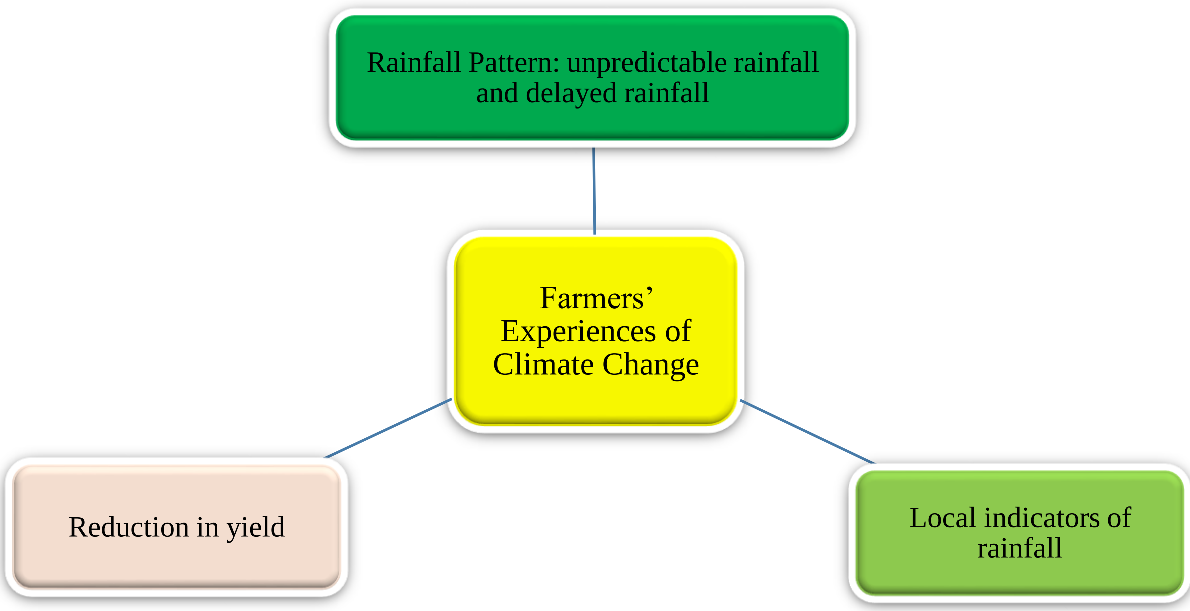
5.5 Farmers' Experiences of Climate Change in Alapa village

This section will be discussed with the aid of Figure 5.5. For this village the perceived experiences of CC could be categorized into:

a. Rainfall pattern (unpredictable rainfall and delayed rainfall),
b. Reduction in yield due to CC,
c. Local indicators of rainfall.

Figure 5.5

Categories of farmers' experiences of Climate Change in Alapa village



Source: Olaniyan B. S. (2021)

5.5.1 Rainfall pattern

In this village the major experience of CC has been the change in rainfall pattern. There has been a reduced amount and intensity of rainfall and later onset of rain, and in one particular year, no rainfall at all.

Question: About thirty years ago, when do rainfall begin? What of now; are there any changes in the rain density and the month which rain begins to fall or is it still the same as before?

Baba W: Rain fall starts from the month of April.

Baba D: The amount of rain fall was much before and rain fall begins from the month of March and stops by November.

Baba T: Yes, rain fall begins from April/May now.

Question: Have you experienced a situation where there is delay in rainfall? E.g., when the rain is expected to start falling by April but it was delayed till June?

Baba T: Yes, it has happened before. Our fathers shared the story of the event with us. The year was called 'ọdún afẹ́fúùfùta', that year it was only the wind that was blowing and no rainfall at all. But still all the crops that were planted grew well.

Question: Has anything been done locally or traditionally to change or correct this, that makes rain fall when it doesn't fall as expected?

Baba K: Nothing is done; the only thing done is to pray and God answers our prayer.

This confirms Malcolm et al. (2012), who noted that changing local precipitation patterns is one way that climate change will affect agriculture. Challinor et al. (2007) also mentioned that climate change was going to alter precipitation patterns and Akpodiogaga-a and Odjugo (2010) reported that there had been a reduction in the amount of rainfall in Nigeria and the number of rain days has also decreased.

The farmers noted that there had been a reduction in their yield because of occasions of delayed rainfall, unpredictability of the rainfall, theft and cattle entering their farms; all of which are linked to climate change.

Question: With the changes in the climate condition, has this situation done any harm to the crops most especially cassava and yam? For example, let's say eighty meters of land is being cultivated and the yield used to be three bags but now due to climate change, the yield has now reduced to one bag? Do you experience such situation?

Baba G: As there is a break in the rains currently, root and tuber crops grow well because too much rain also spoil the crops. Yes, there is reduction in crop yield. Crop yield isn't as much as it used to be as farming is not as buoyant as it was 30 years ago. By the time cattle has eaten out of *it, thieves stolen and some varieties that only grow during rainy season do not grow because of the late rains, what is left is not up to what it was before climate change (àyípadà ojó) sent the Fulanis down south and the rains became unstable.*

This view corresponds to Ajetomobi et al. (2011), who mentioned that change in rainfall patterns affects the cropping calendar; hence modifications in the growing season may lead to a drop in yield (p. 614). The effort of farmers in trying to adapt their farming activities to the changing climate sometimes results in crop failure as their calculations are not always accurate and the efforts like changing planting dates may have an adverse effect on the yield, rather than increase it (Adejuwon, 2005, 2006). This modification is done with the help of their indigenous knowledge of the environment, and the indicators that they look out for, as are discussed next.

5.5.3 Local indicators of rainfall

The farmers take aspects of their environment into account when predicting the timing of rainfall. Indicators include the intensity of solar radiation and direction of the wind.

Question: What are the local ways of identifying the rainy season? How do you know that rain will soon start falling?

Baba H: When there is severe heat and when the sun starts shinning so bright that it scorches the skin. Wherever you are, in the house, under the tree it would be hot, that means the rains would start soon. When the harmattan period ends and there is heat, there will be changes in the wind, the wind will become cold. Normally the breeze is hot during dry season so when you begin to feel cold breeze we know the rains are close-by.

Question: Is there no other thing, like the trees or the reaction of the birds, that are noticed when rain is about to fall?

Baba L: This is also part of the things noticed. Trees like igi osè (baobab tree; Adansonia Digitata) will start growing new leaves when the rainy season is near and birds perch on it but their nests are not visible then the rains are here. When the dry season is approaching, the leaves from this tree will wither off.

Question: Is there any other thing that is noticed like the sound of birds apart from the trees?

Baba J: The wind direction is also noticed, this is called àfẹ́kún, when the wind moves from west (right) to east (left) the rains are about to start and when the wind changes to the opposite direction (from east to west), the dry season is around the corner.

This supports Fitchett and Ebhuoma (2018), who submitted that farmers use markers from animals, plants and weather patterns, such as cloud cover, to predict rainfall for the growing season. Nyakaisiki et al. (2019) also noted that farmers use animal, plant and atmospheric predictors to forecast seasonal changes, which stems from their relationship with their environment.

5.6 Brief Description of Gaa Ogbe Village

Gaa Ogbe is a small settlement about 44km from the state capital city, Ilorin. The settlement is found near the major town Igbaja, in the Ifelodun local government area of Kwara state. The name Gaa is derived from the name the Yòrùbá people call the encampment of Fulani agro-pastoralists, which is usually on the outskirts of their town. This group of Fulanis have moved southwards and settled in the area, where they engage in crop farming and breed cattle. Their location is relatively stable, so alhough they may move when weather conditions become unbearable, they usually return to that same location after some time. The homesteads (*gaa*) usually accommodate an extended family of about 20 people, related by blood or marriage, and are often in remote areas far from the host community (Fasona et al., 2015).

After a long drive from Ilorin to Igbaja, we boarded a rusty van at Igbaja junction. After about 15 minutes of travelling, we entered the village settlement. On alighting, I noticed about 15 widely spread houses; they were round mud huts with thatched roofs. These villagers had originally been Fulani, but having stayed in the area for so long they now spoke Yòrùbá fluently. Indeed, the head of the settlement recounted stories of guarding their farmland as a young boy in that community.

The farmers plant yam, cassava, sweet potato, and cocoyam alongside maize, millet, beans and vegetables and they breed animals. They had perfected the art of domesticating guinea fowl by gathering the eggs from the forest and giving them to a domestic fowl to incubate. When the eggs hatched the chicks regarded the hen as their mother and learned to act as domestic fowl. We saw them that day with the hen, but *unfortunately the pictures were lost with my stolen laptop.*

Being a small settlement, only three farmers were available for the focus group discussion; the other three were at a function. The meeting was held at the home of the village head, who was himself a farmer. As we were waiting for the other two to arrive, he mentioned that the rain would start falling soon so the other farmers needed to arrive before it started. But he reassured us that the rain shower would not last long so there was no cause for alarm. As soon as the other farmers entered, the rain started and lasted 2 hours. Being female, the researcher was not allowed to have pictures of herself with these farmers, because their religious rules did not allow it, see Figure 5.6.

Figure 5.6

Cross section of focus group discussants and the EA

Source: Olaniyan B. S. (2021, permission granted)

5.7 Farmers' Experiences of Climate Change in Gaa Ogbe

The farmers in this settlement reported that climate change had had a negative effect on farming, even drawing agriculture backwards, using the words of Agbe S presented below.

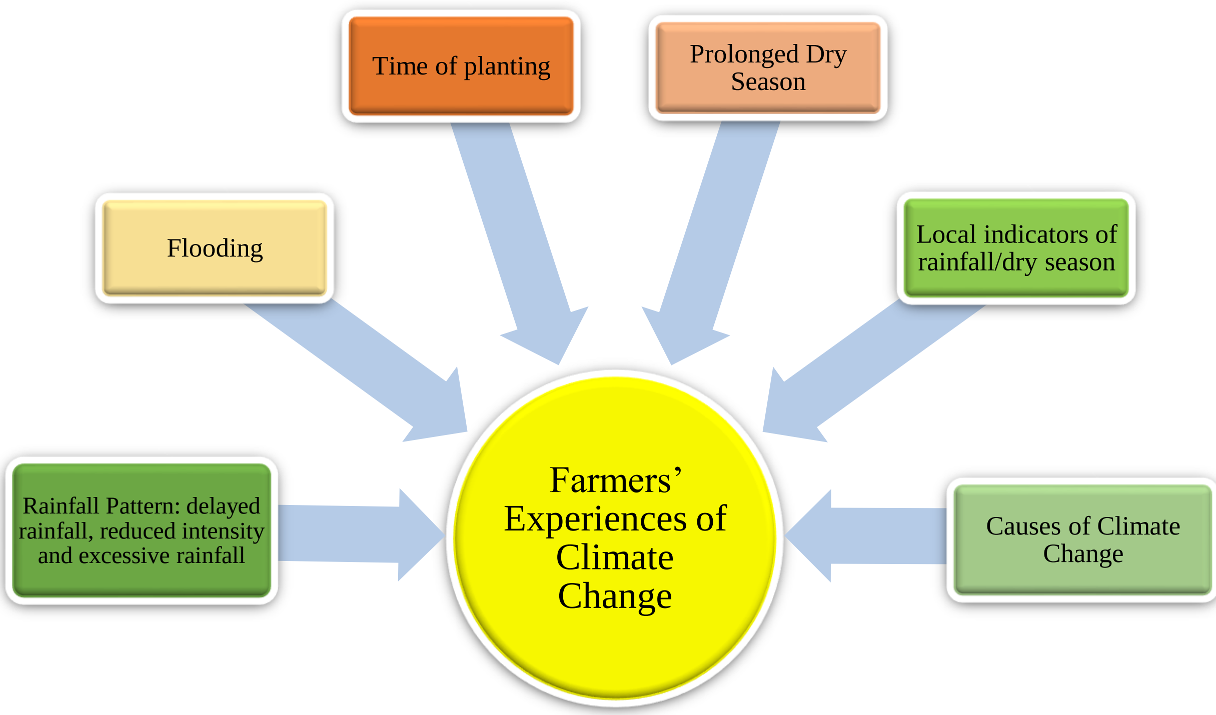
Agbe S: Climate change has drawn back agricultural processes and it has been affecting crops like corn and beans. There was a year that beans were planted and none of the farmers here were able to harvest anything because the rain stopped before time, so all the growing beans got spoilt because there was no water to keep it growing. The same thing also happened to corn and millet, *there are times that these crops will be planted and they'll grow well and sometimes they don't yield well. So the climate change has really drawn agriculture backwards.*

The categories to be discussed for this village, as shown in Figure 5.7, are:

a. Rainfall pattern: delayed rainfall, reduced intensity and excessive rainfall
b. Flooding
c. Time of Planting
d. Prolonged dry season
e. Local indicators of rainfall/dry season
f. Causes of climate change.

Figure 5.7

Categories of farmers' experiences of CC in Gaa-Ogbe village



Source: Olaniyan B. S. (2021)

5.7.1 Rainfall pattern

The farmers noted that the onset of the rainy season had changed over the years from January to April. They thought that the intensity had also been reduced, although they pointed out that there had also been incidences of excessive rainfall in the farming season that had led to farm crops getting spoilt.

Question: Can you tell us the changes that have happened to the climate. Like twenty years ago and now, what is the difference between the rain fall then and now?

Agbe S: The rainfall used to begin from the month of January but now it falls between the months of March to April. And the rain fall then was heavy and constant, those days it will fall in one part of the village heavily and not get to the other part. The rainfall amount was much then and was regular, rain fall now is no longer regular and the intensity has reduced.

Question: Have you ever experienced a period of time whereby rain fall started before the expected period of time?

Agbe T: Yes, in fact it happened a couple of times. But it rotates, for example, before when rain fall begins from the month of April, it may last till November. But now it's not so. When rain begins from the month of April/May, it now stops mostly in the month of October. We observe the rains before planting.

Question: Has it happened before, that the rainy season stops sooner than expected?

Agbe Y: Yes, it has. But this doesn't affect the yam. It only affects crops like pepper, millet, beans and corn. Once you have planted the yam at the appropriate time early/late onset of rain doesn't affect it. We do not do irrigation.

These weather events had also been mentioned by Mutekwa (2009) in his study on climate change adaptations and the effects perceived by farmers of CC on their farming activities. Edoga (2007) noted that the farmers' major concern is when the rain would start, how long it would last through the season and the possibility of the dry season being prolonged. Getting a hint into these parameters helps to ease their worries as touching their farming activities.

5.7.2 Flooding

The farmers recalled incidences of flooding in years back because of excessive rainfall that had led to farmlands being washed away, especially those by the riverbank, or the whole village becoming waterlogged. But they noted that such excessive rainfall had not happened recently.

Question: Have you experienced flooding before?

Agbe Y: Yes, it has happened before when crops were planted close to the river side, the whole crops were washed away by the water. We couldn't pick one crop out of the farm. Though this doesn't happen yearly, it only happens when the rain is heavy. It swept the land away and it happened after 5 years. But it has reduced because the rainfall amount has reduced. The whole village used to be waterlogged before

Question: What was done after the event of the flooding?

Agbe Y: Nothing was done to it. What happened is that erosion doesn't wash the farm away yearly, this only happen in years when the rain fall is much. We do not abandon the farmland because the year one doesn't plant there, might be the time another person will get a bumper harvest when they plant there.

Adeoye et al. (2009) reported that, in Nigeria, flooding had become a major issue, which led to loss of lives and properties with farmlands being submerged in water for weeks and in some cases being washed away. This corroborates the farmers' record of flooding in the excerpt above. Adedeji et al. (2014) also mentioned seasonal flooding as one of the manifestations of climate change though the farmers in this village noted that flooding is no longer a frequent occurrence for them due to reduction in the amount of rainfall. Adesina and Odekunle (2011) recommended the planting of cover crops like beans, groundnuts and sweet potatoes to reduce sheet erosion due to flooding. Nwaiwu et al. (2013) reported that flooding occasioned by torrential rains does happen in Nigeria and this has led to soil erosion and loss of farm crops, just as the farmers explained while recounting their experiences.

5.7.3 Time of planting

Another consequence of climate change identified by the farmers was a change in the time of planting. They noted that due to the change in the rainfall pattern they had to modify the planting time for most crops, though for root and tuber crops they maintain the time of planting as delay in time of rainfall or drought has less effect on these crops, provided they take the necessary precautions. It is pertinent to note that sometimes, despite all their precautions, extreme weather may still affect root and tuber crops.

Question: You have already talked about when to plant yam, cassava and potato. And you said that these are planted when rain starts falling, have you ever experienced a period of time whereby rain fall started before the expected period of time?

Agbe S: Yes, in fact it happens a couple of times. But it rotates; for example, before when rainfall begins from the month of April, it may last till November. But now it's not so. When rain begins from the month of April/May, it now stops mostly in the month of October. We observe the rains before planting.

Question: So how does this affect farm crops?

Agbe T: It affects farm crops but it does not really affect yam. It only affects crops like maize and millet. The rain may stop falling while these crops are still growing and the yield will be low.

Question: Has it happened before that rain fall stops sooner than expected?

Agbe Y: Yes, it has. But this doesn't affect the yam. It only affects crops like pepper, millet, beans and corn. Once you have planted the yam at the appropriate time early/late onset of rain doesn't affect it. We do not do irrigation.

Adebayo et al. (2012) reported that farmers in Adamawa state, Nigeria, had identified altering planting schedule as being one of their strategies for adaptating to climate change. Below et al. (2010) also submitted that small-scale farmers in Africa adopted different timing of farm practices as a way of adapting to climate change.

5.7.4 Prolonged dry season

Another effect of climate change that the farmers noted was prolonged dry seasons. Although they noted that is does not happen every year, when it does it has debilitating effects on all their crops, even yam that seems to be resilient to other expressions of CC change. The farmers pointed out that cassava was the only root or tuber crop exempt from this effect.

Question: Have you experience prolonged dry season?

Agbe S: Yes, this happens but it doesn't happen yearly.

Question: When it happened, did it have any side effect on yam or cassava?

Agbe T: The thing is that the time when rain was supposed to start, it didn't and the yams have started growing then dry season came in to stop the rain, the yams didn't grow well. Then another set of yam seeds were now planted because there was delay in rainfall. But this didn't affect the cassava planted.

Question: So rain doesn't really affect yam but prolonged dry season can?

Agbe S: Yes

Question: What will now happen to the yam during the period of prolonged dry season, will it get dry?

Agbe S: Yes, the yam will get dry from the roots even when it is still in the heap and get burnt.

Bello et al. (2012) concluded that rainfall was reduced and becoming more unpredictable as Nigeria experienced the most common features of climate change, as was confirmed by the farmers in this study. Ogbeibu and Uyigue (2008) submitted that farmers who plant immediately after the first and second rains make huge losses if the subsequent rainfall is delayed and the crops are burnt on the farm. Climate change has disrupted the local calendar, by which the farmers run their farming activities; thus, the changes in weather pattern affects agriculture in Nigeria adversely. Enete and Amusa (2010) also stated that when the temperature rise exceeded what the plants could bear during a prolonged dry season, the crops become stressed, which reduces the growth rate and eventual yield.

5.7.5 Local indicators of rainfall/dry season

In order to effectively plan their farming activities, the farmers use some physical aspects of their environment to predict seasonal changes. Such knowledge has been passed down through the ages; it is now more useful as the official channels of forecasting weather have failed while these phenological markers have remained predictable. Things like trees sprouting leaves and the behaviour of birds have helped them predict when the rains will start, even they are delayed.

Question: On Sunday, we were on our way back to Ilorin when they said that rain will soon start falling. And truly we were drenched in the rain till we got to Ilorin. So how do you locally identify the rainy season.

Agbe S: (chuckles) you have really come to learn, there are different ways of knowing. According to what we were taught by our fathers, if the weather has been cold before then an intense heat occur that scorches the body, it is a sign that rain will soon start falling.

Question: What are the other things that serve as a signal that rain will soon begin? Things like animals, trees, and birds etc.?

Agbe T: They are quite many, we have a tree called Igi osè (baobab tree), during the dry season, this tree usually shed off all its leaves but when new set of leaves are noticed on this tree, it means rain will soon start falling and then the wind will start blowing very well. Once the wind changes direction, we expect rains within 3 days of such occurrence. We also have a tree called Igi fuúfù when this tree start growing, it also a sign that rain will soon start falling.

Question: The baobab tree that you mentioned earlier, is it also changing with the climate?

Agbe T: Yes, it is.

Question: So, you will still be able to know when rainfall will begin.

Agbe T: Yes, we know.

Question: So, what are the local ways of knowing the dry season is near?

Agbe S: There is a bird called àṣá (hawk) when the rain is about to stop falling, this bird will be seen in the sky, it won't fly around the sky, it will just spread out its wings and stay still in the sky. The rain may fall once or twice after this before it stops. The wind direction is also one of the things to take note of.

Question: When the rain is about to stop falling, the way the wind blows, is it always heavy or light?

Agbe Y: When the rain is about to stop falling, there is reduction in the way the wind blows.

These indicators are similar to those identified by Abdulrashid (2020) as being used by farmers in Katsina state to forecast the weather and so help make taking prompt action to avoid flood disasters. Furthermore Makwara (2013) documented that indigenous people in Zimbabwe use the appearance of some animals and the flowering/fruiting pattern of some plants to forecast the weather. Okonya and Kroschel (2013) also noted that farmers in Uganda identified that they feel intense heat, wind blowing from east to west and some trees shedding their leaves when the season is about to change.

5.7.6 Causes of climate change

The farmers believe that God is in charge of whatever happens with the weather and life generally. This was reflected in their responses about what caused climate change and what they do to mitigate the effect of extreme weather conditions.

Question: What do you think is the cause of climate change?

Baba S: I can't really pinpoint the cause of climate change, but I think God is doing what pleases him. We only take note of the weather and also follow what it dictates.

Question: So, what are you doing to prevent whirlwind?

Agbe S: Nothing is done to protect the farm from whirlwind, we only pray and beg God about it. Though we do attend workshops and we were told to always plant trees.

This is in agreement with Boillat and Berkes (2013), who reported that Quechua farmers stated that lack of respect for their culture which angers the gods and the Christians prediction involving disasters towards the end of ages have caused climate change. Ahmed and Haq (2019) reported similarly among the indigenous people in Bangladesh. When their perceptions were sought on climate change most said nature or God was responsible for climate change.

5.8 Brief Description of Iludun Oro Town

Iludun-Oro is a small town in Irepodun local government area that is 48 km from Ilorin, the Kwara capital city. The town is one of the nine communities that make up Oro kingdom in Kwara state. It is a peri-urban community possessing both rural and urban characteristics. The houses are modern and the access road is paved with asphalt; in the town there is a microfinance bank, a central mosque, several big churches and various small-scale businesses. There is a college of education in the larger Oro town and students from the college are resident in the town.

Alongside this evidence of modern urbanization, there are large expanses of farmland, where the indigenous farmers plant yam, cassava, sweet potato, maize, rice, beans and cashew nuts. Some Hausas, who have migrated from the northern part of Nigeria, plant large quantities of Okra. The presence of the nomadic Bororos herdsmen, who were believed to have crossed into Nigeria from other neighbouring West African countries in search of greener pastures for their animals, is a source of tension as their herds leave a wake of destroyed farm products.

The farmers have access to loans which they source from the microfinance bank, which has boosted their productivity. Nevertheless, this means that they have run into debt if their crops have been destroyed by cattle invading their farmlands. Even when one of them switched to growing melons (*ègúsí*), which cows do not eat, the herdsmen set the cattle onto the farm and all the growing crops were destroyed by being trampled underfoot. They also raise chicken and goats for household consumption and, when necessary, a source of emergency funds. It is pertinent to note that only five farmers participated in the focus group discussion (see Figure 5.8) as there were other farmers' meetings that day. Efforts to reschedule our discussion were futile as the harvest season was approaching, and the farmers were fully committed.

Figure 5.8

A cross section of focus group participants in Iludun-Oro

Source: Olaniyan B. S. (2021, permission granted)

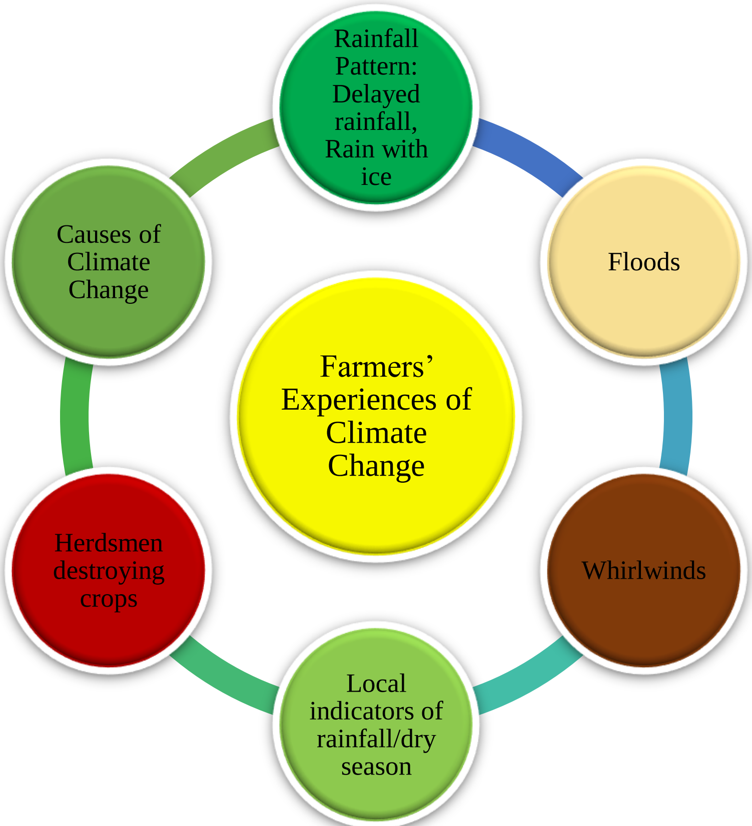
5.9 Farmers' Experiences of Climate Change in Iludun-Oro

The farmers had a lot to discuss about climate change. Their responses were categorized into recurring themes, which are discussed, with the aid of a pictogram shown in Figure 5.9 under the following subheadings:

a. Rainfall pattern
b. Floods
c. Whirlwinds
d. Local indicators of rainfall/dry season
e. Herdsmen destroying crops
f. Cause of climate change,

Figure 5.9

Categories of Farmers' experiences of CC in Iludun-Oro



Source: Olaniyan B. S. (2021)

5.9.1 Rainfall pattern

One of the changes the farmers noticed in the climate has been a change in rainfall pattern, which takes the forms of delayed onset of rainy season, rain falling with hail and excessive rainfall leading to floods.

Interviewer: It has been noticed that the climate is changing. I want to ask what the rainfall intensity was like some years back and how it is now.

Mama M: It has changed.

Sir O: In the olden days, rainfall begins from the month of February; this is the month that farmers will start making heaps, those that would make ridges for maize, groundnut etc. and the type of maize they plant then grows for three months. They plant the white maize then but now not all farmers plant the white maize. Some maize will be all white and some have a touch of red, by the *month of august all maize would have gotten dry but it's not so now. But now, rain starts between mid-April and May.*

Mama M: It is as if it doesn't rain because the rain falls once and stopped then come back around August so we may not count that of April/May as rain.

Sir P: We also experience the falling of ice from the sky too during this time.

These responses are in agreement with Idowu et al. (2011), who posited that climate change influences crop production negatively in the form of unpredictability in the rainfall pattern, floods and increased incidences of crop pest and diseases. Ishaya and Abaje (2008) also reported that indigenous people in Nigeria had noticed a reduction in rainfall and a shift in the timing of rains, which they had garnered from their indigenous experiences.

5.9.2 Floods

Another expression of climate change identified by the farmers was cases of floods, which they said started recently refelcting the change in weather pattern. The floods led to loss of farm crops planted in the lowland (by the river bank) and upland (lands far away from the river bank).

Interviewer: Do you experience flood?

Mama M: Yes, we do experience it; especially for those of us that plants rice.

Interviewer: And flooding doesn't happen before right?

Mama M: It never used to happen before, but it started few years ago and the flood use to wash away all the rice that are planted on the farm. The previous year around July ending till August, all the farm crops like the yams that are planted on the upland, rice and cassava were washed away by the flood from July till August last year.

Ogbo et al. (2013) identified that as the earth warms up, the rainfall pattern changes, which makes weather extremes like floods become a frequent occurrence. These disasters are a result of long-term changes in the climatic condition that had only manifested itself much later. This buttresses the farmers' point of view that flooding started recently. Wahab and Ojolowo (2012) also stated that the occurrence of floods in rural areas is particularly worrisome because of the loss of crops and farmlands.

5.9.3 Whirlwinds

Whirlwinds are another form of weather extreme that they identified. They pray to God to avert this disaster and/or protection when it does happen. They do not cut down the trees as they serve as windbreaks protecting their houses.

Interviewer: Do you experience heavy wind here?

Sir P: Yes, we do experience it but it has its own time. We mostly experience this during the first rainfall of the year and when rainfall is about to end.

Interviewer: So, as a community according to what you said that some people call the rain, what have you been able to do concerning whirlwind?

Mama M: We pray and we also keep trees.

Interviewer: So you don't cut down all the trees?

Mama M: Yes, we don't cut down all trees, we reserve them.

This is in agreement with Zięba et al. (2020), who noted that whirlwinds as a form of windstorms have become common due to climate change. In addition, Boissière et al. (2013) reported windstorms happening in Papua Guinea due to climate change.

5.9.4 Local indicators of rainfall/dry season

In trying to stay afloat amidst the changes in the weather pattern, the farmers use their knowledge of local indicators to forecast the weather and help them make decisions about their farming activities.

Interviewer: You know when the rain is about to fall, we only know when the sky gets darker, but what are the local signs that makes us know that the rain will soon begin to fall or that the dry season is getting near?

Mama M: We take note of the weather, when there is intense heat and it is becoming unbearable, it is a sign that the rain will soon begin to fall.

Interviewer: Apart from this, is there no other thing like tree or like the sound made by an animal?

Agricultural extension officer: It was also said that there is a bird and whenever this particular bird makes sound, it means it is calling on the rain.

Mama M: Yes, that is Ẹ̀lúlùú.

Interviewer: Is it Ẹ̀lúlùú that used to make sound like òdéré kókò and we call it òdéré kókò?

Sir N: That is Àdàbà (dove).

Mama M: No, Ẹ̀lúlùú is different. It is Àdàbà (dove) that use to make òdéré kókò sound.

Interviewer: So when that bird starts making sound, it means the rain will soon fall and when the grass also grows flowers it means the rain will soon stop.

Agricultural extension officer: it is also said that when sugar cane plants starts having flowers.

Interviewer: What does that signify? Does it mean that the rain will soon stop or it will soon begin to fall?

Sir P: It means that the dry season will soon commence; also, when white birds start flying.

Mama M: The birds that moves with cows

Interviewer: Which bird is that?

Agricultural extension officer: Cow egret

Sir N: When this bird starts flying it is a sign that the rain will soon stop.

Sir O: Lékeléke (cow egret) cannot be relied on because it follows the cows almost all the time. But it is only this bird Ságogo and Ìrìrì (àṣá). When these birds Ságogo and Àṣá dúdú starts flying *like now they are inside the tree and you can't see them around now, but when they start flying again, that means that the dry season is near.*

Interviewer: So there is no tree that also gives signal? Like this igi Ọdán, does it have any signal it gives?

Baba N: It doesn't give sign; its leaves fall off normally during the dry season when there is no rain at all. And it also starts growing new leaves in the dry season.

Interviewer: So when this tree starts shedding its leaves, it means we have entered deep into the dry season?

Baba N: Yes

Interviewer: Is there any other tree?

Mama M: Yes, cashew tree too, when the dry season is drawing near, the leaves starts turning red.

Interviewer: So this is how you know when the rainy and dry season is about to commence, birds like Ẹ̀lúlùú, Ságogo and Àṣá? Is there is no way through which we can use the Ẹ̀lúlùú bird to call the rain when there is no rain

Sir P: No, the bird calls on the rain naturally, when we are not rearing the bird, the bird cannot be commanded.

Mama M: It is only those that are into traditional medicine that can do that.

Wahab and Ojolowo (2012) identified local indicators that are used by various communities in some parts of the world, including Nigeria, to predict seasonal rainfall; these might include behaviour of birds, activities of insects, emergence of leaves or otherwise on some trees and cloud formations. Similar indicators were mentioned by the farmers, as shown in the excerpts above. I must note that at the start of this meeting it was a sunny day with a clear sky but one of the farmers told us to finish on time as it would rain heavily within the next two hours. Exactly two hours after this statement, the rain started, and lasted the whole night. We got back to Ilorin in that heavy rain.

5.9.5 Herdsmen destroying crops

The farmers noted that there has been an increase in the influx into the area of cattle herdsmen from the northern part of Nigeria and some West African countries in search of grazing for their animals. This had led to conflicts as the cattle enter farms and eat the growing crops. They alleged that the herdsmen sometimes intentionally set the cattle loose on farms owned by people that had challenged them and there were cases reported daily of people being attacked and even killed on their farms by these herdsmen. The issue of the herdsmen was a recurring theme in our conversations, which the farmers repeatedly mentioned as shown in the excerpts below.

Interviewer: Do you plant the orange flesh potato here?

Mama M: Yes, we planted it but the Bororos (nomadic herdsmen) and their cattle don't let most of our crops grow.

Extension agent: That is a national issue, whenever we go to communities to give them inputs, we call a meeting of farmers, cattle breeders, village heads and police to facilitate peace.

Mama M: Our situation here is worse. It warrants us going to see the head of the Bororos (Seriki) because they are disturbing us a lot. The cattle breeders sometimes get to the farms before dawn. There was a time they were found on my farm around 2am. As big as the melon farm is, last year all my crops were eaten. They started from my first farm, all the maize that I planted was eaten by the cattle then they moved to the second farm before they now started invading other farms. They toured around all the farms. I know the amount of yield I do reap on my rice farm yearly but because my crops were eaten by the cattle I couldn't harvest much.

Sir N: We lost millions of naira last year.

Mama M: Because of the damage that was caused by the cattle's last year, I decided to plant melon this year, but still all the melons were marched by the cattle and it is not as if my farm is small.

Sir O: It is acres of land

Agricultural extension officer: Is it the king of this place that gave the Bororos the chance to rear their cattle here or is the Bororos also living on this land?

Sir P: There are some of the kings that give them lands, and the ones that were given lands to rear their cattle are not causing harm, but the Fulanis that wander around. And then there are some that gives chance to those that wander around. If order is given by the government, there will be changes.

Various studies have reported an increase in clashes between farmers and herdsmen as a result of the farmers' encroachment on grazing routes and the herdsmen setting their cattle loose on farmlands to consume the growing crops. Many lives and properties have been lost in reprisal attacks on both sides. The struggle for land use has been exacerbated by dwindling vegetation due to overgrazing and climate change in the north and competing land usage by other sectors in the south, both of which have reduced the land available for farming. Furthermore, the rapidly growing population of Nigeria puts increasing pressure on the agricultural sector to feed the population. It is pertinent to note that the relationship between the herdsmen and their host communities used to be cordial but things went sour when the boundary of respect for each other's resources was breached (Dimelu et al., 2016; Ezeonwuka & Igwe, 2016; Ikezue & Ezeah, 2017; Ofem & Inyang, 2014; Ukamaka et al., 2017).

5.9.6 Causes of climate change

The farmers had an intriguing perspective on the causes of climate change, which they attributed to the activities of Hausa farmers in their community, who plant okra. The Hausa were believed to perform rituals that delay the onset of the rainy season so their okra crops can grow well.

Mama M: We also observed that in an area where okra is being planted, before if they plant okra around March or April, rain will fall after that. But now they have started planting it late and the more they plant it late, the more the rain will be delayed. I noticed that. It was said that those that plant okra have a traditional way of preventing the rain from falling. I don't want to believe this statement before, but for the past three years, I have also been observing and believing that the statement is true. These okra farmers were chased away from Sao, even in my town, the okra farmers also requested for a land because we have a big river called Odò Ọ̀tìn but our king didn't give them because it is said that in a town where okra is planted, they don't let rain fall. Once the clouds gather the okra farmers start burning some charms and the rain will not fall.

Sir P: And it is noticed that in this Ìrẹ́pọ̀dúǹ town, we have problem with rain every year. And in this town, people come to buy okra from different places, they hit millions of naira and they use trailers to export the okra and it is affecting other crop farmers. Because I have even gone to speak to one of the okra farmers that if it is that way, I will also come and join them in planting okra.

Tume et al. (2019) have reported community leaders and seers invoking the god of rains at the beginning of the rainy season to ensure a good harvest. But for this town, the purported rituals were made to stop the rains from falling. Buchanan (1943) gave a detailed description of such rituals to stop the rain in Nyasaland.

5.10 Brief description of Kaiama Town

About 150km from Ilorin, in the northwest of Kwara state, lies the town Kaiama, in the Kaiama local government area. It has an agrarian society that is known for their big yams and yam flour (*èlùbó*) used to prepare *àmàlà*, which is a popular delicacy amongst the Yòrùbá people. Kaiama is called the food basket of Kwara state because the major economic activity of the area is farming; yam, cassava (*pákí*), sweet potato (*kukundunku*), guinea corn, soya bean, melons, groundnut and beans are grown in large quantities.

The people of Kaiama are known as the Bokobaru, which is their language, although the people also speak Fulani, Hausa and Yòrùbá. Their mode of farming yams is to make bigger heaps and to use whole tubers rather than yam cuttings or yam mini-sett, as are used in other places. This results in bigger yam tubers during harvest. The smaller tubers are divided into two groups; some are processed into *èlùbó* while others are kept as seed yams for the next season.

5.11 Farmers' Experiences of Climate Change in Kaiama

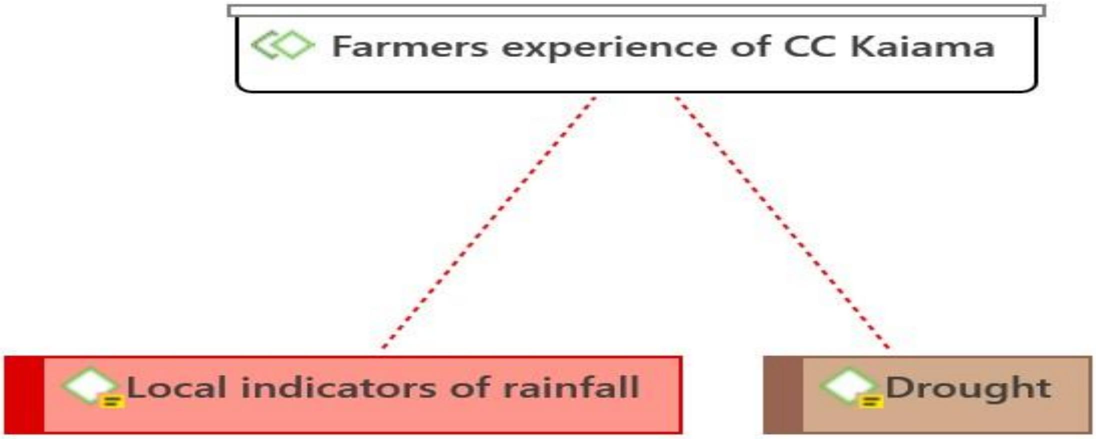
For this village the farmers noted drought as being the major problem. This is because the village is located in the Guinea savannah and the vegetation cover had been thinning over the years. Hence the data in this section would be discussed under just two subheadings, as shown in Figure 5.10, namely:

a. Drought
b. Local indicators of rain.

The data for this village was scanty as the researcher could not travel to Kaiama because of the bad roads, so an extension officer was trained and sent there but the data returned was not as probing as the researcher would have liked. There are also no photographs for the village, only audio and video data.

Figure 5.10

Categories of Climate Change in Kaiama



Source: Olaniyan B. S. (2021)

5.11.1 Drought

The farmers reported a change in rainfall pattern, which the explained as the dry season being longer than usual.

Interviewer: Are you aware that there is change in weather. If yes, for how long have you known?

Mallam A: I observe changes in the climate every year.

Interviewer: How do you predict rain locally?

Mallam S: There is a difference in how to predict rain. Sometimes the rain may begin by May in a year and starts falling by June the following year. But the yam growth is still very OK.

Interviewer: How do you manage your farm during long drought?

Mallam S: I make mulch, so that the penetrations of the sun will not destroy the yam. In the case of yam, more heaps are made during long drought. Ridges can also be made but you need to get very big mounds.

Ayinde et al. (2018) researched farmers' vulnerability to climate change in Kwara state, and reported that, amongst other factors, the farmers identified drier weather as an indicator of changing climate. The data also showed that the farmers in Kaiama perceived a longer dry season than usual.

5.11.2 Local indicators of rainfall

The farmers observe the direction of the wind, cloud cover and the temperature to predict when the rains will start in order to plan their farming activities, because they plant different varieties of yam at different times during the year.

Interviewer: How do you predict rainfall?

Mallam A: If the wind is blowing from the northeast and the clouds covers the sky from there and the blowing of wind cease, then it means that no matter how the rain will fall.

Mallam S: The rain can be predicted during heat period after the harmattan. If the harmattan is prolonging and the heat is getting longer for like two to three months, that is rain is about to commence. When the cloud is covered and there is reduction in wind, then it means rain will soon fall.

5.12 Brief Description of Yeregi village

Yeregi is a small agrarian village in Moro local government area, about 36km from the state capital Ilorin. Though the village is close to Malete, where Kwara State University (KWASU) is located, it remains relatively untouched by the modernization evident in the area arising from its proximity to KWASU. On arrival at Malete, we (the researcher and EA) had to board motorcycle as that was the only means of transportation to Yeregi. The access road was flooded as it was the middle of the rainy season and we frequently had to stop to avoid being drenched by the trucks conveying sand from the villages along that route for sale in the city.

On getting to the village, the only modern building was the central mosque, the houses were built with mud and old iron roofing sheets. All around were small garden plots with different crops planted on the same heap, which we were told was to maximize space and ensure there would be food close by in situations where the villagers could not get to the main farm. This garden is called *oko etílé.* Right beside the gardens were a raised platform where cassava was being dried for eventual processing into cassava flour, known as *láfún*, see Figure 5.11.

Figure 5.11

Sights from Yeregi Village

Footnote

A. *Raised platform for drying farm products, cassava being dried at varying stages of pulverization.*
B. *A heap where okra, amaranthus, cassava, maize and yam were planted together in a mixed cropping system.*

Source: Olaniyan B. S. (2021)

Inhabitants of this village are predominantly Muslims of Yoruba extraction and the contact farmer had to go and inform the Chief Imam that we had arrived. After he gave his blessings and other farmers were sent for. While waiting for them, the Chief Imam came out to see who the researcher was, after assessing that I was properly dressed, with my head covered, he told us to go ahead but to keep in mind and factor into our schedule that Jumat prayers were held at 2pm. We did this, and at 2 pm we had a break while the farmers went for Jumat.

In the bush around the village live the Fulani herdsmen; their women could be seen hawking milk curds (*wàrà*) in the village. One incident of note was when we were on our way to the bigger farm. When the farmer and I were almost there, a Fulani man was coming towards us. The farmer told me to move to his left side so he positioned himself between the Fulani and myself. He then started making small talk with the Fulani in Hausa language telling him that he could not afford to pay bride price for this one, as the herdsman would have to sell all his cows and the money would still not be enough to pay the bride price as I was a married woman. When he left, the farmer then told me what transpired in the conversation and emphasized that we had to finish on time as the herdsman could come back to attack us, and the farmer was not armed. Then the EA arrived and asked what had transpired because he had met the herdsman on his way and was worried we might be in danger. The EA then volunteered to walk down to the farm while the farmer took me on the motorcycle.

On the farm, they plant yams, cassava, sweet potato, cocoyam, maize, millet, okra, leafy vegetables and melons; large quantities of all theses are sold in the big market at Malete during the cyclical market days (i.e., every 5 days).

5.13 Farmers' Experiences of Climate Change in Yeregi village

Farmers in this village identified that the weather pattern had changed over the years and were able to succinctly articulate the changes they had noticed, such as an altered rainfall pattern, reduction in the intensity of the rain, incidence of strong winds, prolonged dry season and floods. Their responses were categorized and will be discussed under the following subheadings:

a. Rainfall: Unpredictable rainfall, reduction in rainfall intensity.
b. Floods
c. Drought
d. Whirlwinds
e. Reduction in yield

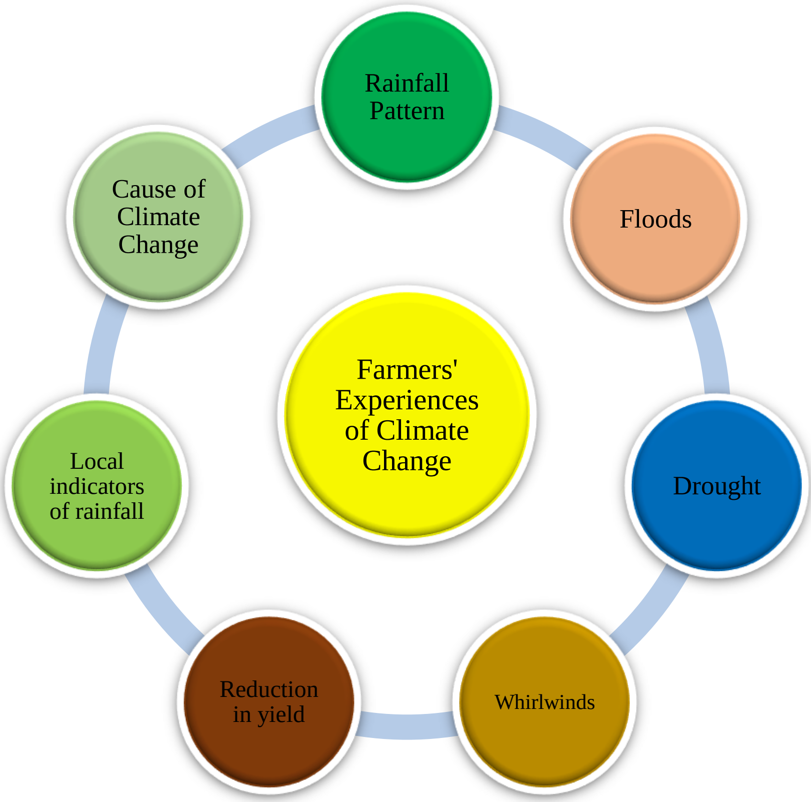
f. Local indicators of rainfall

g. Cause of climate change

A pictogram is presented in Figure 5.12 to aid the discussion.

Figure 5.12

A representation of the categories of Farmers' experiences of CC in Yeregi



Source: Olaniyan B. S. (2021)

5.13.1 Rainfall pattern

Changes in the rainfall pattern is a major CC issue for the farmers as their farming activities depend on the rainy season. They identified that rainfall had become unpredictable as the rainy season had sometimes started earlier than expected but also that it sometimes was delayed. They also noted that the rainfall intensity, which they referred to as *owó òjò*, had been reduced compared to earlier times when the ground would be soaked.

Interviewer: How was the rain back in those days and now? What have you noticed that has been different about the climate?

Man 1: For instance, back then if the rain should start falling from the month of April, it will fall regularly that even if you plant yam on a stony land, the land will become tender. But now, rain is falling truly, but if the rain should fall heavily today within a month the rain may still be falling in between but it won't be heavy. The intensity has reduced.

Local people in Kwara state understand that irregularities in the timing, amount, duration and onset of rainfall is on the increase, as reported by Tunde and Ajadi (2019). The responses of the farmers are in agreement with this previous study.

5.13.2 Floods

Flood used to happen in this village in the old days, but channels had been built to allow the water to pass through and drain water from the village during heavy rainfall. These gutters are cleared regularly to forestall flooding. But the road leading to the village was waterlogged as there was no drainage channel.

Interviewer: Have you ever experience flood here?

Man 2: No, our settlement is not close to the river and houses are not built closer to each other.

Interviewer: What of years back in the olden days?

Man 3: They built houses with mud then and when the rain is heavy, it does happen. So we created a channel for the water to pass through; flooding only use to happen when the channel is blocked.

Interviewer: So you must make sure that the channel is not blocked?

Man 4: Yes, we make gutters for the water to pass through.

This is in agreement with Adeoye et al. (2009), who submitted that flooding happens in places not close to the coastal line or rivers when there is no surface drainage or the existing drains have become blocked through negligence.

5.13.3 Drought

The farmers identified that there had been incidences of no rain at all in some previous years but this had now changed to being prolonged dry season which affects their crops.

Interviewer: Has it ever happen that there was a time when rain didn't fall at all, called drought?

Man 5: Yes, it happened some years ago that we have been expecting that rain will fall in the month of May, we have planted maize and rain didn't fall at all and all the crops that were planted didn't grow.

Interviewer: Is there increase in the dry season? I know there was a time that it was said that rain fall for five months and this sun now shines more than before.

Man 1: Yes, we have prolonged dry season, it is either the rain doesn't fall early or it stops earlier than expected. We make heaps and immediately the rain starts falling in the month of April we start planting, because we don't know the pattern through which the rain may take.

Previous studies have reported increased temperature in Kwara state and other parts of Nigeria with the resultant effect of drought because of the change in rainfall pattern (Ishaya & Abaje, 2008; Ladan, 2014; Mortimore, 2010; Ogbo et al., 2013; Tunde & Ajadi, 2019). This supports the farmers' responses that they are aware of the changes in the weather pattern over time.

5.13.4 Whirlwinds

The farmers also mentioned that there had been increased occurrence of whirlwinds (*ìjì líle*) which could be very bad at times and take down many trees in the surrounding bush. And they reiterated that it is now a common occurrence.

Man 2: Another thing that is noticed is that the wind blows a lot now, there was a time that the wind tide was very strong and it fall a lot of trees in the bush. And there are times that the rain is will be falling in the neighbouring village and it won't fall here. Instead of the rain to fall, it will only make the wind blow.

Interviewer: You mentioned something about the wind tide that it fell trees, is this common here.

Man 6: Yes, it happens frequently here. Before we only experience strong winds when the rain is about to fall and when it is about to stop falling.

The farmers' assertion is supported by various articles that have noted strong winds as one of the expressions of climate change (Ayinde et al., 2011; Ifeanyi-obi et al., 2012b; Ifeanyi–Obi & Nnadi, 2014)

5.13.5 Reduction in Yield

A consequence of climate change that the farmers have to deal with is reduction in their annual yield due to the stress on the crops brought about by early or late onset of rains that disrupts the growth cycle of the crops. Consequently, the farmers refuse to plant if the rains had not arrived as they do not want to lose their crops. They have, for example, had to change to other varieties of yam that mature earlier, but for which the yield is not as good as those that they had abandoned.

Interviewer: As we have been saying that there have been changes in the climate, like where I went to yesterday, they said rain use to begin in the month of February before but now in the fourth month they may still be expecting the rain to fall. So, in a case where you have prepared the heaps and you have seen the first and second rain and the yams have been planted and then the rain stops, what do you do then?

Man 6: There is nothing that we do, if the yam has not started growing before the rain stops, it will be left in the soil and when the rain starts falling again, the yams will grow but it may not be big. And if the yams have been growing before the rain stops, there are times that it will survive and sometimes it doesn't.

Man 4: There are some yams that we do harvest in the dry season then like Pàsá, Bọ̀rkí and we don't really plant them again instead we plant ódàbí ìyàwó (new yam) because this yam grows faster than others, but its disadvantage is that this new yam is not as thick as the other yams.

Man 1: In a case like that when the rain falls earlier than expected, we don't plant anything because the rain may stop half-way and then begin to fall again at the normal time when it is expected to fall. When rain fall at the unexpected time, we sometimes plant ègúsí (melon) or yangan (maize).

Obayelu et al. (2014) noted that reducing crop yields was one of the threats climate change has posed to agriculture. Other studies have noted an increase of pests and diseases due to climate change, which also leads to loss of farm crops (Kalu & Egbe, 2011; Olaniyi et al., 2019; Oluwasusi & Tijani, 2013; Oyekale & Oladele, 2012; Ozor et al., 2010).

5.13.6 Local indicators of rainfall

Since the timing of the onset and end of rainfall is now unpredictable, the farmers use their indigenous knowledge to predict rainfall and plan their farming activities accordingly.

Interviewer: Is there any other thing that you see as a sign that makes you know when the rain is about to stop falling apart from the wind direction?

Man 2: Yes, the cloud also gives a sign. There will be a particular time when the sky will be clear and there will be no cloud but when you start seeing the cloud again, it means that the rain will soon start falling.

Interviewer: So is there any other sign that you see apart from, maybe like a tree or animal?

Man 3: Yes, there are some other things like this tree here, igi osè (baobab).

Interviewer: Baobab tree?

Man 3: Yes, even if there is no rainfall at all but as soon as this tree starts growing new leaves, and there is no bird nesting on this tree, there's crop that is planted during such time that won't grow.

Interviewer: Does it shed its leaves?

Man 4: Yes, all its leaves.

Interviewer: So, it means that when it starts growing new leaves, it means the rain is near and when it starts shedding leaves it is a sign that the rain will soon stop falling?

Man 5: Yes.

These indicators are consistent with those identified by Boillat and Berkes (2013) who noted that the form and colour of clouds are used short term weather predictions. Jiri et al. (2015) also submitted that farmers use tree phenology, animal behaviour and cloud cover to predict the rain.

5.13.7 Cause of climate change

Whereas science has indicated that climate change is as a result of greenhouse gases being trapped in the atmosphere causing Earth's temperature to increase. Human activities like indiscriminate felling of trees have exacerbated the problem. By contrast, the farmers blamed climate change on the sinful actions of men that led to punishment from God.

Interviewer: Now that the climate is changing, is there anything that we have been able to do about it and the effect it is having on farm crops?

Man 1: We have not been able to do anything, we look up to God and we pray; though we have been informed earlier that there will be some changes in the climate and that there will be changes in the rainfall. Our behaviour is what is affecting the climate and making it change. Our sins are too much.

This stance by the farmers agrees with Fabiyi and Oloukoi (2013), who posited that "Indigenous knowledge and practices of the local population are entrenched in religious beliefs, culture and past experiences of the people". Furthermore Boillat and Berkes (2013) reported that local people in Bolivia believed that lack of respect for their customs and people's bad lives and infidelities had been responsible for climate change. Ahmed and Haq (2019) also reported that the indigenous people in Bangladesh noted that sinful human acts are inviting climate change (p.685).

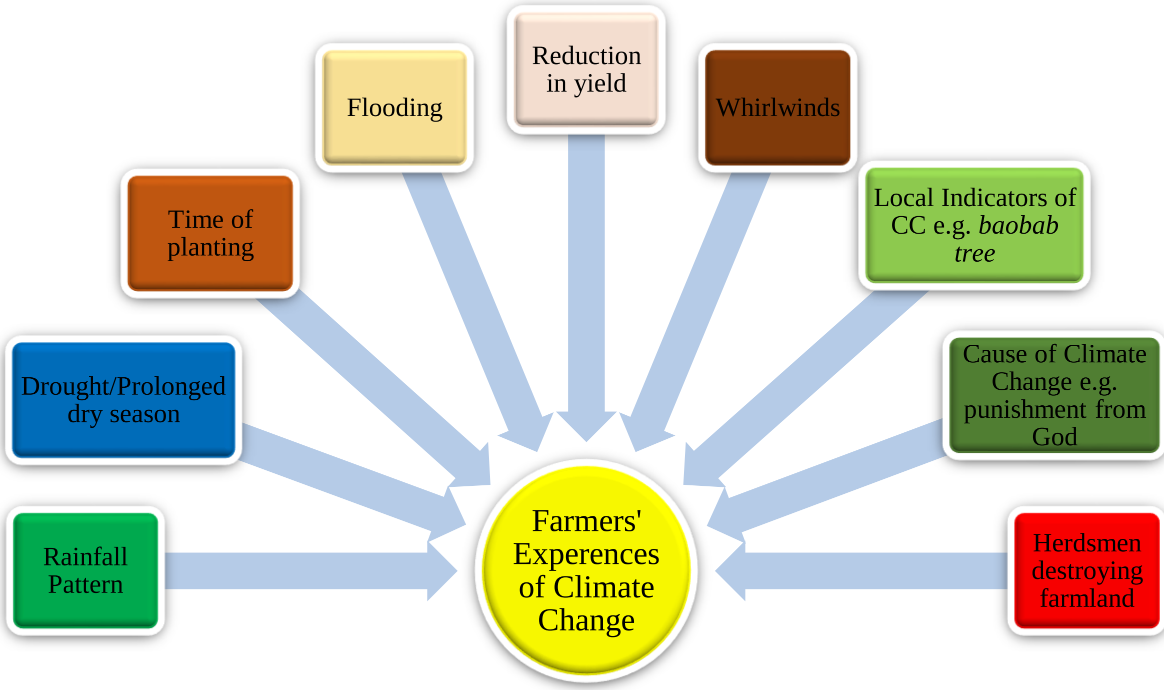
5.14 Summary

This chapter has presented details of the findings related to Research Question 1. **What are Nigerian root and tuber farmers' experiences of climate change?** An attempt was made to give a panoramic view of the farmers' responses across the six villages.

A brief description of the context of each village was given before delving into the classification categories according to the data indicating their experiences. The root and tuber farmers' reported that their experiences of climate change included changes in the rainfall pattern, drought, floods, whirlwinds, reduced yield and clashes with herdsmen who had been driven southward by the adverse effects of climate change further north. A pictorial representation for the study area is given in Figure 5.13. The farmers' responses to these occurrences, known as adaptation strategies will be discussed in the next chapter.

Figure 5.13

Categories of Farmers' experiences of Climate Change across the villages



Source: Olaniyan B. S. (2021)

CHAPTER 6: FARMERS' RESPONSES TO CLIMATE CHANGE

6.0 Introduction

The root and tuber farmers' experiences of climate change were discussed in detail for each village in the previous chapter. Their adaptation or coping strategies in response to climate change are presented here according to the farmers' responses. These results are presented in detail along with an attempt to ground the findings in previous studies. In consonance with the previous chapter the responses are presented per village because of the slight variations in their experiences. The responses were elicited during the personal interviews and participants' observation. Most of the responses stemmed from the farmers' indigenous knowledge, but the scientifically motivated ones are also highlighted. The indigenous knowledge employed in root and tuber farming was also explored and reported, as it is intertwined with their responses to climate change, see Figure 6.1. Most of the data for this chapter were tailored towards answering RQ 2, which is: **How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?**

Figure 6.1

Interconnectedness of the IK, experiences and responses to CC

Source: Olaniyan B.S. 2021

6.1 Indigenous Practices and Responses to Climate Change in Aigoro village

The indigenous knowledge employed in root and tuber production are discussed here, the specific ones used in responding to climate change have been highlighted. When analysing the data, care was taken to highlight the variation in production methods for the different root and tuber crops of yam, cassava and sweet potato grown in this village. The themes in the data are an aggregate of recurring concepts that emerged from the data, as identified by the researcher. The research supervisor agreed with the themes and they were validated by a test and measurement expert, who is also a Yòrùbá man, and thus familiar with the IK presented in the data. The indigenous knowledge employed at different stages of production are discussed thus:

a. Site selection
b. Land preparation
c. Time of planting
d. Varieties planted
e. Seed selection
f. Post planting practices
g. Storage
h. Pest and diseases

The other villages will be discussed using the same format.

6.1.1 Site selection

This refers to decisions taken in choosing a spot for planting. The farmers noted that they look out for some specific things on a land before deciding to plant on it, especially for yam as has a great nutrient demand, and they do not use artificial fertilizer in the belief that it does not produce as good a crop.

A good site for yam farming is virgin land filled with trees (land where nothing had been planted before), which provide a canopy for the young plants and when they are burnt and allowed to decay they provide nutrients that the well-established (fully leafed) yam plants need. If such forest land is not available, the next alternative is land where *akíntọ̀lá* (Siam weed) is in abundance, as its presence indicates soil fertility. Neina (2021) reported that *Chromolaena odorata* (Siam weed) is used as a form of natural fertilizer in Ghana which is planted on fallow land for the purpose of enriching the soil. The weed is invasive and hardy but when cleared and incorporated into the soil, where it decays, it introduces nitrogen in the soil, see Figure 6.2. The plant is found mostly in sites rich in humus indicating dark loamy or sandy-loam soils which are very good for root and tuber crops. Any land suitable for planting yam is also good for planting other tuber crops.

Figure 6.2

Ewé Akíntọ́lá (Chromolaena odorata, Siam weed)

Source: Olaniyan B. S. (2021)

Alfa: We were taught by our fathers that a land that should be used for the cultivation of yam should be a land filled with trees

Question: What type of soil?

Alfa: Loamy soil. A land where akíntọ́lá (Siam weed) grows on it, when yam is planted on the land, the yam grows very well. The varieties of yams that are planted on this type of soil are ọ̀kùn, ẹlẹ́ntú. But there are some yams that prefer the sandy-loamy soil, which is where they grow better e.g., aṣàgá; this is the variety of yam that turns red after cutting it. Other varieties of yams that like this kind of soil are ìgángán and ewùrà.

6.1.2 Land preparation

Land preparation is usually done before or immediately after the first rains, on pre-selected plots before planting crops. They include clearing the land by slashing and burning any vegetation on it, then making mounds, called *ebè*, in which the seeds are planted. The mounds may be individual or form straight lines called ridges, see Figure 6.3. Although the cost of labour for mounds is high, they serve multiple purposes as they are used for multi cropping. As Agbede (2006) has indicated, manual mounding improves the nutrient available to the crops as it reduces the density of the soil which allows the tuber to grow well. This supports the farmers' practice of making mounds to plant their root and tuber crops.

Figure 6.3

Mounds made for planting yams and other crops

Source: Olaniyan B. S. (2021)

Alfa: When the first rain falls, we would have made the round mounds, you now see the yam that was harvested the previous year, we make abà (farm shack) and store the yam in this shack, and we put dry grass under the yam. The yams that have decayed won't grow but the ones that have started springing out are what will be planted after the first rain.

6.1.3 Time of planting

Farmers must plan the time of planting to ensure their crops get the necessary amount of rain to grow properly.

For yam: The first planting during wet season of September or October is for varieties of yams that require a lot of water. The water is trapped in the mound and so ensures the plant has enough water to withstand the intensity of the sun during the subsequent dry season. The second planting is done in December during the harmattan, which ensures that the scars on the yam seeds are properly healed. In this case grasses are placed on the mounds to keep the plant cool, which is called *ìdíhàn* (mulching). **For cassava:** Planting can be done anytime during the farming season as the cassava plants remain on the mound for at least a year, through all the seasons. Planting the varieties that mature in only 6 months needs more careful planning of the planting time. **For sweet potato:** Needing only 3 months to grow to maturity, sweet potatoes are planted as many times as possible within a year.

Alfa: What happen is that the local yams that we were taught how to plant by our forefathers years back, the mounds for these varieties of yams are made by the month of September or October the heaps will be made. Some farmers may make round mounds while some will make their ridges on a straight line. Some farmers prefer planting in the month of December during harmattan, when the surface of the yam seeds would have healed up. When this is planted during the harmattan, some farmers add mulch on top of the mounds called ìdíhàn.

Egesi et al. (2007) confirm that proper timing of planting yam reduces the severity of some diseases that are particular to yam. Olasantan (1999) reported that dry season planting in western Nigeria starts in October, while planting to coincide with the start of the rains is carried out in February or March. This tallies with the farmers' schedule, albeit with a slight regional variation.

6.1.4 Varieties planted

The farmers use varieties of roots and tubers that have been handed down by their forefathers alongside some improved varieties introduced to them by the scientists through the extension agents. They also use varieties of yam originally indigenous to the northern Nigeria.

For yam: *Ọ̀kùn*, *Ẹlẹ́ntú* (planted during rainy season), *Òkókùmọ̀*, *Gbẹ́gi*, *Ewùrù*, *Gaun-gaun* (high yielding and drought resistant), *Àṣàgá*, *Ìgángán* and *Ewùrà* (water yam). *Giwa* and *Pasa* (varieties from the northern part of Nigeria). **For cassava:** *Òdóńgbó* is an indigenous variety that takes two years to mature, but is said to produce very big tubers and to taste better. *Okọ ìyàwó* is an improved variety introduced to the farmers by scientists, which matures in 6 months. **For sweet potato:** The indigenous variety simply known as *Òdùnkún*, the Yòrùbá name for sweet potato, is planted along with the improved orange flesh variety known as 'Vitamin A', due to its being particularly rich in vitamin A.

These varieties are cultivars from the white, yellow yams, which are native to West Africa and water yam which was introduced from Asia (Adegbite et al., 2006). Eruola et al. (2012) studied three different varieties of white yam to determine their suitability for planting in Abeokuta, Ogun state. They were all cultivars of *Dioscorea rotundata,* also known as Guinea yams, namely *efùrù*, *ise-osi* and *oniyere*. He noted that. *Efùrù* is a variant of *ewùrù* in Yòrùbá language, the difference being in the dialect of the speakers.

6.1.5 Seed selection

Seed selection refers to activities needed to determine the best seeds to plant. The quality and sometimes quantity of the seed determine the output during harvest. So proper care is taken to choose seeds that have the greatest potential and are not diseased for eventual planting in the hopes of a bumper crop.

For yam: For the yam varieties that are indigenous to the area, after harvesting the larger ones, any smaller yams that remain are used as seed in the next farming cycle. For the introduced varieties, the farmers make use of any yams that have sprouted in the barn as seed, which accounts for the considerable size of the eventual tubers at harvest, because the yam will not decay but continue growing. **For cassava:** Stalks with the best yield are stored for the next planting cycle. They are stored under shade to avoid direct sunlight on them and decay. The leaves are allowed to fall off, then the stalks are cut into small pieces and planted on the mounds. **For sweet potato:** The farmers pick the vines of the good tubers and replant them. The vines are cut into small sizes and planted with the nodes facing upwards.

Alfa: When the yam has been planted by September, it will be harvested by August or September the following year and when it is harvested, there is always a small piece of yam that will be found on the mound, it is this small piece that comes with the harvested yam that will be replanted, knowing that new set of heap will also be made the same year. As for the yam from the north, the *tubers that were harvested the previous year, they would make aba (farm shack) and they will store the yam in this shack, they will put dry grass under the yam. The yams that have decayed won't grow but the ones that have started springing out are what will be planted in the fifth month after the first rain.*

Sesay et al. (2013) reported that among yam farmers in Sierra Leone the sources of planting material/sett come from reserving small tubers and the heads of tubers. The farmers' practice of not uprooting the whole tuber but breaking off the large ones, to allow a smaller tuber grow, which serves as seed yam is similar to what Ikeorgu and Nwokocha (2001) referred to as yam mini-tuber technique. They grew these mini-tubers from yam mini-sett (explained in Chapter 4) to serve as seed yam because farmers preferred this to the mini-sett technology because it usually resulted in larger tubers at harvest, which would fetch a better price during sales.

6.1.6 Post-planting practices

After planting their crops, farm activities carried out by farmers include clearing weeds, putting stakes on the mounds for the vines to climb on, mulching and generally ensuring the crops were growing properly, see Figure 6.4.

For yam: In the rare cases when herbicide is used for yam, it is sprayed before the leaves come out so it does not kill the plant. Rather than herbicides, the farmers usually clear the weeds manually using a hoe. The trees on the land are either sprayed or burnt to kill them as they will be used as stakes for the vines/trellis to climb on, because the vines get burnt if they lie on the ground during the dry season. Where intercropping was done, millet stalks after harvesting are also used as stakes for the vines after harvesting. Grasses and/or leaves are placed on the mounds to protect the plant from the sun. **for cassava:** All that needs to be done after planting is weeding and adding more soil to the mounds when the growing tubers break the soil to prevent their exposure to sunlight. **For sweet potato:** This crop is very low maintenance as the vines grow and cover the ground so the weeds are suppressed and weeding is not needed. Fertilizer application is also not needed.

Figure 6.4

Post planting practices

Footnotes

A. *Cassava farm with the crops well established*
B. *Sweet potato plant growing on a ridge*
C. *Yam vines on a stick used as stake*
D. *Trees sprayed with chemicals to serve as stake for the growing yam*

Source: Olaniyan B. S. (2021)

Interviewer: You said that if some yams are planted, you put leaves on it, why do you do this?

Alfa: It is because of the sun for Hausa and Yorùbá yams, we put grasses (ìdíhàn) for both varieties of yams. You know the sun comes from above, when the sun heats it; the mulch will prevent the sun from penetrating into the soil so it won't affect the yam.

Interviewer: Do you spray your farm or the only thing you do is to clear it manually?

Alfa: What happen is that for yam farm, we don't usually spray it here. We don't really make use of chemicals here because there are some chemicals that when they touch the leaves of yam, it will get decayed to the root.

Aduo and Nwadili (2019) reported mulching as an indigenous practice of farmers in Ebonyi state, Nigeria. Nedunchezhiyan et al. (2014) mentioned that in India, weed control for cassava was primarily through hand weeding, which corresponds to the actions of these farmers.

6.1.7 Storage

Storing the tubers properly to ensure they do not spoil (usually by rotting), leads to good prices in the market. The methods employed include in-ground storage for cassava and sweet potato, storage in barns for yams, and drying and grinding to form flour for yam and cassava

For yam: Proper storage is important to avoid rot. A large portion of land is dug under shade and yams put in it, then covered with soil. The yams are arranged to allow free flow of air and spaced so they do not touch each other. Ashes or local sponge may also be placed on the ground where the yams are to be stored but a cemented floor is never used. Some yams are dried and processed into yam flour, used to make àmàlà. **For cassava:** Cassava begin to decay as soon as they are harvested so they are left in the soil and harvested in batches. They are consumed immediately or cut into pieces, dried and processed into cassava flour, which has a long shelf life. **For sweet potato:** They are stored in the ground, and harvested only as needed. Once the leaves start turning brown and the tubers are protruding from the soil the plant is mature. Alternatively, 3 months after planting you can harvest it.

Interviewer: How do you store root and tuber crops locally in a case where there is excess?

Alfa: Yams are not placed directly on a cemented floor; it will get spoil. What we do is that a large portion of land will be dug under a shade, and yams will be placed in it and then covered with soil the yams must not touch one other or it will heat up. Ashes can be sprinkled on the ground or local sponge can be placed on the ground where the yams will be stored. Cassava can be kept on the mound. It is also preserved the same way as yam. It can also be cut into pieces and used for cassava flour. Sweet potato is also preserved the same way, there is no way sweet potato is preserved, and it will always be in season.

Tor et al. (2017) highlighted the indigenous ways of storing tubers in Benue state, Nigeria, which included underground storage for cassava, mound storage for sweet potato and barn and underground storage for yam. Otegbayo et al. (2012) mentioned that people prefer pounded yam made from stored yam to that made from fresh yam, hence the need to store the tubers. He further noted that storage increased the sugar content of the yam tuber so stored yams are sweeter. Okeke et al. (2017) concluded that "output of farmers who utilized only the local storage systems exceeds those who utilized both the local storage systems in addition to the modern storage techniques".

6.1.8 Pest and diseases

All the activities the famers take to protect the crops from pests, from the pre-planting stage to storage, were recorded. Activities such as spreading ashes on stored yam, placing palm fronds on the leaves are done to take care of pest and diseases. Although farmers did mention that cassava was very hardy and resistant to disease and pests, so it was not a problem.

Interviewer: How do you control pest and diseases that affects farm crops?

Alfa: When you are about to plant, the traditional way of preventing grains from pest is to mix the grain that is to be planted, e.g. maize, with the black core of used dry cell battery (tiger head) and add kerosene before planting the seeds. This method prevents the seeds to be invested on by termites (ikán). This will protect the planted seeds for 21 days and by this time, the leaves would have started shooting out. This method does not affect the seed or its yield.

Interviewer: Before battery came into existence, what have you been using?

Alfa: There used to be a leaf then from African violet tree (Securidaca longipedunculata) ìpẹ̀ta which was grinded together with dry tobacco leaves (ewé tábà) and sprinkled on the farmland. We also used to put palm fronds on the mounds; this is used for yam when the leaves start falling off due to disease. And the plant grows to maturity. Even for cassava the palm fronds can also be placed on the heaps and it works for it.

Poubom et al. (2005) reported that cassava farmers in Cameroun use traps, scarecrows, plant bitter varieties and mix the ground seeds of *Thevetia peruviana* with the urine of a small boy to poison animals like squirrels and monkeys that attack their farms. Akinbo (2019) reported that extracts from some leaves were used to treat a fungus disease on tubers; it not only suppressed the growth of the fungus but also it reduced root rot.

6.1.9 Responses to climate change

Having discussed the IK used in root and tuber production in this village, a detailed description of IK employed in responding to CC is given in this subsection with an overview given in Table 6.1.

In their bid to maintain productivity in the face of obvious changes in the weather pattern, the root and tuber farmers have made use of their IK, which is readily available, accessible, adaptable and sometimes comes at no cost (Senanayake, 2006). Drawing from their rich repository of knowledge passed down from their forefathers, they have been able to cope with the adverse effects of climate change and sustain root and tuber production, thereby protecting their source of livelihood. As the Yoruba saying goes, *ogbón kìí tán láyé ká wa lo sí òrun*; meaning 'scarcity of wisdom on earth will not cause one to go to heaven to seek it'. Hence the farmers have had to devise means of surviving in the changing times.

One farmer in Aigoro village employed IK in responding to climate change in the following ways:

Change in rainfall pattern: He uses the local indicators to predict the onset of rain, such as *igi òrí* (shea butter tree) whose leaves start blooming when the rainy season is about to start and *igi odán* (*Ficus thonningii)* whose leaves starts falling off as the rainy season approaches. It is worth noting that the farmer said that these phenological markers have been consistently changing along with the changing weather pattern, so they are reliable. For varieties of tuber or root that require plentiful rain, he only plants when the rain begins, but for others the planting date is fixed (i.e. September/October). In cases of extreme weather conditions prayers are offered to God who has all the power to wield.

Table 6.1

Overview of Farmers' experiences and Indigenous Responses to CC in Aigoro village

Categories (IK in root and tuber production)	Farmers' Experiences of CC	Indigenous Responses to CC
Site selection Virgin land *Akíntọ́lá* (Siam weed) Loamy and sandy soils	-Unpredictable Rainfall -Delay in onset of rainfall -Reduced frequency of rainfall -Drought -Change in time of planting	**Rainfall Pattern** Predicts using local indicators Prays to God Plants as at when due
Land preparation Slash and burn Mounds (*ebè)*		**Drought** *Ìdíhàn* (mulching) *Ebùjó* (shrinkage) *Àgbìnpò* (intercropping)
Time of planting Yam is planted first in September/October then December Cassava and sweet potato are planted all year round.		**Pest and diseases** *Ìpẹ̀ta* (African violet tree) *Ewé tábà* (tobacco leaves) Palm fronds Black core of battery
Varieties planted Indigenous and improved varieties of yam, cassava and sweet potato		**Animals and Thieves** *Aṣọ́komásùn* (scarecrow) *Pàkúté* (trap) *Agogo* (bell) *Wasa* and *Àsírí* (charms)
Seed selection *Egùn* (yam milking) Yams that sprouted in storage Cassava stalk with best yield Sweet potato vines		
Post planting practices Mulching (*Ìdíhàn*) Weeding Staking Adding soil to mounds		
Storage In-ground storage Processing into flour		
Pest and diseases Black core of dry cell battery *Ìpẹ̀ta* (African violet tree) *Ewé tábà* Palm fronds		

Source: Olaniyan B.S. 2021

Interviewer: So you don't plant any crops till you see the rain?

Alfa: Yes, we don't plant until the rain starts falling. The only thing that we do is to pray to God to allow rain to fall.

Drought: To protect the crops against the effect of a prolonged dry season or drought, the farmer practised mulching (*ìdíhàn*) by placing placed grasses, which were keep in place with a stone, on the mounds. This helps with protection from the sun and conserves moisture in the mound. It was reported that if the grasses were lifted up after some weeks that spot will be wet. *Ebùjó*, which is the process of the mounds shrinking because of the effect of mist on it, also protects the plant within. So, the mounds are made while there is still a bit of moisture in the air. The farmers also practise *àgbìnpò* (intercropping), which is planting crops together, which have different maturity dates, to serve as a safety net; if one crop should fail, the farmer will still get a harvest from another to cushion the failure, as shown in Figure 6.5.

Interviewer: So you practice mixed cropping?

Alfa: Yes, for example if a farmer plants different crops and then the rain suddenly stops falling, if the farmer doesn't get gain from maize, the farmer will get gain from millet. Like potato for example, it would have finished growing before the rain will stop falling. We do mix cropping so that it will cover up for the following year in case there is drought.

Pests and diseases: Due to climate change there has been increased incidences of pests and diseases attacking root and tuber crops. The leaves of *ìpẹ̀ta* (African violet tree) and *ewé tábà* are ground together with water, which is then sprayed on the field at planting time as a preventive measure against pests eating the seeds. The black core of dry cell batteries is also ground up and mixed with seeds of maize before planting to forestall insects feeding on them. Palm fronds are also placed on the yam vines and cassava when the farmers notice the leaves are falling off which would affect the growth of the tuber. It is reported that the leaves then stop falling off and the yams grow to maturity.

Animals and thieves: Due to deforestation, monkeys and cows invade farms and eat the growing crops so the farmers place *aṣọ́komásùn* (scarecrow) on the farm to fool the animals into thinking that a human is present. *Pàkúté* (traps) are also set on the farms to catch animals and thieves. *Agogo* (bells) are placed around the farm to scare birds away. *Wasa* and *àsírí* (charms) are placed on the farm to deter thieves; the *wasa* charm turns to a snake when someone steals from the farm but will not bite the person if he or she drops the crops. *Àsírí*, on the other hand, is no longer used because it is lethal to humans, and there is concern that the thief might be a family member.

Figure 6.5

Picture of an intercropped mound

Footnote: This mound has yam growing in it alongside okra, amaranthus, maize and cassava. Usually cassava is the last crop to be harvested.

Source: Olaniyan B. S. (2021)

Alfa: Aṣọ́komásùn (scarecrow) is used to scare away animals like Ááyá (red colobus monkey). There is also a bird called Àgáńrán (scarlet-billed Senegal parrot) this bird eats corn; bells can be hanged on the farm and the sound of the bell will scare the bird away. We use a thing called wasa (the use of voodoo/magic), once a thief enters the farm the thief will be bitten by a snake if he/she refuse to drop the stolen crops.

All these measures are in agreement with Makhado et al. (2014), who highlighted intercropping, shifting the cropping calendar, and cover cropping as some of the adaptation strategies used by farmers to combat climate change in Southern Africa. Notably, they did not document the use of charms as a deterrent for thieves.

6.2 Indigenous Practices and Responses to Climate Change in Alapa village

The subheadings used to discuss results in the previous section are used for this section, although the discussion is limited to only yam and cassava as these are the only root and tuber crops planted in this village. The slight variations in the indigenous practices are also highlighted.

6.2.1 Site selection

Because yam requires a very fertile soil, the sites used for planting it may be considered as the benchmark for other crops. Any land that is good for yam is also good for cassava. In selecting a site to plant yam, the farmer a looks for land that has very dark green coloured grasses to show that the soil is fertile. Land that has lot of trees growing on it is also considered to be good, as the trees are burnt overtime and as the leaves fall and decay, they provide nutrients for the crops. This does not happen if the trees are not burnt, so the yield would be less. A land that has been abandoned for a long time is also good for yam production as it would have regained nutrients lost from being over-farmed. The farmers also look out for *Akíntọ́lá* (Siam weed) on the land, its presence indicating fertile land.

Baba T: The reason why it seems yam grow apart from the use of fertilizer is that for example, the way through which we see how dark the colour of the grass that is on the soil is, this type of land is mostly used for making yam heaps. Secondly, the type of land cultivated for yam is a land that has lots of trees growing on it. In some other places, if the land has been used for farming before and it has been abandoned for a very long time it is good for planting yam because the land would have regained its nutrient.

Odoemelam and Ajuka (2015) reported that farmers in south-eastern Nigeria practice bush fallow, which they believed enabled a depleted soil regain its fertility. This corroborates the farmer's practice of selecting fallow land for yam production.

6.2.2 Land preparation

In preparing for the farming season, the farmers make small mounds for yams then from around August/September they add more soil to make the mounds bigger. This is to allow the yam to grow big as they would stop growing if they encounter hard soil. The mounds for cassava are smaller than those for yam. Millet is planted on the mounds and the stalk would be used as stakes for the yam after harvesting the grains. Cassava is planted on the same mounds as millet and yam.

Baba T: By March, that is when the first set of heaps will be made for yam. A small heap will be made, and millet will be planted on it and by August/September, another heap of soil will be added to the previous heap to make it bigger.

Question: What is the function of the millet that is planted on the yam heaps?

Answer: Firstly, the millet itself is food and we harvest it separately. Then the millet stands as a stake for the yam leaves to vine over. Yam leaves that are left to crawl on the floor and didn't vine over anything or stick, won't be as good as the yam that the leaves are allowed to vine over a stick or millet.

Verter and Bečvářová (2015) noted that the cost of mounding and staking accounts for 40% of the cultivation cost for yam production in Nigeria, hence the practice of using millet for stakes reduces that cost considerably.

6.2.3 Time of planting

To ensure a good chance of a bountiful harvest, the farmers follow a routine in their planting activities. The planting season starts by March when mounds are made and maize or millet are planted on them. By August or September more soil is added to the heap to make it suitable for the yam that will be planted. The yam seeds are planted from October (dry season varieties) through to March (rainy season varieties), when the rainy season starts. Cassava is planted anytime during the year as it spends a whole year on the mound and goes through all the seasons.

Question: When do you start making heaps for yams? When do you start farming season?

Baba T: The farming season begins from March. By March, heaps will be made, some farmers plant maize and some plant millet. Millet can be planted by early March; it is a good season to plant millet. But by the last week of May to the first week of June, that is when the planting of millet is common among farmers. By August/ September, that is when the first set of heaps will be made *for yam. A small heap will be made, and millet will be planted on it and by August/September, another heap of soil will be added to the previous heap to make it bigger.*

Planting at the appropriate time ensures the yam seed would have been well established and growing properly before the rains cease, which reduces the risk of disease for the growing tuber. This is in agreement with Adipala et al. (1998), who noted that, in Uganda, manipulating the planting date helps reduce the incidence of cassava mosaic virus disease as the plant would have grown past the vulnerable stage before the disease carrier ,whitefly, becomes abundant.

6.2.4 Varieties planted

The farmers use plant varieties passed down by their fathers and specific to their locality. In this village, farmers use different cultivars of white and yellow yam; namely, *ódabí ìyàwó, ehùrù, ṣófíní, lásìńrín, àpalà* and *wàwàgi*. These varieties are best harvested in August or they get spoilt. Some can be propagated from cut tubers while other are propagated by seed yams, called *egùn*. For cassava, the variety they plant is *oko ìyàwó*, which matures in one year.

Baba T: There are different varieties of yams, there are some varieties of yams called ehùrù, ṣófíní, lásìńrín and wàwàgi, they are varieties of yams that has to be harvested in August or it would be wasted, they cannot be cut into pieces as seed. If it is not broken on time it will grow to a stage and stop growing, then will have a branch that is the egùn which will become a burden for the initial tuber so it is better to break it on time so that the seed yam can grow properly.

Knowledge of the varieties that grow best in their region have led to a successful root and tuber production every year. This knowledge has preserved the varieties for seed from one generation to another, consequently, the farmers protect these jealously and do not see the seed yams. Scarcelli et al. (2006) reported that farmers in Benin planted wild yams along with the cultivated ones and by process of selection over time got tubers that closely resembled the cultivated yams. This was done using their indigenous knowledge.

6.2.5 Seed selection

Having viable seeds, cuttings or stalks, as the case may be for yam or cassava involves activities to pick the right seed stock. The farmer noted that some varieties of yam can only be grown using seed yams, while others can be grown using cuttings. Cassava is grown using the stalks.

For yam: In this village they had devised a means of producing seed yams by breaking off the tubers while leaving the root in the mound, which was then covered and allowed to grow smaller tubers, called *egùn*, that could be used as seed in the next planting season. This is what Morse (2018) referred to as milking. **For cassava:** After cassava is harvested; the cassava stalks that are to be replanted will be kept under shade, as the stalks undergo a colour change when exposed to the sun. If the sun's rays fall on these cassava stalks for too long, the cassava sticks may not grow again when planted. But when the stalks are kept in a shade and the leaves are allowed to wither off, the stalks can be planted and they will grow.

Baba T: The broken yam will be removed from the soil and the remaining yams called egùn will be covered again with soil for it to continue growing. The yam that grows again from the previously broken part will be planted by the next planting season.

Question: Why is the matured yam broken from the root?

Baba T: This is done so that the yam seeds egùn that will be planted during the next planting season can grow because the seeds that are gotten from yams that are not broken from the roots won't yield much up to the seeds that are gotten after breaking matured yams from the soil. If one uses the mature yam there would be lot of scars and the yam will not grow well but if it is egùn, the scars would have healed up and another tuber grow from it and it grow well when used as seed. Some even have small tubers that you don't need to cut when planting.

The seed selection method practised in this village confirms Asiedu and Sartie (2010), who submitted that farmers get seed yams by choosing small tubers from the harvested crops, tubers from second harvest of early maturing varieties and by cutting larger tubers into pieces (p.308).

6.2.6 Post-planting practices

Post-planting activities done by the farmer after planting the crops include weeding, staking, mulching and applying herbicides.

For yam: After planting the practice of placing dry plants on the heaps along with some soil to protect the yam seeds from direct sunlight penetration of the sun is called *ìdíhàn*. When the yam leaves start coming out the farmers put them on the stakes so they can climb it as they grow. After planting they spray herbicide to kill the weeds before the yam leaves emerge, then they weed manually after the yam leaves have emerged. **For cassava:** The weeds are cleared manually after planting; thereafter once the cassava has started growing leaves, chemicals are sprayed on the weeds once or twice.

Interviewer: After planting, what are the things that are done?

Baba T: It will be mulched (lèdíhàn), plant debris will be placed on the mounds and covering it with soil, to prevent the yam seeds that are in the heaps from the penetration of the sun. When the yam leaves start coming out, it will be placed on the stakes that are on the heaps so that the leaves can climb over them. If the leaves are allowed to crawl on the ground, it won't yield up to the yam that the leaves are allowed to vine on the stake. It is the duty of the farmer to put the yam leaves on the stakes. Then the weeds are cleared up to four times. The weeds are cleared manually but after the invention of chemical, the yam is sprayed immediately after planting at first to stop the weeds from growing after which it will be weeded manually.

Nedunchezhiyan et al. (2014) indicated that farmers in India had to look for alternative ways of clearing weeds because of the high cost of manual weeding and labour shortage and increasing costs are major problems for them. So spraying with herbicides are the preferred method of weed control, adding to the costs of production. This support the Alapa village farmers' use of herbicide to suppress weeds after planting the yam, which reduces the number of times that manual weeding is needed.

6.2.7 Storage

Storage refers to activities done after harvesting the root and tuber crops, which includes preparing the storage facility and processing the crop into flour. The farmers do not store cassava; it is processed immediately into cassava flour for *láfún*, *garri* and *fufu*, which are ingredients used to prepare local delicacies.

There is a communal storage facility where the yams are kept in each village. When the stored yams start growing in storage, the growing part may be broken. In addition, if the yams are allowed to grow while still in the storage, even if not broken, the yam won't boil properly when cooked. In-ground storage is also done. In this village they do not hang yams, as the yield is too great to expend the amount energy needed to hang all the yams. Akangbe et al. (2012) also reported that most of the farmers in Asa local government, where Alapa village is located, store their yams in barns, while other use indigenous plant material, a pit with a thatched roof or a ventilated store shed to store their yams. This confirms the findings of this study.

Interviewer: How are the yams stored?

Baba T: There is a parlour where the yams are kept in each village. When the kept yams start growing in the storage, the growing part will be broken. When the yams are allowed to grow when it is still in the storage and it is not broken, the yam won't boil properly when cooked. We also dig the ground here but this doesn't stop the yam from growing. Only small-scale farmers hang yams, the yam yields are much and it can't be hanged.

6.2.8 Pest and diseases

In this village the farmers do not do anything specific about pest and diseases; they clear weeds from the farmlands and take proper care of the crops. This supports Braimah et al. (2007) who reported that although farmers in Ghana are aware of the damaging effects of pests on their crops, only a few attempted any form of measures to control them.

6.2.9 Responses to climate change

The indigenous ways of responding to climate change are discussed with the aid of Table 6.2. For a farmer in Alapa village, responding to climate change takes several forms, as follows.

Table 6.2

Overview of Farmers' experiences and Indigenous Responses to CC in Alapa village

Categories (IK in root and tuber production)	**Farmers' Experiences of CC**	**Indigenous Responses to CC**
Site selection Dark green colour grasses Land filled with trees Fallow land *Akíntọ̀lá* (Siam weed)	-Unpredictable rainfall -Delay in onset of rainfall -Reduction in yield	**Rainfall Pattern** Predicts using local indicators Prays to God Plants as at when due.
Land preparation Mounds (*ebè)*		**Reduction in yield** *Àgbìnpò* (intercropping)
Time of planting October-March Cassava is planted any time of the year.		**Animals and Thieves** Ahéré (farm shack) *Dogs and Pàkúté* (trap) *Agogo* (bell) *Ewé láà* (Castor plant) L*àpá* (Jatropha curcas) *Wasa* (charms)
Varieties planted Indigenous varieties of yam and cassava		
Seed selection *Egùn* (yam milking) Cassava stalk stored under the shade		
Post planting practices *Ìdíhàn* (Mulching) Weeding Apply herbicides Staking		
Storage Stored in large room In-ground storage Processed into *garri, lafun* and *fufu*		
Pest and diseases Nothing		

Source: Olaniyan B.S. 2021

Change in rainfall pattern: He makes special prayers to God that rain should fall, he predicts the onset of the rainy season by observing the *igi osè* (baobab tree), which starts growing leaves when the rainy season is approaching, and the increasing daily temperature when there is going to be a change in season. He also uses *ìdíhàn* (mulching) to conserve water in the mounds after planting, as the grasses placed on the mound prevent the sunlight from penetrating the mound and destroying the seeds planted. The use of mulching to conserve water in the soil and protect the tuber from the sun is similar to the findings of Sekelemani et al. (2020), who indicated that crop farmers in Botswana use soil and water conservation mechanisms to adapt to climate change.

Interviewer: Has anything been done locally or traditionally to change or correct this, that makes rain fall when it doesn't fall as expected? Like rainmaking

Baba T: We don't do that here; they use it for evil purposes to disrupt people's occasion. Nothing is done; the only thing done is to pray and God answers our prayer.

Reduction in yield: The farmer does *àgbìnpò*, meaning planting different crops together, which helps to maintain the soil fertility, ensure the farmer has something to fall back on if one crop fails, and the residues of a crop can be used for the production of another, for example, millet stalks are used as stakes for yam, which reduces the cost of production. Essentially he practices intercropping. Anju et al. (2014) reported that farmers in Kerala, India practise crop rotation and intercropping as a strategy for adaptation to climate change. These have led to increased profit, production of more than three crop and protection of the soil.

Animals and thieves: Ahéré (a farm shack) is built on the farm for children to sleep in so that they can watch over the farm at night. If these children also have a bell, they can ring it to scare away the monkeys. Traps and dogs are also used to catch and scare the red Colobus monkey away. *Ewé láà* (castor plant) or *làpá* (Jatropha curcas) is planted around the farm to prevent cows from entering, as these plant repel the cows because they are bitter and have spikes on them.

The farmers also make use of various charms to protect the farm, one of which is that the elders have some drugs that when they are placed on the farm, the thieves would not even think of entering the farm. There is another called *wásá*; if this is placed on the farm and a thief enters to steal, this particular thing will turn into a snake. If the thief drops the stolen crops, the snake will not harm the thief but if the thief did not drop the stolen crops the snake would harm the thief. There is another type of local medicine that is also used on the farm, so that if a thief enters the farm and steal crops, the thief would not be able to find his or her way out of the farm unless the thief drops the stolen crop, if not the thief would keep walking around the farm looking for a way out so that the farm owner could catch the thief. There is another charm that is used so that if a thief enters the farm, the thief will be beaten by invisible hands until the thief drops the stolen crop. The use of charms to protect the farms from thieves is similar to reports by Akullo et al. (2007) that farmers in Uganda "plant lab-lab around their farms as they believe it prevents night dancers from intruding in their gardens and other related cases of witchcraft".

6.3 Indigenous Practices and Response to Climate Change in Gaa Ogbe village

The response of farmers' from Gaa Ogbe village is discussed using the same template as for the preceding villages, although for this analysis, cocoyam is included because these farmers plant it in addition to yam, cassava and sweet potato.

6.3.1 Site selection

In selecting a site for yam production, the farmer looks out for a place where many trees are growing, there is plenty of organic matter and *akíntọ̀lá* leaves (Siam weed). When this land is cleared and all the trees and leaves are burned, the land is very good for planting yam. Another thing to look out for is the presence of *lámùrè* (tiny black ants), which is a sign that the land is no longer fertile so it cannot be used for planting yams, although it can be used for planting other crops. The land must also drain water well so the yam does not rot on the heap. Any land that is good for yam is also good for the cassava, sweet potato and cocoyam, although cocoyam can also be planted in a water-logged area or by the river bank. This way of selecting land with soil that is suitably fertile for yam production supports Neina (2021), who noted that yam extracts a lot of nutrients from the soil; hence the need to plant it in a very fertile soil.

Interviewer: How do you know a land that is best for planting yams?

Agbe: As for yam, if one isn't scared that the place is a bush, a place that has lots of trees growing on it, and has plenty organic matter and akíntọ̀lá leaves (Elizabeth weed) When this land is cleared and all the trees and leaves are burned, the land is very good for planting yam. Another thing to look out for when looking for a land to plant yam is when a land is filled with tiny black ants (lámùrè), such a land cannot be used for planting yams. It is not that these ants will infest on the *yams but this is a sign that the land is no longer fertile and it is not good for farming yam. This type of land can be used for planting other crops.*

6.3.2 Land preparation

For this village, activities that are carried out to prepare the selected site for farming primarily revolve around tilling the ground and making mounds for yams, cassava and sweet potato, whereas cocoyam is planted on flat ground. This difference in land preparation for the different root and tuber crops is in consonance with the view of Howeler et al. (1993) that tillage system of root and tuber crops varies according to the specific crop to be planted. They noted that cassava can be planted on a mound, ridge or flat ground as it is highly adaptable, whereas yam is planted on mounds or ridge if the soil is heavy soils and planted flat in light soils and cocoyam can be planted in upland or lowland.

Interviewer: So, a land that is good for cultivating yam is also good for cassava, sweet potatoes and cocoyam?

Agbe: Yes, it is. Yam, cassava and sweet potatoes are planted on mounds. While cocoyam can be planted on a water-logged land and they can also be planted on upland. Cocoyam does not need heaps.

6.3.3 Time of planting

To ensure proper growth, especially with the advent of climate change, the farmers have to plan the time of planting with some degree of accuracy. For this village the time of planting varies depending on the farmer involved and the crop to be planted.

For yam: Before, the planting season used to begin in September but now due to the climate change, September may be used for first preparing the heaps. There are various ways this is done: some farmers may start making the heaps by October and then plant during the rainy season; other farmers may start planting during harmattan, when the sun is not scorching; and some farmers may even keep the yam seeds until after the first rains fall in March or April before planting. **For**

cassava: Cassava does not have a particular planting season. It may be planted anytime during the rainy season. Only if the rain is sparse will the planting be stopped. The farmers either cut the stalks beforehand then plant them or use a long one and cut it as they plant. **For sweet potato:** Sweet potatoes are planted immediately the rains start; that is usually from the month of June until sometime in July. **For cocoyam:** Cocoyam is planted between March and May.

Interviewer: When do you plant the yam seeds, cassava, sweet potato and cocoyam?

Agbe: September is used for making heaps. Though there are two ways, some farmers may start making the heaps by October and start planting during the rainy season and some farmers may start planting during harmattan when the sun is not scotching. Some farmers may keep the yam seeds till March or April after the first rain fall before planting. We start planting from October or November. Sweet potatoes are planted immediately rain starts falling; it is planted by the month of June till around July. Cassava planting starts when the rains start and ends when the rains stop so it is continuous.

Choosing the right time to plant is essential. Thus the farmers ensure they plant at the right time because it affects the tubers produced at the end of the season. The effect of time of planting on yam was researched by Lal and Hahn (1973) and they found out that the longer the growing period, the larger the tubers produced, with the yield being highest for the yams planted just before the rains began in February, ,as opposed to those planted in October, during the dry season or April, when the rains had been established. Thus, proper timing increases yield.

6.3.4 Varieties planted

In this village the farmers plant their indigenous varieties of roots and tubers alongside improved varieties, particularly for cassava, which had introduced to them by extension agents. They, nevertheless, mentioned that they prefer their own methods of planting.

For yam: The villagers plant the *ẹlẹ́ntú, ehùrù, alágbọn* and *ọ̀kùnmadọ̀* varieties of the white and yellow yam. They also plant *ganmù – ganmù* but monkeys often destroy this variety by uprooting it. **For cassava:** *Gbókogbàlà* is the indigenous variety that matures in two years. *Òdóńgbó, oko ìyàwó* and four-one-nine (419) are the improved varieties of cassava introduced. *Oko ìyàwó* was identified as being the best. **For sweet potato:** The cream coloured sweet potato is planted, which the farmers called butter. They had no distinct name for cocoyam; they simply called it coco.

Interviewer: What varieties of yam and cassava do you plant here?

Agbe: There are different varieties of yams. The varieties are so numerous, but the one that we are familiar with and plant very well here are ẹlẹ́ntú, ehùrù, alágbọn and ọ̀kùnmadọ̀. The varieties of yam mentioned grow well here. There are different varieties of cassava now, òdóńgbó, oko ìyàwó and four-one nine (419) are the varieties of cassava that we plant here, but the best is oko ìyàwó.

The inability to name the varieties of cocoyam, coupled with the little emphasis that farmers put on its production is due to its underutilization and relegation to the background, even in research. Boakye et al. (2018) reported that the crop had not been given the priority that yam, cassava and sweet potato had enjoyed and in Ghana it had been marginalized in government policies and research intervention. Doku (1981) also submitted that among the root and tubers crops in Africa, cocoyam had received the least research attention; the little research into it started in the 1960s but had not been sustained. Furthermore, Talwana et al. (2009) indicated that cocoyam had not received any intentional research attention in East Africa, so the production and consumption trends remain unknown.

6.3.5 Seed selection

To ensure a good yield the farmers carefully select yam seeds, cassava stalk, get vines for sweet potato and suckers for cocoyam. They have protected these sources over the years as the quality and quantity of the produce depends largely on the quality of seed stock.

For yam: The farmers have two methods used to select seed yam. The matured yams are broken off from the root during harvesting, then the root of the yams will be left to continue growing in the soil. The new set of small yams that now grows from the remaining root is will be reserved for planting in the next farming season. This is called *ègùn iṣu*. The heads of the harvested yams can also be cut and planted, but this method is not as good as planting the small seed yams. **For cassava:** The thin cassava stalks are the ones that are good to be planted. For cassava to grow very well, the farmers make sure that the leaves from the stalk are already withered before it is planted. **For sweet potato:** The sweet potato vines are planted, taking care to cut close to the buds so that it can grow on time. This stock is collected from another village (Ajase). Sweet potatoes stock does not have any specific needs; as long as they are planted the right way, the potato will grow. **For cocoyam:** The sucker from cocoyam is planted with the lower part in the soil, but the farmers can also use the tuber as seed.

Interviewer: How do you identify the yam seeds, cassava, sweet potato and cocoyam that should be planted after harvesting?

Agbe: The yam seeds that are allowed to grow after harvesting yams are what will be replanted. When cassava stalks that are big and thick are planted, they don't grow; even if it grows it won't have any yield. Instead, the thin cassava stalks are the ones that are good to be planted. If you want the cassava to grow very well, make sure that the leaves from the stalk are already withered before it is planted. The potato vines are planted where it starts having buds. This is the part that will be placed in the soil. Once the vines start budding you cut a short length close to the bud in order for it to grow on time. If it is too long it will take a longer time. The sucker from cocoyam is what will be planted, you can also use the tuber. The lower part of the sucker is put in the soil.

Onwubuya and Ajani (2012) reported scarcity of planting materials as being a limiting factor in the production of cocoyam in Anambra, Nigeria. There the corms and tubers are used for planting so there is competition between consumption and production, which has limited the increase in cocoyam production. Elsewhere in East Africa, Talwana et al. (2009) reported that farmers use the tip of the corm as one of the methods for planting cocoyam, but, as it deteriorates with time, this part can only be used when planting is done immediately after harvesting.

6.3.6 Post-planting practices

Post-planting activities carried out on the farm include clearing weeds and mulching. Weeds are moulded together into round shapes and placed on the mounds during dry season. This is locally called *ìdíhàn* (mulching) and it protects the yam from the sun's heat does not penetrate and dry out the soil and spoil the growing yam. It can be observed that when the mulch placed on the heap some days previously is removed, the place that the mulch covered will be wet. Weeding is also done three times during the season to allow the yam to grow well. The farmers also put sticks on the mounds to serve as stakes for the leaves to climb up as the yam leaves must not touch the ground; if it touches the ground, it will get dry. For cassava they clear the weeds, while sweet potato does not need clearing as it covers the farm floor, thereby suppressing weeds itself. They usually plant cocoyam along waterways so again weeding is unnecessary, as shown in Figure 6.6.

Interviewer: How do you care for the yam after planting?

Agbe: We look for weeds, and then we mould these weeds together into round shapes and we place them on the heaps during dry season. This is locally called ìdíhàn (mulching). This will protect the yam from the sun so that the heat coming from the direct penetration from the sun will not spoil the growing yam. We clear the weeds when the weeds start growing and some farmers make use of chemical. We clear the weeds for cassava.

Figure 6.6

Picture of cocoyam planted behind a makeshift bathroom in the village.

Source: Olaniyan B. S. (2021)

The observation by the farmers concerning the length of the stakes determining the length of the tubers is similar to reports from Ghana by Ennin et al. (2014) that vertical staking enhanced more shoot development, which translated into a higher number of tubers and greater yield, although there was no mention of the effect of the length of stakes on the tuber yield.

6.3.7 Storage

Proper storage of root and tuber crops ensure that the famers get a good price for their produce. The yams are usually stored on the farm but with the cattle crisis, the famers have had to change storage practices. They store some in-ground by digging a hole and some are kept at home. Cassava are either left in the soil and only harvest when needed or processed into cassava flour, *garri* and *fufu*. Sweet potato and cocoyam are harvested for immediate consumption and are not stored. Some of the products of root and tuber processing are shown in Figure 6.7. Tor et al. (2017) reported that farmers in Benue state stored their root and tuber crops by delaying harvesting, storing in barns and pits, as was done in Kwara state.

Figure 6.7

Pictures of some products of yam and cassava processing

Footnotes

A. *Dried cassava chunks*
B. *The dried chunks grinded into flour called láfún*
C. *Dried yam tubers/chips èlùbó kóró*
D. *The dried tubers/chips grinded into yam flour used for àmàlà*

Source: Olaniyan B. S. (2021)

6.3.8 Pest and diseases

To forestall total loss of their produce the farmers had identified two of the most important pests attacking yam and cassava. These are *eṣú* or locust, although the infestation does not occur every year, and *inúrín* which are a small breed of termites that are usually found on small farm paths and which eat tubers from within, leaving an empty shell for the farmer to harvest. When the termites are noticed, the farmers have to count their losses and plant another crop in that field, essentially practising crop rotation. This breed of termites only infests yam so the other crops will survive. Braimah et al. (2007) also mentioned termites as one of the insect pests affecting yam in Ghana, which corroborates these farmers' observation that termites attack their yams. Such an attack has significant economic importance, as it reduces the quantity and quality of the yield, resulting in a loss of income for the farmers.

Interviewer: What about insects and pest, do insects spoil yams?

Agbe: Yes, there is a very small breed of termites locally called "inúrín", these are the insects that spoils the yams and when these insect infest on the yam, they'll eat it all up. They eat the tubers from within you just meet an empty shell. But it is not as if they may infest the whole yams that are on the farmland. The insects may only be on a particular part of the farmland.

6.3.9 Responses to climate change

In adapting to the various effects of the changing climate the farmers had to use knowledge imbibed from their parents in observing and responding to the changes around them. The farmer's responses to CC will be discussed with the aid of Table 6.3.

Change in rainfall pattern: The farmer uses the local indicators to predict the onset or end of the rainy season. Signs that rain will soon start falling include *igi osè* (baobab tree) growing new leaves as the rainy season approaches after having shed its leaves during the dry season and *igi fuúfù* tree, which starts growing leaves when the rains are imminent. There is also the bird *àṣá* (hawk), which will be seen in the sky staying still in one spot with its wings spread out when the rain is about to stop falling. The farmer also ensures he plants his yams at the right time to give them time to develop properly before the rains cease. During the time of excess rainfall, he harvests the growing tubers as too much rain would cause them to rot. The harvested tubers can be eaten or replanted later.

Table 6.3

Overview of Farmers' experiences and Indigenous Responses to CC in Gaa Ogbe village

Categories (IK in root and tuber production)	**Farmers' Experiences of CC**	**Indigenous Responses to CC**
Site selection Land filled with trees Organic matter *Akíntọ̀lá* (Siam weed) *Lámùrè* (tiny black ants)	-Reduced intensity of rainfall -Delay in onset of rainfall -Excessive rainfall -Flooding -Prolonged dry season -Change in time of planting.	**Rainfall Pattern** Predicts using local indicators Plants as at when due Harvest the tubers during excessive rainfall season.
Land preparation Mounds (*ebè)* Cocoyam is planted on flat ground		**Flooding** Early harvesting
Time of planting October-April for yam. Cassava is planted throughout the season. June-July for sweet potato March-May for cocoyam		**Prolonged dry season** Replanting of yam seeds Intercropping *Ìdíhàn* (Mulching) Staking
Varieties planted Indigenous and improved varieties of yam, cassava, sweet potato and cocoyam		**Pest and diseases** Crop rotation
Seed selection *Egùn isu* (yam milking) Head of harvested yams Thin cassava stalk Sweet potato vines Cocoyam suckers		**Animals and Thieves:** Dogs *Pàkúté* (trap) *Agogo* (bell) Charms *Aṣọ̀komásùn* (scare crow)
Post planting practices *Ìdíhàn* (Mulching) Weeding Staking		
Storage Stored at home In-ground storage Processed into *garri*, *lafun* and *fufu*		
Pest and diseases Crop rotation		

Source: Olaniyan B.S. (2021)

Interviewer: Have you ever experienced a period of time whereby rainfall started before the expected period of time? How does this affect farm crop?

Agbe: Yes, in fact it happens a couple of times. It affects farm crops but it does not really affect yam. Once you have planted the yam at the appropriate time early/late onset of rain doesn't affect it. We do not do irrigation. On the other time, when the rain falls constantly, it affects the yam and cassava and they'll start getting decayed. Yam should be planted on a land that doesn't retain water. Nothing is done to protect the tuber crops from the excess rain fall. The tuber crops can be harvested to protect it from the rain

Flooding: to forestall spoilage of his yams and erosion by flooding, the farmer harvests the ones he plants by the river bank earlier than those he had planted on upland. Harvesting earlier than usual to keep the crops safe is similar to what Ozor and Nnaji (2011) reported as change in harvesting dates is a measure of adaptation to climate change.

Interviewer: Why do you harvest the yams that are planted by the riverside quickly?

Agbe: That is because it grows quickly and if it is left to stay longer in the soil, it will get spoilt because of the constant water it receives from the river. That is why yams that are planted by the river side are harvested faster than the ones planted on plain lands.

Prolonged dry season: Replanting of yam seeds is a response when a prolonged dry season has caused the yam seeds planted earlier to dry up or get burnt. Intercropping also serves as a safety net for the farmer; in case of crop failure he has something to fall back on. Grasses are moulded into round shapes and placed on the mounds, called *ìdíhàn*, to conserve water in the soil. Stakes are placed on the mounds so the vines can climb on them as they will dry up if left on the ground. The farmers believed that the length of the sticks that are placed on the mounds would determine the length of the yam. These practices are confirmed by Nyong and Bassey (2019), who identified mulching and making mounds as some of the measures adopted by farmers in Akwa-Ibom state, Nigeria in adaptating to CC.

Pest and diseases: the farmers practise crop rotation on any plot where they discover the presence of *inúrín* (small termites). This helps to control the small termites as he mentioned that they only attack yams and leave the other crops untouched. The practice of changing the crop planted on the farm plot to check the activities of small termites is corroborated by Enete et al. (2011), who mentioned diversified crop rotation as a measure of pest control.

Animals and thieves: the farm can be protected through the use of traps and dogs. The traps would be able to catch monkeys and when a monkey hears a dog barking, it won't come near the farm. Some farmers do make use of local charms to stop people or animals from entering the farm. A *Aṣọ́komásùn* (scare crow) is also put on the farm to scare monkeys away, but this would be ineffective for humans. McLennan et al. (2012) also reported that farmers in Uganda make use of man traps to catch chimpanzees that raid their crops.

6.4 Indigenous Practices and Responses to Climate Change in Iludun Oro village

The practices and Reponses used in Iludun Oro village will be discussed using the same template for the preceding villages.

6.4.1 Site selection

Appropriate site selection is crucial to obtain a good seasonal harvest. When planting in the bush, the farmer can check the soil texture by digging a sickle into the soil and he would look for land where *akíntọ́lá* (Siam weed) is growing because it adds nutrients to the soil. If there are places that cannot be cleared with a cutlass, the farmer might resort to using a hoe, but now flat plane land can easily be cleared because akíntọ̀lá (Siam weed) has revived the soil. The need to check the soil texture corroborates the ideas of Luka and Yahaya (2012), who reported that farmers in Nasarawa state, Nigeria check the soil texture before choosing a site for yam production.

Interviewer: How do you identify the best land to use for the cultivation of yam?

Sir K: There are different types of land, we have the plain land and a bushy land is different from a plain land. A plain land can be classified into three; sandy soil, loamy soil, humus soil and we plant yam with these three. The varieties of yam that is to be planted on each type of land are also different. If a farmer wants to plant in the bush, the farmer needs to check the soil texture by digging your cutlass [sickle] into the soil. Another thing to look out for is a land that has akíntọ́lá (Siam weed) growing on it; this particular leave adds nutrients to the soil.

6.4.2 Land preparation

For this village, when planting in the bush the farmers first clear the land of all the trees. When the farmer is ready to cultivate such land, millet can be planted on it and later used as stakes for the yam vines to climb on. Another way is to leave the trees on the land, but they are then burned or dried with chemicals, so the leaves will climb over these trees. Agbede (2006) espoused manual clearing as one of the tillage practices practiced by farmers in southwestern Nigeria.

Interviewer: Do you plant in the bush and how do you go about it?

Sir K: There are two ways of planting yam in the bush, for instance if the land is cleared and all the trees are cut, when the farmer is ready to cultivate such a land, millet can be planted on it and the yam leaves will vine over the millet this is because most of the tress that are previously on the land are cut off. If another land is to be cultivated, the trees on the land can be burned with fire but now most people make use of chemicals. So the leaves will vine over these trees.

6.4.3 Time of planting

There was a time when farmers would plant yam around October, but if it seems that conditions are unfavourable, they then devise a method of covering up the yams under a shaded place and allowing them grow for a time. They are uprooted and replanted on the mounds. For upland they plant by October through to December and April, whereas lowland (by riverbanks) is planted in February. Cassava is planted at any time of the year. The time of planting explained by the farmers corresponds with Bergh et al. (2019), who noted that farmers in central Nigeria plant their yams in November or December.

Interviewer: How do you plant yam?

Sir K: There was a time that we plant yam around October, but when it seems that things are not going as it should be, we now devise a method.

Interviewer: Which method did you devise?

Sir K: We cover the yam up in a place and allow the yam to grow there, after the yam is allowed to grow for a while in the storage; it will then be planted on the heaps. This is because yam cannot *be planted the way it is being planted before. In recent times, if two hundred seeds of yams are planted, it may not yield up to five hundred pieces of yams after harvesting. But if the yams are kept in a wet place and allowed to grow there for a while before it is planted on the heaps, it will yield well.*

6.4.4 Varieties planted

For yam: The varieties *gbakùmọ̀, ẹlẹ́yintú, laásìńrín, ehùrù, ọ̀kùnmọdò, ọ̀dọ, eríńfọn, ajímókùnní, abáyàwó, ìgángán, dàgídàgí,* and *àgàtú* are planted in this village. **For cassava:** *Gbókogbàlà, ọkọ ìyàwó (called dọ́dún in ekiti), tòmùdé,* and vitamin A are planted in this village. **For sweet potato:** There are three varieties of potato that are mostly planted by farmers. There is also the local potato, Hausa potato, and a third one with orange flesh.

The choice of variety to plant has a huge effect on the eventual product. This is supported by Ajiboye et al. (2021), who highlighted the indigenous knowledge of farmers on the status and uses of some varieties of yam in southwestern Nigeria.

6.4.5 Seed selection

For yam: Selection is done during harvesting, when the seed yams are separated from the rest. Big yams cannot be used to make a sett; instead the slim ones are used for making yam sett. The size of a yam sett also depends on the variety of yam. For example, the *lásìńrín* variety of yam needs bigger sett while that of *eríńfọn* and *àgàtú* should be smaller because when the sett for this yams are made bigger than they should be, only the leaves grow and there will be no seed. **For cassava:** The good stalks are selected and planted, making sure the nodes are facing up. Also the selected stalks are kept safely so the bark does not peel off before planting, as the stalk would not grow without bark. Mignouna et al. (2015) reported that most of the farmers they surveyed in Nigeria and Ghana produced their own seed yams, which allies with what applies in this village.

Interviewer: *After making the heaps, how do you identify the best yam seeds to plant, the yams that are to be eaten and the one to be thrown away?*

Sir K: *When yam is being harvested, I as a person when I request for the help of others during this time, I use to request for the help of male and female. The males will be harvesting the yam while* *the females will be giving me the harvested yams and I will be using knives to be cutting the yams and this is how I know the right yam seeds to plant and the one that is not good for planting. Big yams cannot also be used to make a sett; instead, the slim ones are used for making yam sett. The size of a yam sett also depends on the variety of yam; some yams grow better with small set, while some setts will be bigger, e.g. a variety of yam called lásìńrín, the sett must be bigger while that of eríńfọn and àgàtú is smaller; when the setts for this yams are made to be bigger than it should be, the leaves will only grow and there will be no seed.*

6.4.6 Post planting practices

After planting yam seeds, the farmers add mulch (*ìdíhàn*) to protect the yam from the sun. This is done at least by March 15, because the sun from mid March until April is always intense. They also weed the land, but this depends on the land expanse. They make use of herbicides, either before the yams start growing or even when the yam starts growing leaves. The herbicide is specifically for yams. Odjugo (2008) submitted that mulching improves soil moisture by reducing runoff and evaporation so also increasing infiltration during the rainy season.

Interviewer: So, after planting yam, how do you take care of the heaps? Do you weed it or you make use of herbicides?

Sir K: After planting yam seeds, the first thing we do is to add mulch (idihan) to protect the yam from the sun. For example, this is year 2019, if yam seeds are planted by the month of September or October, by January or February the following year, the mulch should have been added, latest by March 15, this is because the sun around this period till April is always intense. We do weed the land, but this depends on the land expanse. We make use of herbicides before the yam start growing and even when the yam starts having leaves, herbicides can also be used; yams has its own chemical.

6.4.7 Storage

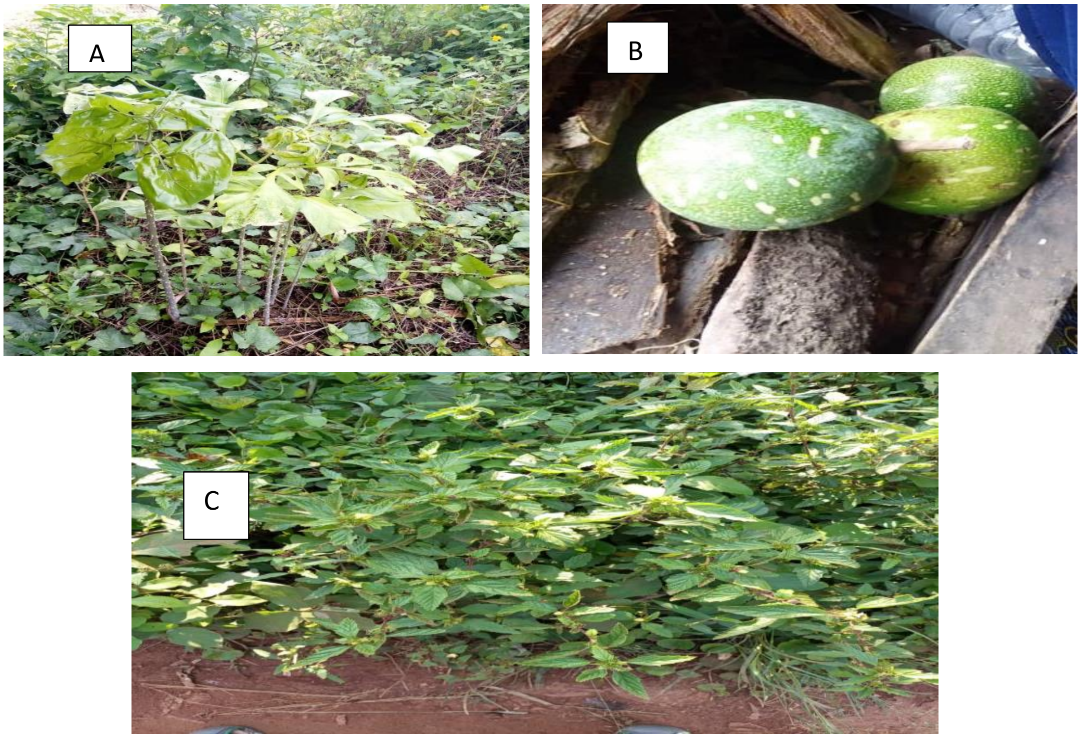
When the farmers are harvesting, they separate the yams to be sold from those for seed. Those that will be planted in April would be covered in the ground; these yam seeds will get spoilt if they are merely under shade. The seeds will first be kept in an open place for fifteen days before anything will be placed on the seeds. If anything is placed on the seeds before fifteen days, it will get spoilt. Cassava is uprooted and processed immediately as it starts to spoil once harvested. This is supported by Raheem and Chukwuma (2001), who posited that fresh cassava roots will get spoilt within three days if left unprocessed.

6.4.8 Pest and diseases

An herbal mixture is made from *ìtagìrì* (Christmas melon, *Adenopus breviflorís*), which is cut into pieces and placed in a big clay pot or plastic container that has been used for reserving rain water on the farm. And *ògìrìṣákọ́* (*Anchomanes difformis*) is also uprooted and pieces added to the water, after which *olọ́ọ̀sẹ́ǹpètu* (*Gliricidia sepium*) is be tied together like a broom and dipped in the mixture. Once it enters the mixture, it will foam and bring out bubbles and the mixture will be sprinkled on the yam seeds to prevent insect infestations. The components of the herbal mixture are shown in Figure 6.8. This is in agreement with Bamigboye (2015), who reported that farmers in Ekiti state, Nigeria treated their seeds with *ògìrìṣákọ́* potion to guard against soil dwelling insects. This particular farmer hailed from Ekiti hence his knowledge of the potion.

Figure 6.8

Constituents of herbal mixture used to prevent pests attack



Footnotes

A. *Ògìrìṣákọ́ (Anchomanes difformis)*
B. *Ìtagìrì (Christmas melon, Adenopus brevifloris),*
C. *Olọ́ọ̀sẹ́ǹpètu (Gliricidia sepium)*

Source: Olaniyan B. S. (2021)

6.4.9 Responses to climate change

The IK used by the farmers to respond to CC is discussed with the aid of Table 6.4. The farmer concerned responds to CC as follows.

Change in rainfall pattern: Proper timing of planting. He covers the yam allows the yam to start growing in a suitable storage place. After being in the storage, it will then be planted on the heaps. The Muslim cleric prays and rain falls while the traditional worshipers also perform some rainmaking rituals. He also predicts the onset of rainy season using local indicators.

Interviewer: Which method do you devise?

Table 6.4

Overview of Farmers' experiences and Indigenous Responses to CC in Iludun Oro village

Categories (IK in root and tuber production)	Farmers' Experiences of CC	Indigenous Responses to CC
Site selection Soil texture *Akíntọ̀lá* (Siam weed)	-Rain with ice -Delay in onset of rainfall -Excessive rainfall -Flooding -Whirlwinds -Change in time of planting.	**Rainfall Pattern** Predicts using local indicators Proper timing of planting Prayers and rainmaking rituals
Land preparation Clear and cut trees Mounds (*ebè)*		**Flooding** Enlarges the river path Places sandbags at river bank Vertiver grass
Time of planting October-April for yam while cassava is planted throughout the season.		**Whirlwinds** Reserve trees
Varieties planted Indigenous and improved varieties of yam, cassava and sweet potato		**Pest and diseases** *Ìtagìrì* (*Adenopus-brevifloris*) *Ògìrìṣákọ́* (*Anchomanes difformis*) *Olọ́ọ̀ṣẹ́ǹpètu* (*Gliricidia sepium*) Rainwater
Seed selection Slim yams used for setts Good cassava stalk Sweet potato vines		**Animals and Thieves** *Pàkúté* (trap) Guards D*ẹ́rùboko* (charms) *Aṣọ́komásùn* (scare crow)
Post planting practices *Ìdíhàn* (Mulching) Weeding Herbicide		**Herdsmen** Centipede powder Potash and beans mixture *Ọmúajá leaves* (*Ancistrocarpus densispinosus; Tiliaceae*) Charm
Storage Sold In-ground storage for seeds Cassava is processed immediately		
Pest and diseases *Ìtagìrì* (*Adenopus brevifloris*) *Ògìrìṣákọ́* (*Anchomanes difformis*) *Olọ́ọ̀ṣẹ́ǹpètu* (*Gliricidia sepium*) Rainwater		

Source: Olaniyan B.S. (2021)

Sir K: We cover the yam up in a place and allow the yam to grow there, after the yam is allowed to grow for a while in the storage, it will then be planted on the heaps. This is because yam cannot be planted the way it is being planted before. In recent times, if two hundred seeds of yams are planted, it may not yield up to five hundred pieces of yams after harvesting. But if the yams are kept in a wet place and allowed to grow there for a while before it is planted on the heaps, it will yield well.

Floods: He made channel for water by the side of the river, thereby enlarging the river and he uses sandbags to line the river bank. Also, he plans to plant vertiver grass, which the scientists had showed us at the workshop mentioned in Chapter 5.

Interviewer: What have you done about flood?

Sir K: About the issue of flood, what we have been able to observe is that we make passage way for water by the side of the river and we block its banks. Like the workshop we both went for some times back, vertiver grass was mentioned.

Whirlwinds: As a community they don't cut down trees, especially around the houses, so they serve as windbreaks against heavy winds.

Interviewer: So, as a community what have you been able to do concerning whirlwind?

Sir K: We pray and we also keep trees, we don't cut down all trees, we reserve them.

Pests and diseases: The farmer makes use of the herbal mixture that was explained in section 6.4.8.

Animals and thieves: The farmer sets trap, uses a scarecrow and guards the farms. The farmer looked for a small clay pot, it is called *dẹ́rùboko*, it is not an original charm but whoever gets to the farm will think it is a charm. Cowries and red cloth can be tied around this clay pot, together with black soap and a broom stick tied together with big sewing needle, and a dead bush rat is one is available, can all be added to the pot and placed on the farm. Whoever enters the farm will be scared to steal the crops, because the person would not be sure if it is real charm or not.

Conflict with herdsmen: A very big issue for the farmers in this village is the conflict with herdsmen; the farmers have recently lost considerable income from cattle damage. Accordingly, they have been encouraged not confront the herdsmen physically but rather counteract this using IK, as follows in their own words.

a. *The man gave me the charm because he pitied me after seeing all the labour I had undergone on the farm and he said the charm must not touch my hand, the charm was put in a plastic and he said that any cow foot print that I see, I should pour little out of the charm on each of the foot print and he further said that if the charm did not kill all the cows, he should be called a bastard. But he said it must not touch my hand that if the charm touches any human, it will lead to leprosy, but the cure is still the charm. He said the infected person should be brought to him and he will make the cure.*
b. *I was told to store centipedes in a container and when they are plenty I should dry it and then grind it. After grinding it, I was told that it can be used in two ways. The first way is if farm crops are kept in the farm and it was eaten in such a situation, the centipede charm can be added on some of the already harvested crops this will be used as bait for the cows to eat. When the cows eat these crops, they will die. The other way of using it is to heat palm oil and pour centipede mixture inside the hot palm oil. This mixture will then be poured on the cow dungs and the cows excreted on the farms will excrete to death.*
c. *We were also taught the local medicine that can be made from potash and beans by the Tapa's. To make this, they said the cow dungs can be parked randomly and then it will be mixed together with grounded potash and as you are stirring the mixture together with the potash, the cows that own the dungs will start having stomach disorder till they die. But you will make sure that the potash is grounded and it is much. So it will be mixed together with the dung. A woman used it some time ago and that year about seven cows died near our farms. Because after making the mixture, the mixture will now be buried.*
d. *Ọmúajá (Ancistrocarpus densispinosus; Tiliaceae) leave is soaked with water and used to spray the farm. This leaf is poisonous and when it is eaten it has effect on the cows even human being must not eat it.*

The responses of this farmer to CC are supported by Sekelemani et al. (2020), who mentioned changing of planting techniques and adjusting planting dates as some of the adaptation strategies that crop farmers in Botswana had employed in response to CC. Also Makhado et al. (2014) submitted that farmers in southern Africa responded to CC using by using the indigenous knowledge passed on by elders in guessing the weather, storing seed, and preservation, amongst other applications. Furthermore Speranza et al. (2010) reported that agro-pastoralists in Kenya mentioned prayers and offering sacrifices as one of the ways of reducing drought.

6.5 Indigenous Practices and Responses to Climate Change in Kaiama

The preceding templates persists. As mentioned in Chapter 5, the data for this village is scanty because it was gathered solely by the extension agent, as the researcher was not able to travel on that route.

6.5.1 Site selection

To ensure a good harvest the farmer takes great care to select a piece of land that would give the crops an environment that enables them to thrive.

For yam: This farmer looks for soil that has *gbada pe*, as it is believed this soil is good for yam. **For cassava:** Cassava requires less fertile land than yam, so the crop is often planted on abandoned farmland. So, land that has been used for cultivating yam for up to six years, and is no longer productive for that crop may still be used for growing cassava. **Sweet potato** can also be planted on a land suitable for cassava. This observation about cassava tallies with that of Pradyawong et al. (2018), who noted that in Asian countries cassava can be productively grow on marginal lands with minimal agrochemical input.

Interviewer: How can a farmer select a suitable site for planting yam, cassava and sweet potato?

Mallam S: There is a type of soil called gbada pe. This soil is good for yam. Farmers look for soil that has gbada pe and use it for farming. Cassava like a less fertile land, so it is planted on an abandoned farm land. A land that has been used for cultivating yam for four, five or six years that is no more producing can be used for planting cassava. Sweet potato can also be planted on the type of land that is used for planting cassava.

6.5.2 Land preparation

Land preparation ensures that the soil is in a good enough state to support the growth of root and tuber crops in a given farming season.

For yam: After identifying a good site, the farmer burns down all the trees there, clears the land and make soil ridges, which are left for some time before planting the yam. **For cassava and sweet potato**, he makes mounds rather than ridges.

According to Howeler et al. (1993), root and tuber crops need a loose-textured soil that does not become compacted over time, and so allows for the expansion of the tubers. Hence the need for the tillage practice of making ridges or mounds for such crops.

6.5.3 Time of planting

A farmer must plant root and tuber crops at the proper time to ensure a good crop yield.

For yam: In this area planting should be between November and March, allowing for both dry and rainy season planting. **For cassava and sweet potato:** Farmers plant these crops during the rainy season. Irizarry and Rivera (1993) reported that, when they experimented with three different planting dates in Puerto Rico, the date of planting had a significant effect on the weight, size and shape of the mature yam tubers.

Interviewer: How is yam, cassava and potato planted?

Mallam S: I plant yams after making heaps during dry season. After planting inside the heaps, I make the mulch. It is planted during dry season. Cassava is planted during rainy season. The stems are planted. Sweet potato is planted after cultivating in rainy season. It is only the leaves and the stem that is planted.

6.5.4 Varieties planted

The varieties of root and tuber crops planted determines the general wellbeing of the plants, their resistance to disease and so the yield.

They have *asha* for rainy season and *korogbara* for dry season. The varieties of *asha* are *sabuda, kuna, koroguna, wero soja, alumo, wesu, owu soja, seja zaria* and *odabi iyawo*, while those for *korogbara* are *korogbara tinko, korogbara sika, guna, afi, sesonku, kabi, alasin, aguwo, zaria, gomiya, gbepu* and *towazere*. In their studies, Ajiboye et al. (2021) found different varieties of yam thrived in the various places they surveyed, which accounts for the many names of varieties across the villages.

6.5.5 Seed selection

The state of the seed automatically determines the final produce, hence the need for caution when selecting seeds.

After harvesting the farmer gathers the yams together and separates the seed yams from the larger ones. He plants cassava stems and sweet potato vines. The practice of using smaller tubers as seed yams aligns with the findings of Asiedu and Sartie (2010), who submitted that farmers get seed tubers by selecting small tubers from each harvest.

Interviewer: How do you get your yam, cassava and sweet potato seeds?

Mallam S: How I do plant yam is after cultivating yam heaps, I harvest it during dry season and I gather them together and select the seed yams from the big yams. The seed yams will be the one that I will plant. I do the planting by digging the heaps, after digging the heaps for some centimetres, I put the yam seeds inside and cover it seriously and put mulch on top of it. That is how I plant yam.

6.5.6 Post planting practices

Activities carried out on the farm after planting by this farmer include putting mulch on the mounds in which yams were planted; he does not remove any weeds in the cassava farm in order to conserve the soil moisture. The farmer’s practice of mulching supports ideas from Adeniyan et al. (2008), who submitted that mulching reduced the soil temperature, increased the soil moisture and, as the mulch materials broke down, added nutrients to the soil. This farmer’s practice of not weeding the cassava plot in order to conserve moisture contrasts with the popular practice of weeding cassava plots to forestall loss of crops due to competition for soil nutrients by weeds (Melifonwu, 1994; Nedunchezhiyan et al., 2014).

6.5.7 Storage

This farmer processes his yams into yam chips, called *èlùbó kóró*. After harvesting, the yam is peeled and parboiled in water after which it is sun dried for seven days or more. The dried chip is then ground to produce yam flour (*èlùbó*), which is used to prepare *àmàlà*. There was no data indicating how he stored his cassava and sweet potato. The processing of yam chips is in agreement with the recommendation by Ojokoh and Gabriel (2010) that yam should be stored as yam chips.

Interviewer: What do you use the yams for?

Mallam S: The yams are used for pounded yam and it is sold raw. It is also used for yam flour. After digging the yam from the soil, peel it and parboil it in some level of water after which it is sun dried for seven days or more. After which it becomes complete yam flour. I package it and call people to come and buy. After which I collect my money and go my own way.

6.5.8 Pests and diseases

The farmer uses some chemicals to control pest and diseases. The use of pesticides by root and tuber farmers in Rwanda and Burundi was reported by Okonya et al. (2019), who recommended that farmers needed to be trained in the proper use of such chemicals and be encouraged to use an environmentally friendly integrated pest management system, such as cover crops to suppress weeds, rather than the use of chemicals.

6.5.9 Responses to climate change

This farmer’s indigenous responses to climate change are discussed with the aid of Table 6.5. The major problems this farmer had arising from climate change were drought, pests, diseases and animals and thieves. Hence, the discussion is centred on these.

Drought: the farmer mulches the yam plants in a long drought, as the mulch on the yam mounds protects the plants from moisture loss as well as preventing sunlight penetrating, which would destroy the yam. For cassava, no weeding is done so that the moisture content will be conserved. He also predicts the rain by observing the length of the harmattan season; if it is more prolonged than usual, then the rainy season is about to commence. Also, when there is sufficient cloud cover, and reduced wind, then it means rain will fall soon.

Interviewer: How do you take care of your crops during long drought?

Mallam S: For the yam in long drought, it is the mulch that is on the yam heaps that protect the yam so that the penetration of sunlight will not distraught the yam. In a cassava farm, the cassava won't be weeded at all so that the moisture content will still be there so that there won't be any problem.

Table 6.5

Overview of Farmer's experiences and Indigenous Responses to CC in Kaiama

Categories (IK in root and tuber production)	**Farmers' Experiences of CC**	**Indigenous Responses to CC**
Site selection *Gbada pe* for yam Marginal soil for cassava	**-**Drought	**Drought** Mulching of yam No weeding of cassava.
Land preparation Clear land and burn trees Ridges for yam Mounds (*ebè)* for cassava and sweet potato		**Pest and diseases** *Chemicals*
Time of planting November-March for yam. Cassava and sweet potato is planted during rainy season.		**Animals and Thieves** Trap and gun Charms Scare crow
Varieties planted Indigenous varieties of yam, cassava and sweet potato		
Seed selection Small tubers Cassava stem Sweet potato vines		
Post planting practices *Ìdíhàn* (Mulching) No Weeding		
Storage Processed into *èlùbó kóró*		
Pest and diseases Chemicals		

Source: Olaniyan B.S. 2021

Pest and diseases: The farmer makes use of chemicals to counteract pests and diseases like *ota pia* pia (dichlorvos).

Interviewer: How do you protect the farm from pest and diseases?

*Mallam S: For insect, there is a chemical substance called ota pia pia (*dichlorvos*) that is sprayed on the farm amidst the insects and diseases.*

Animals and thieves: For monkeys he sets traps, shoots at them or uses scarecrow, while for thieves he uses charms that work in diverse ways. The first type is put on the footstep of the person and wherever he or she goes, the thief would come back to the farm by his or herself. The charm may also make the person fall sleep on the farm so they could be caught while still asleep. The last one is that the person will be stuck on the farm until the farmer comes to release him or her.

Interviewer: How do you protect the farm from animals and thieves?

Mallam S: In the daytime, I move round the farm and if I catch any thief or monkey, I shoot at them. I also make use of local medicine for the thieves, any thief that enters the farm to steal, this medicine will be put on the footstep of the person and wherever the thief go, the thief will come back by his / herself. The thief may also sleep off and be caught wherever he/she is sleeping. Apart from this one, I also have some things that I use for human beings that whosoever want to steal from my farm will remain there.

The farmer's responses to climate change are in agreement with the works of Enete et al. (2011), who reported that farmers in Enugu use mulching as an adaptation strategy and McLennan et al. (2012), who submitted that farmers in Uganda use traps as a deterrent for chimpanzees entering their farms.

6.6 Indigenous Practices and responses to Climate Change in Yeregi village

This section is discussed using the existing template as the previous villages

6.6.1 Site selection

In selecting a site to plant yam the farmer looks for virgin land, called *àjùbà*, which is then cleared. Cassava is also planted on this soil as they intercrop yam, cassava, millet and maize on the same mound. Virgin land (where farming had never been carried out) is selected in the belief that it is very fertile and yam needs a fertile soil to grow well. Once the soil is perceived to be insufficiently fertile farmers move to a fresh site. This practice is known as shifting cultivation, which was found by Kio (1972) to be a practice common in Nigeria. It is not sustainable because of the population to landmass ratio, hence it could lead to deforestation and large-scale food shortage.

Interviewer: So is it the yam that you plant in the rainy season that you make the heaps like that of yangan (maize)?

Man A: The making of heaps begins from July till October. If the heap is made on àjùbà, another heap of sand can be added to it.

Interviewer: Which one is "àjùbà"?

Man: A virgin land, the land will be cleared with cutlass [sickle] and the heaps will be made.

6.6.2 Land preparation

In preparation for planting, the land is cleared with a sickle and the mounds are made. For rainy season planting, a straight-line ridge can be made. First the land is cleared, and about three months later, when the harmattan has ended, the farmers start preparing the land and making mounds because rain will soon begin to fall. After the first and second rain showers, they start planting. Neina (2021) noted that yam farming in Ghana requires freshly cleared land that is ploughed then mounds or ridges are made on it (p.2).

Interviewer: So you start making heaps in the month of July, is it for the rainy season or dry season?

Man A: Yams can be planted on these mounds either in the dry season or rainy season. When the yam mounds are made, millet can be planted on it and by the month of September another heap of soil can be added to the previously made mound that is when yam will now be planted.

6.6.3 Time of planting

Yams are planted by the month of September, when more soil is added to the mounds to ensure enough space for the eventual tuber. Some farmers start planting cassava in January while others will plant the cassava stalks together with yam on the same heap by the middle of June. When the dry season arrives, the only thing that will be left on the heap is the cassava; the yams would have already been harvested allowing the cassava to grow well. The importance of planting at the right time was espoused by Marcos et al. (2011), who reported variations in yields for different planting dates and concluded that the best time to plant was when the crop would get just enough rainfall and sunlight.

Interviewer: When do you plant root and tuber crops?

Man A: By the month of September another heap of soil can be added to the previously made heap, that is when yam will now be planted. According to what we learn from our fathers, there are some farmers that plant yams and cassava together on the same heap. So that these two crops will not affect each other according to the wisdom of the elders, like on the 15th of this coming month (August), cassava sticks can be put on yam heaps, it will be planted by the side of the heaps as well as maize. And by dry season, the only thing that will be left on the heap is the cassava because the yams would have been harvested by then.

6.6.4 Varieties planted

In this village, the farmers plant their indigenous varieties of yam like *pàsá* and *bọ̀rkí* but the newly introduced improved variety called *ódàbí ìyàwó* (new yam) is planted in greater quantities because of its fast growth, which helps in time of drought. The neglect of some of the indegenous varieties may lead them to be endangered, as it supported by the findings of Ajiboye et al. (2021), who could classify yam varieties as endangered or not, based on their availability and use by the indigenous farmers.

Man A: There are some yams that we do harvest in the dry season then like pàsá, bọ̀rkí and we don't really plant them again instead we plant ódàbí ìyàwó (new yam) because this yam grows faster than others but its disadvantage is that this new yam is not as thick as the other yams.

6.6.5 Seed selection

After harvesting, the yams are sorted and the ones that are already dead will be separated for *elùbọ́* (yam flour) or immediate consumption. The small tubers are kept for replanting and the head of the big tubers will be cut and replanted. The cassava stalk and the vines of sweet potato are also planted. The method of seed selection agrees with Sesay et al. (2013), who posited that farmers in Sierra Leone get their planting material by reserving the head of tubers and small tubers, amongst other sources.

Interviewer: How do you know the right yam seeds to be planted?

Man A: After harvesting, we gather the yams. Some yams are already dead already and they'll be separated for elùbọ́ (yam flour) and it will be eaten. The small yams that are gotten can be replanted and there are some yams too that are not spoilt after harvesting the head of the yams will be cut and it can be re planted, it will also grow.

6.6.6 Post-planting practices

After planting, mulching the mounds will be carried out two months later. Sticks will be placed on the mounds as stakes for the yam plants to climb over, which helps the yam to grow well and also prevents the sun from destroying the leaves. When the rain starts falling and the weeds start growing, they will be cleared manually, no matter how big the farm is. These agronomic practices agree with Ennin et al. (2014), who noted that staking increased the weight and yield of the tuber as against no staking at all. Also Aduo and Nwadili (2019) submitted that mulching acts as a fertilizer and improves the soil physical properties.

Interviewer: So, after planting yam or cassava, do you weed it?

Man A: Before the rain starts falling, it will be mulched and when the rain starts falling and the weed starts growing, it will be cleared manually no matter how big the farm is.

6.6.7 Storage

Yams are stored inside a shed. The famers put a layer of sticks on the ground with sponge covering them, on which the yams will be placed. When the yams start growing in the shade where it is kept, the growing parts will be broken off, so that when the rainy season starts, the yams can then be planted. If the growing parts are not broken off, the yam will no longer be good for food. Cassava is processed into cassava flour or left unharvested. Because everything in the heaps cannot be harvested at the same time, sometimes it remains two years in the soil before it is harvested. But after two years the cassava will start having lesser weight and then decay. Sweet potato is sold or eaten straight after harvesting as it cannot be stored for long. The storage of yam was explained by the farmers to be similar to what Osunde (2008) had identified as being practice in the Guinea savannah zone of Nigeria where this study area lies.

Interviewer: *How do you keep the tubers when the harvest is much and everything is not sold in the market and you can't eat everything?*

Man: *the way we keep it is that some people may put sticks on the round and put sponge o the sticks and the yams will be placed inside. When the yams start growing in the shade where it is kept, the growing parts will be broken and when the rain starts falling, the yams will then be planted. We use cassava to make cassava flour besides everything in the heaps cannot be harvested in the first place, it can use two years in the soil before it can be harvested. After two years the cassava will start having lesser weight and then it will decay.*

6.6.8 Pests and diseases

To counteract pests, the farmers make use of herbs such as *ìpẹ̀ta* (African violet tree) and *lẹgun óko* (potherb) to treat their seeds before planting, although these herbs are reportedly poisonous so not used much recently. They also believe that the rain will wash insects away. Such actions are similar to cultural control of pest as submitted by Asante et al. (2008), who reported that farmers in Ghana made use of ash, *dawadawa* and cow dung to control pests in stored crops while they pray for rain to wash away the field pests. Similarly, Akinbo (2019) also identified plant extracts from *uda* (*Xylopia aethiopica*) and ginger as being used as fungicides in southeastern Nigeria.

Interviewer: After planting, how do you locally protect the crop pest and diseases?

Man A: In the olden days, there are some herbs that the juice can be squeezed out and sprayed on the plants. It is locally called ìpẹ̀ta and lẹgun óko. But lẹ̀gun óko is stronger than ìpẹ̀ta. After washing the leaves and getting the juice out of it, then it will be mixed together with the seed that is to be planted. After planting it and àparò go to the heap to eat the seeds, the bird will die? For yam, there is no drug that can be used to avoid the pest to infest it other than rain. If the rain falls, it will chase the insect that are underneath the soil away.

6.6.9 Responses to climate change

The farmer's responses to climate change are discussed with the aid of Table 6.6. This farmer responded to CC in the following ways:

Table 6.6

Overview of Farmers' experiences and Indigenous Responses to CC in Yeregi village

Categories (IK in root and tuber production)	**Farmers' Experiences of CC**	**Indigenous Responses to CC**
Site selection *Àjùbà* (virgin land) Shifting cultivation	-Unpredictable rainfall -Reduction in rainfall intensity -Floods -Drought -Whirlwinds -Reduction in yield	**Rainfall pattern** Prays to God
Land preparation Clears land Mounds (*ebè)* or ridges		**Floods** Drainage system
Time of planting September for yam. January/June for cassava		**Drought** Early maturing variety.
Varieties planted Indigenous and improved varieties of yam and cassava		**Whirlwinds** Nothing
Seed selection Small tubers Head of big yams Cassava stem		**Pest and diseases** *Ìpẹ̀ta* (African violet tree) *Lẹgun óko* (potherb)
Post planting practices *Ìdíhàn* (Mulching) Staking Weeding		**Animals and Thieves** Scarecrow Guards Charms
Storage Barns Cassava is processed into flour		
Pest and diseases *Ìpẹ̀ta* (African violet tree) *Lẹgun óko* (potherb)		

Source: Olaniyan B.S. 2021

Change in rainfall pattern: He prays to God to send the rain.

Man A: There is nothing that we do, if the yam has not started growing before the rain stops, it will be left in the soil and when the rain starts falling again, the yams will grow but it may not be big. And if the yams have been growing before the rain stops, there are times that it will survive and sometimes it doesn't. We keep praying to God so that the rain will fall.

Floods: The community made a channel for water pass through and ensured it was kept free of debris.

Interviewer: Have you ever experience flood here?

Man A: No, our settlement is not close to the river and houses are not built closer to each other. But our fathers experienced it because they built houses with mud then and when the rain is heavy, it does happen. So we created a channel for the water to pass through; flooding only use to happen when the channel is blocked. We make gutters for the water to pass through.

Drought: He changed to early maturing variety

Man A: Yes, we have prolonged dry season, it is either the rain doesn't fall early or it stops earlier than expected. We make heaps and immediately the rain starts falling in the month of April we start planting, because we don't know the pattern through which the rain may take. There are some yams that we do harvest in the dry season then like Pàsá, Bọ̀rkí and we don't really plant them again instead we plant Ódàbí ìyàwó (new yam) because this yam grows faster than others but its disadvantage is that this new yam is not as thick as the other yams. Response to drought

Whirlwinds: The community do not do anything about it.

Pest and diseases: He uses plant extract from *Ìpẹ̀ta* (African violet tree) and *Lẹgun óko* (potherb).

Animals and thieves: He uses a scarecrow, guards the farm and administer charms that turn into a snake when a thief enters the farm.

Man A: Some people make local charm and put it on the farm, while some will stay on their farm to watch over it at night. And some farmers don't watch over the farm, they may gather their yams and put a charm on it, whoever comes near the crops the charm will turn into snake and it will be chasing the thief. For monkey, we use what Yoruba's call aṣọ́komásùn (scarecrow). Some people wear cloth for it and even put cap on its head. When the monkey sees this, it will be scared thinking *it is human being but if the monkey keeps seeing it every day then it will know that it is not human being that is standing there.*

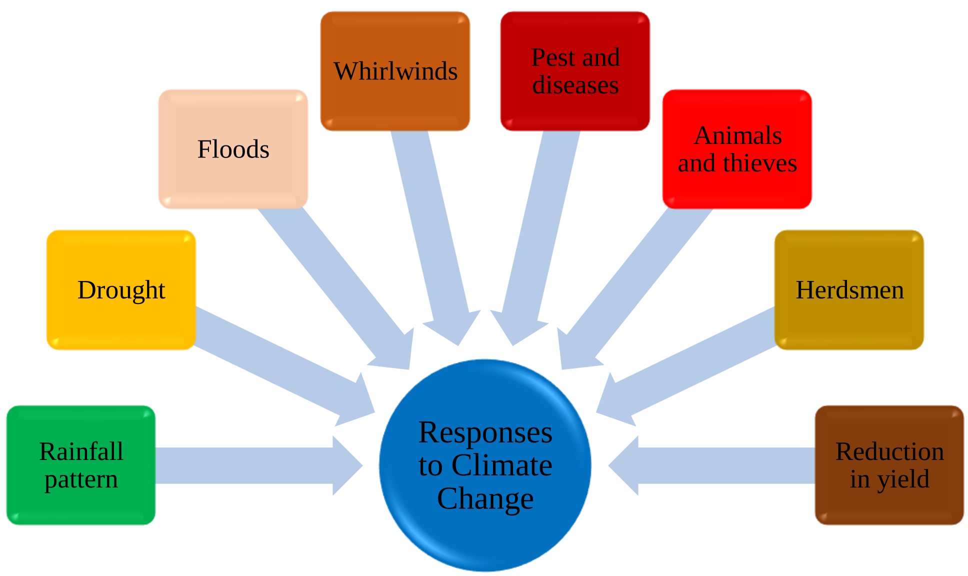
These adaptation strategies of the farmer are in agreement with Shrestha et al. (2018) who identified changes in the crops grown as being one way in which farmers in southeast Asia adapt to CC. Also Ayanwuyi et al. (2010) reported that farmers in Ogbomosho, Oyo state, which borders the present study area, adapt to CC by planting different varieties and treating seed with fungicide.

6.7 Summary

The indigenous practices employed in root and tuber production have been carefully highlighted in this chapter and the ones used in responding to climate change were more closely examined in a bid to find out how they respond to climate change using their indigenous knowledge. A holistic diagrammatic representation of the responses for the six villages is given in Figure 6.9. Having examined their experiences of climate change in the previous chapter and how they respond to it in this chapter, the next chapter will assess why the farmers respond to climate change in the way that they do.

Figure 6.9

Pictorial representation of Nigerian root and tuber farmers' responses to Climate Change



Source: Olaniyan B. S. (2021)

Table 6.7

Overview of root and tuber Farmers' experiences and Indigenous Responses to climate change

Categories (IK in root and tuber production)	Farmers' Experiences of CC	Indigenous Responses to CC
Site selection *Àjùbà* (virgin land), *Akíntọ̀lá* (Siam weed), Loamy and sandy soils, Shifting cultivation, Dark green colour grasses, Land filled with trees, Organic matter, Soil texture, *Gbada pe* for yam, Marginal soil for cassava, *Lámùrè* (tiny black ants)	-Unpredictable rainfall -Reduction in rainfall intensity -Reduced frequency of rainfall -Delay in onset of rainfall -Excessive rainfall -Rain with ice -Floods -Drought -Whirlwinds -Reduction in yield -Change in time of planting	**Rainfall pattern** Predicts using local indicators Prays to God, Plants as at when due Harvest the tubers during excessive rainfall season Rainmaking rituals Proper timing of planting
Land preparation Clear land, Cut trees, Slash and burn, Mounds (*ebè)* or ridges, Cocoyam is planted on flat ground		**Floods** Drainage system Early harvesting Enlarges the river path Places sandbags at riverbank Vertiver grass.
Time of planting September-April for yam. Cassava is planted any time of the year. June-July for sweet potato March-May for cocoyam		**Drought** *Ìdíhàn* (mulching) *Ebùjó* (shrinkage) *Àgbìnpò* (intercropping) Early maturing variety Replanting of yam seeds Staking No weeding of cassava farm
Varieties planted Indigenous and improved varieties of yam, cassava, sweet potato and cocoyam		**Whirlwinds** Nothing Reserve trees
Seed selection Small tubers, Head of big yams, *Egùn* (yam milking), Yams that sprouted in storage, Slim yams, Cassava stalk with best yield, Thin cassava stalk, Sweet potato vines, Cocoyam suckers		**Reduction in yield** *Àgbìnpò* (intercropping)
Post planting practices *Ìdíhàn* (Mulching) Staking Weeding Apply herbicides Adding soil to mounds		**Pest and diseases** *Lẹgun óko* (potherb) and *Ìpẹ̀ta* (African violet tree) *Ewé tábà* (tobacco leaves) Palm fronds Black core of battery Crop rotation *Ìtagìrì* (*Adenopus brevifloris*), *Ògìrìṣákọ́* (*Anchomanes difformis*), *Olọ́ọ̀sẹ́ǹpètu* (*Gliricidia sepium*), Chemicals Rainwater
Storage Barns, Stored in large room, Stored at home, In-ground storage, Yam is processed into *èlùbó kóró*, Cassava is processed into *garri*, *lafun* and *fufu*		**Animals and Thieves** *Aṣọ́komásùn* (scarecrow) *Pàkúté* (trap) *Agogo* (bell) *Wasa* and *Àsírí* (charms) Guards with guns and dogs
Pest and diseases *Lẹgun óko* , *Ìpẹ̀ta* (African violet tree), *Ewé tábà* (tobacco leaves), Palm fronds, Black core of battery, Crop rotation, *Ìtagìrì* (*Adenopus brevifloris*), *Ògìrìṣákọ́* (*Anchomanes difformis*), *Olọ́ọ̀sẹ́ǹpètu* (*Gliricidia sepium*), Chemicals, Rainwater		**Herdsmen:** Centipede powder Potash and beans mixture *Ọmúajá leaves* (*Ancistrocarpus densispinosus*) Charm

Source: Olaniyan B.S. 2021

Indigenous Knowledge employed in responding to climate change across the six villages seemed to be the same because the farmers are from the same ethnic group with a few variations like the use of the herbal mixture as seed preservative which was practiced by a farmer in Iludun Oro who has his roots in another state where those herbs are commonly used. Other variations include using charms to fight against herdmens also at Iludun Oro as against refusing them entry into the village or reporting the issue to the authorities in other places. The farmers in Yeregi did nothing to prevent or reduce the impact of whirlwinds because they felt helpless as against the practice of not cutting trees in Iludun Oro to serve as windbreaks.

CHAPTER 7: THE ROLE OF INDIGENOUS KNOWLEDGE IN CLIMATE CHANGE ADAPTATION

7.0 Introduction

The root and tuber farmers' responses to climate change using their indigenous knowledge was presented in detail for each village in the last chapter. IK employed in root and tuber farming at different stages of production was explored because the famers respond to the phenomenon of climate change as they carry out their farming activities using the knowledge passed down the generations.

This first section of this chapter explores the role that indigenous knowledge plays in their responses to climate change, in answering RQ3, which is: **Why do Nigerian root and tuber farmers respond to climate change in the way that they do?** The reasons for the famers' responses using indigenous knowledge are presented together for all six villages, as there were similar reasons for their actions across the villages.

While the second section of this chapter examines the nature of indigenous knowledge employed by the farmers in responding to climate change. As such, it is an attempt to answer the overarching question of this study which is: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** Answers to this question will help to understand the struggles that the farmers experience as they deal with the changes occasioned by a change in the climate, and give voice to the indigenous peoples who have so often been relegated to the background by academia. It will also provide a resource that could be useful in finding an appropriate adaptive solution to the phenomenon of CC, in a bid to give everyone an opportunity to make their contribution to the adaptation process.

The third section discusses the implications of these findings for education and policies regarding climate change adaptation.

7.1 Reasons for Responding to Climate Change using Indigenous Knowledge.

In dealing with the changes occasioned by climate change the farmers in this study had to navigate from what is known to what is unknown; hence, their use of inherited knowledge to respond to climate change. Indigenous knowledge has been referred to as so many things at various times by different scholars, names like traditional ecological knowledge, local people's knowledge, insider knowledge, indigenous technical knowledge, folk knowledge and people science. The general consensus is that Indigenous knowledge is location specific, exists mainly in oral form, is holistic, and held by a select few called custodians. It is dynamic, modified by the indigenous people as they relate with their environment and often results from trial-and-error type of experimentation in their day to day living. These attributes make indigenous knowledge an essential part of these farmers' responses to climate change (Aikenhead & Ogawa, 2007; Gadgil et al., 1993; Murray Li, 2000; Nawrotzki & Kadatska, 2010).

Most of the farmers had access to extension services so they are introduced to improved crop varieties, new farming techniques and methods, and agricultural inputs such as chemicals and fertilizer. Nevertheless, such input is primarily focused on cereals, with very little relevant to root and tuber crops. In the village of Gaa-Ogbe, they mentioned that they had been taught in the Kwara Agricultural Development Program to dust the yam sett with wood ash before planting and apply fertilizer and pesticides, which they had carried out. But they reported that, although the yield had been satisfactory, it was not comparable to that obtained with their own methods. A major drawback to the 'new methods' was that the yam tubers were not good for pounding when fertilizer had been added. Across all six villages they observed that the tubers had blackened as soon as they were cut open. By way of explanation, Onayemi (1986) has reported that discoloration of yam when cut depends on the polyphenol content of the variety, the part of the yam cut and the time such yam has spent in storage. So, these farmers continued to use their local ways of planting and caring for their root and tuber crops.

Agbe: Yes, we have access to agricultural extension agent. And we make use of the information we get from them and it works for us. We were told that when the yam setts are made; we should add ashes to the surface and then plant it. Also that when the yam is planted, we should add fertilizer. The yam also yields well when it is planted this way too and the yams are also big according to what we were told then. We were also given pesticides that can protect the yam from *pest. We practiced it and the yield was very okay. A representative was sent from the agricultural extension office to come and check the yield. Though the yam grew well but the result can't be likened to the way we locally plant our yams. The local way of planting yam is still preferable.*

This is a classic case of a trial-and-error experiment mentioned above, in which indigenous people do some form of experimentation as they go about their daily lives. Access to other sources of knowledge, which may help in their adaptation to climate change, was also recorded; they said that they listened to agricultural programmes on radio and television alongside regular visits by extension agents. Nevertheless, they primarily use their own ways to adapt to climate change. It is pertinent to note that they had adopted scientific knowledge like improved seeds for other crops but use indigenous knowledge primarily for root and tuber crops, as there have been few scientific interventions for root and tuber crops and those available has not been adopted by the farmers because they do not find them useful.

This preference for their local knowledge learned from their predecessors rather than the scientific knowledge introduced by the extension agents was explored, and the following reasons were deduced from the data:

1. It is effective.
2. It is easily accessible.
3. It is inexpensive.
4. There is resistance to the top-down approach of scientific intervention.

These are discussed in detail in the sections below.

7.1.1 Indigenous knowledge is effective

As stated previously, indigenous knowledge is developed by people residing in a particular location as passed down through the generations orally and by practical demonstrations. It is used in day-to-day living and when confronting challenges posed by life and the environment. IK is learnt by engaging with it over a long time and is oriented more practically than theoretically (Ayeni & Olorunfemi, 2014). The practical orientation of IK makes is well suited for use in daily life as the custodian of such knowledge applies it to situations as they arise in a show-and-tell manner, which the younger generation learns from. This sustained interaction with the environment has helped in developing coping strategies for changes they have noticed over time and responding to them accordingly. By way of example, this is an excerpt from the data supporting the effectiveness of IK employed by the farmers in response to drought:

Farmers: That is what I was telling you, you know that when rain cease to fall, there is no human being that can make rain fall aside God, whatever a farmer is planting, as long as it is not only one crop it will pay off. For example, if a farmer plants different crops and then the rain suddenly stops falling, if the farmer doesn't get gain from maize, the farmer will get gain from millet. Like potato for example, it would have finished growing before the rain will stop falling.

The effectiveness of IK in sustaining the environment and crop production over the years has contributed to its enduring use by farmers and more recently in their responses to climate change. The effectiveness of indigenous knowledge was explored by Husain and Sundaramari (2011) in their study of the indigenous technical knowledge used in coconut cultivation by farmers in Kerala, India, where they found that most of this knowledge passed the scientific rationality test (i.e. the operational principles could be explained scientifically) and were perceived to be effective by the farmers. Also Tikai and Kama (2010) reported that IK has been effective in sustaining agriculture in Samoa, where it is used in management of pests and disease, maintaining soil fertility, weed control and all other aspects of farming in that region. Furthermore, Mairiga and Ibrahim (2021) noted that most of the indigenous people of Ringim local government area of Jigawa state, Nigeria agreed that IK used in handling their environmental challenges is effective. Likewise, Adekunle et al. (2002) reported that the indigenous control methods of hygiene, that is use of herbs and holy books, employed in the control of pests and diseases of cattle by herdsmen in northern Nigeria were effective. Córdoba Vargas et al. (2020) submitted that peasant farmers in the Colombian Andes were not passive victims of climate variability as they had been able to articulate their perceptions of climate variability, which corresponded to the scientific evidence, and they possessed knowledge built on experience that they used to tackle the challenges of climate variability. Knowledge like methods water harvesting and diversifying crops were effective, hence the need to include them in the mainstream adaptation efforts. Collaborating with farmers on climate change adaptation is essential because their coping strategies are mainly geared towards their farming activities. This contrasts with the other players in the mainstream climate change action who need to focus on infrastructural aspects.

In as much as the use of IK had been effective in these famers responses to climate change, it is pertinent to note that such strategies are, nevertheless, only for the short term and more effort needs to be put into finding lasting solutions. For example, manual weeding is constantly required on the farm to control weeds, which is costly to the farmers, so they have adopted the use of herbicides which reduces the number of times they need to weed their farm manually. This gap was also noted by Mavhura et al. (2013), who opined that indigenous coping mechanisms in Zimbabwe tended to be effective only when the magnitude of the floods were low and other measures had to be sought to survive intense flooding. This is where the interface between IK and conventional knowledge becomes expedient in finding a robust approach to climate change that is not only effective but has long lasting effects.

7.1.2 Indigenous Knowledge is easily accessible

Another reason for preferring to use IK is its availability and accessibility. The materials needed to carry out any IK practice are usually available within the community; thus accessibility is guaranteed. Just as farmers in this study reiterated that they do not use fertilizer for root and tuber production because the crop would not be as good for eating, as portrayed by the excerpt below, so they use the waste generated in the house, crop residue and animal dung to maintain soil fertility.

Interviewer: There are some yams that when they are cut, they turn black.

Agba: Fertilizer has been added to such yam, it has been said that fertilizer shouldn't be added to yam again. The soil already has enough manure to make the yam grow well. For example, all the dirt that we acquire whenever we sweep and we pour at the backyard, when such a place is used for cultivating tuber crops, it will grow very well because the dirt has decayed and have added manure to the soil.

This ability to make use of resources within the farmers' reach to solve their problems makes IK relatable and accessible to everyone interested in it. Akullo et al. (2007) noted that farmers in Uganda use locally available resources in their farming and are willing to continue using such because of their accessibility and they do not have to pay for them, while modern technology was not readily accepted because it is not indigenous and they had to pay for it. The indigenous resources are usually well suited for that environment, as espoused by Dweba and Mearns (2011), who indicate that traditional vegetables like *gcamche* (*Obetia tenax (N.E.Br.) Friis*) and *nomdlomboyi* (*Amaranthus viridis L.*) abound in South Africa and are well adapted to the area, thus they thrive and are available when the exotic ones are not. This availability has led to continued preference for such traditional vegetables as they require less input to grow. As Oniang'o et al. (2004) put it, farmers continue to use these resources because they are familiar with them, thus putting the knowledge of things around them to good use in their day-to-day living. As an example, when treating their domestic animals, Ajala et al. (2016) report that rural farmers in Igbomina land, Nigeria made use of readily available resources such as palm oil, alligator pepper, wood ash and salt to manage various animal diseases instead of conventional veterinary medications which are usually not available in the rural areas or are too costly for them to procure.

The accessibility of IK is dependent on one knowing the use of each material because misuse could, in some instances, be disastrous, such as the leave espoused by one of the farmers in Iludun Oro used to deter cows from entering their farms.

Mama M: Ọmúajá (Ancistrocarpus densispinosus; Tiliaceae) leaves when it is soaked with water, it will be poured in a sprayer and used to spray the farm. This leave is poisonous and when it is eaten it has effect on the cows. Even human being must not eat it.

If not used as prescribed and with proper precautions, this mixture may cause harm to the farmer or his relatives.

Some IK is shrouded in secrecy so one needs to belong to a particular sect like *Ogboni* confraternity to access such IK. With the advent of civilization, religion and modernization such IK has been demonized so that even the custodians of such IK do not openly identify as they do not want to be tagged diabolic.

Baba P: There is nothing we can do; the best thing is to pray to God. Those days when Islam has not been to the limelight, they gather together and do some things together and rain will fall. And the reason why people are scared of doing this is because of the religion and they are trying to avoid being tagged a wicked person.

This stigma has led to some custodians taking their IK with them to the grave instead of passing it onto the next generation. Thus, much IK has been lost, so accessibility of indigenous knowledge may be in question.

7.1.3 Indigenous knowledge is inexpensive

The use of local resources by indigenous people in solving local level problems makes IK inexpensive. One does not have to go to school or pay tuition to gain IK about farming, for example; it is 'freely' learnt as you watch the elders do the farming itself, in situations of apprenticeship akin to those for blacksmiths where a small token is paid and the master sets up the apprentice in the trade after graduation. This in itself makes acquisition of IK inexpensive. As Bapfakurera and Nduwamungu (2020) noted, IK provides a cost effective option for development interventions if it is fully explored in a collaborative manner. This may arise from the fact that the inputs cost little or nothing and the farmers find a way to maximize the money spent, such as the expense of paying for labour to make mounds, meaning that the farmers plant many crops with varying maturity dates on the same mound, to reduce overall cost, as shown in the excerpt below.

Interviewer: I was in a place, and I saw some yam mounds where okra, vegetable, cassava and maize were planted on this same heap along with the yam. Why do you do it that way?

Agbe: That is how we do it here also if the land is fertile. They do not disturb each other. There are many reasons why this is done. Firstly, when the land is fertile, different crops can be planted on the heaps together with the yam. Secondly, the crops on the heaps doesn't stop the yam from growing. Thirdly, in order to save money to start making different ridges, the crops are planted along with the yam. Lastly, the scarcity of land can make the farmer maximize the land he has. But notwithstanding, they grow very well. Money to pay labourers to make heaps is expensive.

The practice of intercropping done in this village has multiple benefits, one of which is the reduced cost of labour for making mounds; one mound can accommodate about five crops instead of having to pay for labour to till the land for each. The crops planted together are chosen to have different maturity dates and so they do not disturb each other. Besides, their nutrient uptake differs so soil fertility is maintained. This practice also solves the problem of scarcity of land because of competition with development and cattle migratory routes, so the farmers make optimal use of the land available to them. Intercropping has the added benefit of food security; if one crop fails others would cover the shortfall both in income and availability of food. The cumulative effect of this practice is that the cost of production is reduced considerably, compared to the conventional methods. This accounts for the notion that IK is inexpensive.

This view was also supported by Tikai and Kama (2010), who submitted that small scale farmers in Samoa use IK in crop production because it works and is cost effective. Practices like planting with sticks which can be easily obtained at no cost and not tilling the ground reduces the cost of production for the Samoan farmers. Aluko (2018) also reported that farming activities done using IK are less expensive than the conventional methods as the respondents practice cover cropping, crop rotation and similar strategies to ensure soil fertility, while making use of ash and kerosene to treat their crops when infested with pests. Koocheki (2003) also mentioned that indigenous farming systems have a holistic view of utilizing natural resources and make use of such resources with minimal external inputs, thus having a high output compared to their input costs. Conversely, Kaniki and Mphahlele (2002) noted that while IK has some good ideas that can contribute to the betterment of humanity, inherent in the belief system are some cultural practices that are detrimental to human existence and which need to be modified. Specific practices like clean clearing have been criticized as increasing deforestation because all available vegetation is cleared to give room for agricultural production.

Taking a critical look at the cost of production using indigenous knowledge, the beneficial effect on the environment and the eventual output, one can conclude that IK is inexpensive compared to conventional farming methods. Nevertheless, the effort involved in using IK, and the cost of labour may raise questions around this assertion, as time and energy can be saved using technology for some parts of production, such as using a tractor mounted ridger to till the ground instead of a hoe and sickle.

7.1.4 Resistance to the top-down approach of scientific intervention

The usual top-down approach employed by science in proffering solutions to agricultural problems has led to their not being adopted by the farmers, or creating little enthusiasm when they are used. Scientists in research institutes and universities observe a problem and go ahead to search for a solution, often without consulting the farmers who are most affected. The ‘solution’ is then presented to them by extension agents. Such an approach over time informs the resistance demonstrated, as deduced from the data. A good example is the scenario in Gaa-Ogbe mentioned above, where the farmers tried the innovation but then reverted to their old way of planting yams. Not taking into consideration the local culture, skills and knowledge was identified by Warren and Cashman (1988) as a reason for failure of technological solutions that were intended to solve rural problems. They proposed, instead, that local people should be included when planning and implementing projects that concern them and IK competent individuals are best suited to engender participation by the indigenous people (Kolawole, 2001).

Several scholars have reiterated the need to incorporate the indigenous knowledge of the people into any development effort by the authorities. Failure to do so leads to outright rejection of the 'solution' or a lackadaisical attitude towards it (Kolawole, 2013; Lalonde, 1991a). Hence, Akullo et al. (2007) promoted the need for the indigenous people to own the process, thereby ensuring a good representation of them in programs that are intended for their benefit. Ajani et al. (2013) suggested that indigenous knowledge should complement rather than compete with global knowledge systems in adapting to climate change, while Ndlovu et al. (2020) theorized that indigenous knowledge be integrated into the agricultural curriculum in Zimbabwe so the students whose origins are amongst the local people could accept the blended curriculum and use it regularly in their daily living.

By contrast, when the farmers are involved in conceptualizing the innovation, the resultant effect is they make good use of it. A case in point is the use of herbicide to control weeds on the root and tuber crops farm, which was adopted by most of the farmers in this study because it reduces the number of times they had to manually weed their farm and also cuts down on cost of labour for such activity as described in the excerpt below. Adoption of improved varieties of cassava that mature faster than the indigenous ones is another case in point; because the production period is shortened the farmers get good returns in a shorter time. Sillitoe (2006) argued for proper recognition of IK by giving it a prominent place in mainstream knowledge management but he noted that scientific knowledge should also be not neglected as the technological advances of this knowledge system help in development. Consequently, there should be a negotiation between the two knowledge systems and a compromise reached where the strengths of each are harnessed and deployed for development purposes.

Question: After planting the cassava stalks, what other things are done on the heap?

Answer: The weeds are cleared manually after planting this is our own knowledge; but with the advent of chemicals from the white people, we spray chemicals are on the weeds once or twice after the cassava have started growing leaves. We didn't produce the chemical, white people did. Some only spray once after the cassava plant has grown tall so they don't kill the plant with chemicals. Once it has grown and has branches then they spray underneath it to kill the weeds and the crop wouldn't be affected.

The various reasons espoused above, as deduced from the data, account for the root and tuber farmers continued use of their indigenous knowledge to respond to climate change. This now leads to the question: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** An attempt is made to answer this in the next section.

7.2 The Nature of Indigenous Knowledge of Root and Tuber Farmers in Adapting to Climate Change in Kwara state, Nigeria

The root and tuber farmers' indigenous practices and their deployment of IK in responding to the effects of climate change, which include greater unpredictability of rainfall, prolonged dry season or drought, whirlwinds, floods, increased infestation by pests and diseases, theft, destruction of farm produce by animals and herdsmen and reduction in yield, have been extensively discussed in Chapters 5 and 6 with reasons presented for their continued use of IK. An attempt is made in this section to describe the nature of the IK identified in this study by drawing inferences from the data using the concept map in Figure 7.1, as discussed under the following headings:

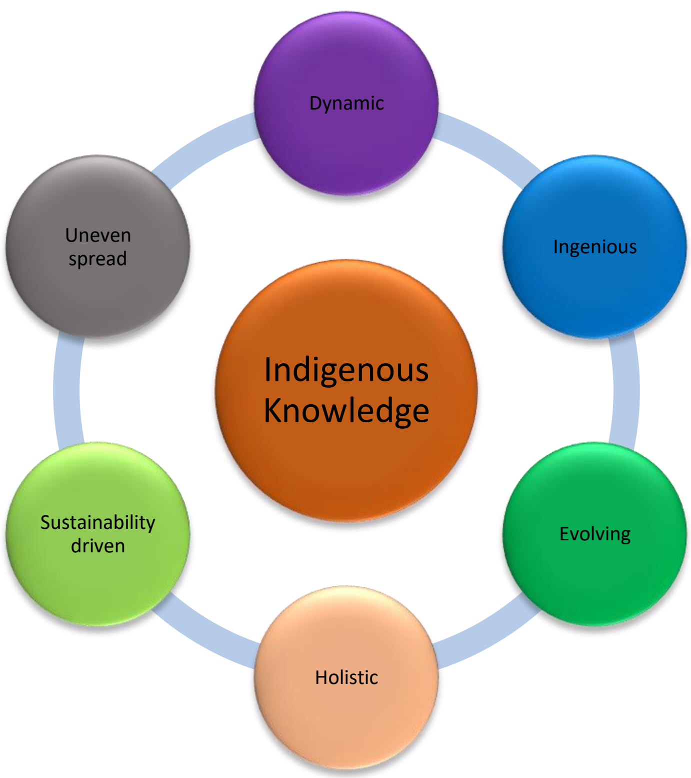
- Dynamic
- Ingenious
- Evolving
- Sustainability-driven
- Holistic
- Asymmetric distribution

7.2.1 Indigenous knowledge of root and tuber farmers is dynamic

Although the root and tuber farmers in the study area use knowledge handed down by their forebears, they identified some changes they have had to make to their farming practices to fully engage with CC and proffer solution to the challenges posed by it. One of the changes mentioned was planting yam varieties that were indigenous to the northern part of Nigeria by farmers in Aigoro village. They needed to modify their cultural practices involved in planting to accommodate those particular varieties by using the methods of the Hausa farmers. This means they allow the yam sprout in storage and plant it only during rainy season, as against their practice of cutting off the sprout in storage and planting during dry season. They realized that the northern variety is more productive in their soils, and so they have added such novel varieties to their seed supply and the IK used in root and tuber production has been broadened to accommodate the new practices. They also mentioned that their interface with the northern farmers exposed them to the knowledge of planting millet on the flat as opposed to making mounds.

Figure 7.1

Concept map of the nature of IK



Source: Olaniyan B. S. (2021)

Alfa T: It is generally called iṣu abuja (abuja yam). It has different varieties too; we call one giwa and pasa. The reason why yam farming is different in the north is that they don't plant yam in the dry season when we plant yam. When the first rain falls in the fifth month, they would have made the round heaps, you now see the yam that was harvested the previous year, they would make aba (farm shack) and they will store the yam in this shack, they will put dry grass under the yam. The yams that have decayed won't grow but the ones that have started springing out are what will be planted in the fifth month after the first rain. The things that we produced in our land we really don't understand it before. For example, millet, we make heaps but they made us realize that we can actually plant without the heaps. About the Hausa yams, when it starts growing in the fifth month, leaves will be placed on the heaps. And the yams will keep growing bigger in the soil as the leaves are blooming because it won't decay again. Unlike our yam here that will first decay in the soil before it starts grows.

Another example of the dynamism of their IK is the case in Iludun Oro where the farmers who have been able to plant a variety of beans called *olóyin* (honey beans), which would ordinarily not grow in the southern part of Nigeria because it needed a consistent 14 hours of sunshine per day to fruit, hence its production was limited to the northern part of Nigeria. This new development was attributed by the farmers to the use of some chemicals which they say are mainly for beans, but this may be due to the increasing temperatures and photoperiod in the rainforest and Guinea savannah zone due to climate change.

Mama M: Like beans now, that heavy variety of beans that is referred to as kọngírí in the olden days and the beans grows better in the north. But we have also tried planting it in here now and it is growing well, we are getting it now. Both white and brown beans, we are now getting it including the tiny variety of beans.

Interviewer: You have been able to plant honey beans here?

Mama M: Yes, we have started getting it.

Sir K: The drugs that are made for the beans are what we are using for it. That is how we are able to get it because that is what is making the olden day's farmer enjoy. There's a thing called aka that is used to store farm produce, so they put the beans there. But we the modern-day farmers *have also been able to get it. You will observe now that beans are now very much available in the market.*

This ability to interface with other knowledge(s), situations and experiences, and imbibe some of each phenomenon and transform it into a broader form was noted by Battiste (2005), who averred that "Indigenous knowledge is an adaptable, dynamic system based on skills, abilities, and problem-solving techniques that change over time depending on environmental conditions". Maila and Loubser (2003) also noted that indigenous knowledge is dynamic and is influenced by the creative actions of such knowledge holders when responding to a stimuli and interaction with external forces. Indigenous knowledge not being static has helped its longevity, because the elders pass it on to the younger generations as adapted to their situations, the youngsters, in turn will pass it on to the next generation and the cycle continues down the ages. This makes IK a good resource for solving problems encountered by the indigenous people, because it is amenable to change as they encounter issues and make progress in life. There are, nevertheless, aspects of indigenous knowledge that are impervious to change and remain sacrosanct despite the changing times.

7.2.2 Indigenous knowledge of root and tuber farmers is evolving

The interface of the root and tuber farmers' IK with other cultures has led to the evolution of IK in that area as it was known. Practices like the use of *Ọmúajá (Ancistrocarpus densispinosus)* to deter cows from entering their farms, which they learnt from farmers in Oyo state, a neighbouring state in southwestern, Nigeria, are being added to their repertoire of knowledge thereby producing a hybrid suitable for the issues at hand, as shown in the excerpt below. The introduction of these practices from another IK has produced a more robust way of responding to climate change, as the farmers are now better equipped to combat the menace of cattle destroying their farms without entering into a confrontational fracas with the herdsmen.

Mama M: Ọmúajá (Ancistrocarpus densispinosus; Tiliaceae) this leaf when it is soaked with water, it will be poured in a sprayer and used to spray the farm. This leave is poisonous and when it is eaten it has effect on the cows. Even human being must not eat it. We were taught from Oyo state, they said that is what they use because we do attend different seminars and they have been talking about this particular leaf for close to five years now before they now showed us the leaf this year.

The movement of people from one part of the country to the other has also resulted in confluence of IK, as noted in Section 7.2.1. Another example of such merger is the case of Sir K in Iludun Oro, who hails from Ekiti state but migrated to Kwara state and has been resident in that village for over 30 years. He came with the knowledge of the use of *tàgírì (Christmas melon, Adenopus brevifloris), ògìrìṣákọ́ (Anchomanes difformis)* and *ọlọ́ọ̀sẹ́ǹpetu (Gliricidia sepium)* to forestall insect infestation of the seed yams. This practice was reported by Bamigboye (2016) to be commonly used by farmers in Ekiti state in preparing seeds for planting so that insects would not spoil them. The other farmers testified that his practice ensures a good harvest and he is the leading producer of yams in their locality. This practice is carried out alongside the IK of the people he settled among. This infusion of knowledge represents a good example of evolving IK (Bamigboye, 2015).

Another farmer in Gaa Ogbe noted that knowledge is not static, and that new findings may come to light in regards to the best way to respond to CC. He gave the example of IK used in Igboho, a town in Oyo state that shares border with Kwara state and the Republic of Benin where the time of planting and storage is different although the town is in a neighbouring state, and added that such knowledge is added knowledge for them.

Agbe: Knowledge is not static and it keeps moving forward, maybe soon another finding will be made that'll be better than the previous information that we were given. The way we plant yam here is different from the way yam is planted in a town called Igboho. When we plant yam during the rainy season, the farmers in that town cannot plant yam. According to what I was told, they are just about to start planting their own yams while we are about to start harvesting here. They harvested the previous yam and then they dig a ground, placed local sponge on the land and then placed the previously harvested yams on it; this is how they store their own yams. When these yams that are stored now starts growing in the place where it is kept, the growing part will be broken off. You can see that this is another added knowledge.

It is pertinent to note that this interaction between indigenous peoples did not produce new knowledge per say, but resulted in a blend of knowledge having features of both components.

7.2.3 Indigenous knowledge of root and tuber farmers is ingenious

The ingenuity of IK employed by root and tuber farmers in the study area is evidenced by their resourcefulness in using plant mixtures to treat their seeds and prevent pest infestations. Such biological control has no adverse effects on the environment, rather such plants are preserved so there is less likelihood of loss of flora and fauna. Also planting different crops together on the same mounds ensures that they get good value for the money paid for labour and they maximize the benefits of such costs to the fullest. In carrying out intercropping, the farmers carefully select plants with different maturity dates and nutrient uptakes, which has the advantage of food security, maintenance of soil fertility and of securing their source of income. These practices usually derive from observing their environments and replicating what happens in nature. In nature it is not unusual to see a mixtures of species growing together on land that has been left fallow. Nature also has a way of producing plants with different maturity dates and nutrient needs, with some covering the ground to conserve water in the soil while others act as shade for them. This mimicry of nature was reported by Gould and Lincoln (2017), who submitted that ingenuity of IK can be explained in two ways. One way is the observation of a natural phenomenon and replicating such by the indigenous people and the other way is in trying to respond to a problem created by nature itself. By being hands-on in their interaction with the land, the farmers can easily recognize changes in the structure, texture and other properties of the land and respond to them accordingly. A case in point is the example given by farmers in Gaa Ogbe concerning the presence of a particular type of ant signifying that the land is no longer fertile hence they then look for another site to plant yam, as presented in the excerpt below

Interviewer: Aside from this type of land, what other type of land can be used for planting yam?

Agbe T: A farmer should be able to identify the best land that will be good for planting yam. But due to the cattle's that now move freely on plain land, it is now not so easy for farmers to identify the best land that will be suitable for yam growth. Another thing to look out for when looking for a land to plant yam is when a land is filled with tiny black ants (lámùrè), such a land cannot be used for planting yams. It is not that these ants will infest on the yams but this is a sign that the land is no longer fertile and it is not good for farming yam. This type of land can be used for planting other crops.

The need to respond to natural phenomena has led to the farmers developing new ways of interacting with their environment and solving problems as they arise, with the resultant effect being maximal use of a farm plot, revitalization of over-used plots and sustenance of the soil in general by the use of mixed cropping to ensure the soil surface is covered with a crop at any given time during the farming season (Lalonde, 1991a; Ogen, 2006).

7.2.4 Indigenous Knowledge of root and tuber farmers is sustainability-driven

The farmers go about their farming activities in such a way as to ensure that the land is kept intact for future use. The statement *dá òrá padà sí ilè*, meaning 'restoring the soil fertility', kept recurring in the data as the farmers described the activities they carried out during the farming season. This may be attributed to the Yòrùbá saying; *e jé ká jé díè ká lè ba jé pé*, meaning 'let's consume it a little at a time so we can consume it for long', which points to the moderation applied by the indigenous people in the use of natural resources to ensure sustainability.

Indigenous agricultural practices are tailored towards sustainability. This is evident in practices such as incorporating crop residue into the soil after clearing the land, which results in the residue breaking down into leaf mould, thereby enriching the soil; burning or spraying the trees, which leads to their decay and supplying nutrients to the soil; shifting cultivation or allowing bush fallow means the land can rest and regain fertility; mulching and mounding, which help to conserve water so it is available for the crop's use during the dry season; and minimal use of agrochemicals, which apart from reducing the cost of production also prevents soil acidity due to overuse of such chemicals. Thus IK uses its system of regulating resources use to ensure that the environment is sustained for future use and that development occurs at a rate that is not detrimental to the incoming generation (Kolawole, 2001; Noyoo, 2007).

The advantages of sustainable practices by the root and tuber farmers is evident in the outcomes of their responses to climate change as deduced from the data. Figure 7.2 summarises these responses and the outcomes are highlighted below.

Figure 7.2

Summary of the outcomes of responding to CC using IK

IK is Sustainability-driven	Intercropping= Food security
	Proper selection of intercropped plants= Crops grow without affecting each other. Presence of soil cover prevents soil run off and erosion suppresses weeds.
	Mulching= Regulation of temperature and water conservation in the mound
	Shifting cultivation= Soil fertility is restored
	Reserving and planting trees= Windbreaks and shade for plants and man
	Enlarging waterways and sandbags as barriers= Prevents flooding
	Biological control of pest and diseases= Prevents crops losses while protecting the soil and environment
	Proper timing of planting ensures the crops are well establshed before the rains cease.

Source: Olaniyan B. S. (2021)

- Intercropping ensures food security as the crops have different maturity dates hence there is always something to be harvested; either for food or sale. Also, if one crop fails the others would survive and the farmers make some profit at the end of the farming season. Another benefit of intercropping is that soil fertility is maintained during the period under use as the different crops have varied nutrient requirements and uptake and some of the crops fix nutrients, such as nitrogen from the atmosphere to enrich the soil. Intercropping has the added advantage of ease of production as considerably fewer mounds need to be made with less acreage of land is used each season, so the farmers spend less on labour for land cultivation and use the available land optimally.
- Proper timing of crops during intercropping ensures that the crops grow without affecting each other adversely and provide a covering for the soil against weeds and evaporation as it is not left bare. This also prevents soil run off and erosion as the surface of the soil is protected by the growing crops.
- Planting at the onset of rainy season ensures that the plants are well established before the rains stop, especially in situations when the rains might stop abruptly. This practice ensures

there is enough moisture in the mounds where water is trapped when they shrink due to temperature change across the seasons.

- The use of indigenous plants as preventive and intervention measures prevent crop losses due to pests and diseases. This practice also keeps the soil texture and general environment intact in contrast to the use of chemicals, which may leach into the surrounding waters or water table and contaminate them. This is because the plants are biodegradable while chemicals remain in soil for a longer time because of their synthetic nature.
- Mulching protects the seed yams from direct penetration of sunlight, which makes the mound conducive for the growing seeds. The soil beneath the mulch remains damp during the dry season showing that it also conserves water in the mounds, and the grasses break down over time to form leaf mould or humus, which also enriches the soil.
- Shifting cultivation helps the soil regain its fertility during the time the land is left uncultivated. As nature never leaves a vacuum, plants grow on such land and fall off, decompose and enrich the soil, where another plant grows in its stead. This continuous cycle of growth-death-regrowth revitalizes the land over the time that another portion of land is being used by the farmers, hence agricultural production is sustained.
- The use of the scarecrow, traps, bells, human guards and charms reduces losses due to theft and animals, especially monkeys. Although apart from charms, the other methods are only effective for a short time because the animals either get used to the presence of the scarecrow or learn to avoid the traps, while the human guard cannot be on the farm all the time. The disadvantage of charms is that anyone could fall victim of it as it is not discriminatory, only the person that place it there is presumed innocent by the spirit operating the charm.
- Planting castor and Jatropha plants at the edge of the farms keep the cows away because they are not palatable to the animals. It also reduces confrontation with the herdsmen who might retaliate physically against farmers who try to stop their cows from entering the farms; there have been reports of loss of lives.
- Enlarging the waterways, using sandbags at the edge of the river and planting living barriers prevents floods and farmlands being washed away, hence preserving the farmers' labour and eventual income.

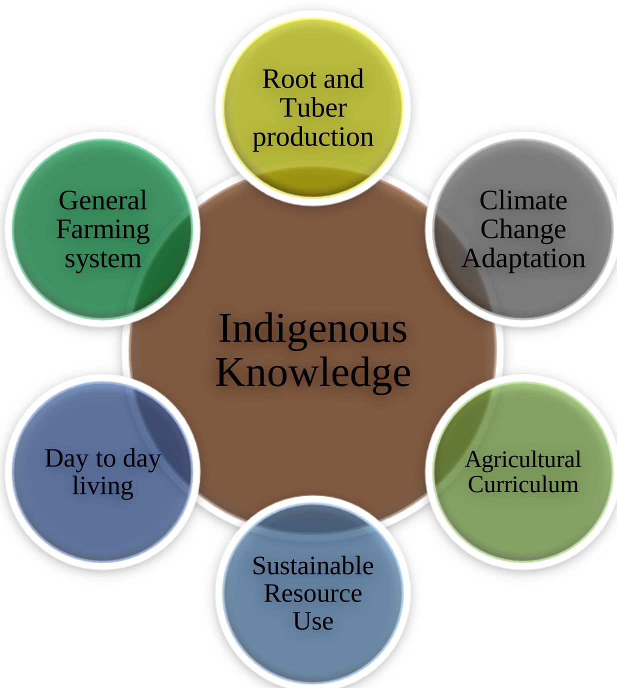
- Reserving and planting trees to serve as windbreaks to protect against whirlwinds also protects the houses around. The trees also provide shade from the sun and the falling leaves add nutrients to the soil when they decay.

This sustainability mind set has kept indigenous knowledge alive and relevant through the ages and this needs to be harnessed by mainstream sustainable development advocates and organizations. Clune and Zehnder (2018) submitted that technology and innovation, which is one leg of the tripod on which sustainability framework stands, deals with designing methods of doing things using fewer resources to achieve more which mirrors what the farmers in this study practice by practices such as intercropping, mulching, shifting cultivation. These practices have not only sustained root and tuber production but the environment as well. Although some might argue that agriculture also contributes to the accumulation of greenhouse gases in the atmosphere, the minimal use of agrochemicals in root and tuber production negates that notion (Bamigboye & Kuponiyi, 2010).

In their daily interaction with the environment, indigenous people have been known to deal holistically with issues when they arise. For example, the root and tuber farmers, in preparing the land for yam production, clear the land and make mounds thereby conserving water in the mounds. These mounds are also used to plant other crops (before and after yam) which ensures the soil surface is protected from erosion by water runoff. Also, the plants cleared are incorporated into the soil to break down into humus, thus reducing the use of inorganic fertilizers and preventing soil acidity. In cases where there are trees on the land, they are not cleared immediately as they serve as shade for the growing crops; instead, they are killed off gradually by setting fire beneath them with the ultimate aim being decomposition into humus. All these practices, along with many more not mentioned, ensure the environment is protected and with the added advantage of cost of production being reduced. This all-encompassing thinking about the environment and the end game of production is what Berkes and Berkes (2009) referred to as holism of indigenous knowledge, which essentially means looking at the big picture and how each unit of action affects the whole system positively or negatively, as the case may be. They argue that holistic thinking amongst indigenous people is possible because they do not make clear stratifications of life around them because as they believe all things are intertwined and trying to unpack them complicates things. Moreover, they do not have a ‘one size fits all’ approach to solving problems but look critically at each problem and find solutions that will benefit the whole system. A diagrammatic representation of IK holism is shown in Figure 7.3. Govender (2012) noted that IK can be described using the metaphors of complexity theory as an indigenous knowledge systems is a complex system of many parts intertwined with one another; a particular metaphor he used was holism. He explained that in an indigenous knowledge system, humans are viewed as being one with their environment, thus their relations with other components of their environment must be taken into consideration when assessing them. The various relationships the human is involved in lead to a production of new realities, worldviews and a holistic change of perspectives as he or she engages with the environment in a dynamic but connected manner. This view is supported by Davis and Sumara (2008), who noted that complexity theory is applicable in describing any living system and that includes the study of cultures, which is an integral part of indigenous knowledge.

Figure 7.3

Representation of holistic use of Indigenous Knowledge



Source: Olaniyan B. S (2021)

It was further noted by Aikenhead and Ogawa (2007) that to indigenous people there is no compartmentalization of arts, science, etc., as life is viewed as being intertwined with the environment, other people and the spiritual. Hence, life issues are handled looking at the effects on all relationships involved and deploying all available resources for problem solving. Their worldview is essentially a relational one where emphasis is placed on the spiritual, sense of community and respect for others (Hart, 2010). The deep reverence for the spiritual was a recurring theme in the data, as shown in the excerpt below. Climate change was referred to as an act of God, they resorted to prayers during times of uncertainty, and they prayed for rain or performed some rituals or spiritual activities to bring about change.

Interviewer: I want to ask Sir, have you stayed closed to twenty years or more in this settlement? What did rainfall look like back then compared to now? You know we have been talking about climate change so how does it look like back then, before someone like me was born?

Baba T: For rain then it is God that changed it not humans. When we were much younger and rain falls, it falls in three ways. It was in the beginning of the year, middle and at the end of the year. There is nothing like that again now, God does as he desires.

Koocheki (2003) also noted that indigenous people see the world as an integrated whole, which is expressed in their dance, songs, paintings and stories and is adapted to the cultural, social and natural world; hence it is utilized in all aspects of daily living in a participatory manner through dialogue and collaboration.

Dei (2000) sums up IK as being holistic and relational as indigenous people connect the physical, spiritual, cultural, ecological, political and material forces together in making sense of life. He explained that IK comprises *ancient knowledge* from the ancestors passed down the through the ages, *experiential knowledge* gained by observation of their surroundings, encountering problems and proffering solutions to them and *inspired knowledge* which arises from interaction with the spiritual world through dreams, visions, intuition and divination (p. 114). Nakashima et al. (2012) opined that indigenous worldviews have a holistic understanding of humans' interaction with their environment and is a mixture of community know-how, deductive reasoning, empirical understanding, social organizations, spirituality, rites, rituals, practices and technology as a whole unit.

Mistry and Berardi (2016) argued that indigenous knowledge is situated within several interlinked facets of the people's lives and in seeking solutions to changes like climate change they would not respond to that alone, but instead find a solution that cuts across everything so they are well equipped for eventual changes that may arise in other facets of their life. This has contributed to their resilience over time. They further noted that indigenous knowledge has the advantage of being able to cope with complex situations by engaging with the issues over a long period, gaining understanding of them and pooling resources together to address them. The solution to such an issue is then simplified and translated into simple rules that are easy to remember and are enforced by the society at large (Gómez-Baggethun et al., 2013). A good example is the taboo attached to killing of some animals that has led to conservation of those endangered species.

The interconnectedness of life in indigenous knowledge, as mentioned by the scholars above and referred to as holism, has sustained not only root and tuber farming in the study area over the years but also the environment at large. It is pertinent to note that science too has played a significant role in their daily living and farming system, with the advent of herbicides, fertilizers, improved varieties being amongst the innovations available to the farmers. Besides, the use of technology in other aspects of their daily living also enhances their productivity.

7.2.6 Asymmetric distribution of indigenous knowledge

A point of concern arising from the data is the asymmetric distribution of IK in the study area, especially amongst members of the same Yoruba tribe. Only one or two of the plants used as pesticides are common across the villages, the others differ. Some are not used for the same purpose or are not known at all in a different village. A specific example is the use of *ìtagìrì* (*Adenopus brevifloris*), *ògìrìṣákọ́* (*Anchomanes difformis*), and *olọ́ọ̀ṣẹ́ǹpètu* (*Gliricidia sepium*) by a farmer in Iludun Oro as insecticide on his yam setts, which was not replicated anywhere else in the study area, although the leaves from *ògìrìṣákọ́* (*Anchomanes difformis*) was reported by another author as being commonly used in Ekiti state, Nigeria as insecticide in vegetable production. It is pertinent to note that the said farmer hails from Ekiti state but had long been settled in the study area and had brought the IK with him, but that knowledge has remained with only him until he shared it during the study.

The non-uniformity in IK practices contrasts with the characteristic universality of scientific knowledge and may account for the scepticism attached to IK by scientists as they feel it is not transferable or confirmable. This disparity in the spread of IK in the study area may have arisen due to relocation or death of custodians who had not passed on their knowledge, and the rigorous and often laborious process of developing or integrating new knowledge into the repertoire of indigenous knowledge in any given society. Furthermore, the abandonment of farming by youths for white collar jobs may be another reason for the uneven spread of IK. With many youths preferring less onerous office jobs to the back-breaking work of farming the gap in knowledge between the current farmers and the younger generation increases as tutelage on IK declines.

Another reason for the asymmetry in IK deduced from the data is the demonization of indigenous knowledge by religious institutions, so that practices like using charms to protect their farms and crops are within the purview of a reserved few, who either do not identify with either of the two introduced religions (i.e. Christianity and Islam) or prioritizes his profits over his faith. The farmers mentioned that some practices like rainmaking were no longer in existence in their villages because of either of these two religions, or the fear of being labelled a wicked person by the majority of society, who have been indoctrinated by religion and/or civilization. Also, some IK is held in trust by some exclusive societies like *Ògbóni* confraternity, *egbé awo* (herbalists), and hunters, which require initiation and apprenticeship before access to such knowledge.

7.3 Implications for Agricultural Education

Having explored the nature of IK employed by root and farmers in responding to climate change, an attempt is made to chart the course for including the findings in mainstream climate change adaptation programs and the agricultural curriculum at the secondary and tertiary levels by proposing possible topics to be included in the curriculum.

Incorporating the lessons learnt from the root and tuber farmers on sustainable farming with land management and adaptation to climate change into the agricultural education curricula at all levels would be beneficial. As Zidny et al. (2020) submitted, such incorporation would enhance the relevance of science at colleges because the topics would make more sense to students if they were familiar and relatable and what they were being taught was based on their real life experiences. In other words, the town meets the gown in a confluence of knowledge. This would substantially reduce the misconception students have about the nature of science because they would see that science abounds around them, although it may be termed indigenous science in academia.

Such integration could take the form of adding topics to the existing curriculum or of creating a new curriculum for climate change adaptation wherein indigenous knowledge is given an equal footing with western science, as an added requirement for science students particularly those studying agriculture. Some possible areas in which students should be taught about climate change adaptation and corresponding IK practices are given in Table 7.2, while the areas identified for root and tuber production are shown in Table 7.3. It is pertinent to note that the tertiary curriculum referred to in the table is that of the University of Ilorin, while that of secondary school cuts across the country.

The integration of IK alongside scientific knowledge in adaptation strategies has become expedient as climate change is a problematic issue that demands much attention so that life on Earth as we know it can be sustained or face the risk of extinction of flora, fauna and humans. Action has to start from each person, hence the need to teach the younger generation what has been proven to work. Blending the versatility of IK with the reliability of science would produce an effective approach to adapting to climate change, as the two worldviews merge to a hybrid that makes use of all available resources to sustain food security, life and livelihoods in the era of global warming (Nyong et al., 2007). Songok et al. (2011) noted that local farmers in Nandi and Keiyo districts of Kenya responded to climate change using both indigenous and scientific techniques; they noted that IK alone is no longer reliable, but should be enhanced by integrating scientific methods with it. Hence, they planted the local crops alongside improved varieties to ensure food security and also kept indigenous cattle alongside the highly breed varieties; crossbreeding these to give disease resistant and high milk yielding offspring. Other scholars also echo the sentiment that integrating indigenous methods into the mainstream science curriculum has the potential of producing more resilient, effective and sustainable strategies for adapting to climate change (Makondo & Thomas, 2018; Nkomwa et al., 2014). This is what this study is also proposing for Nigeria; an amalgamation of indigenous and scientific knowledge, which harnesses the strengths of each worldview in a way that balances out their weaknesses, and notably the two knowledge systems being accorded equal significance in the whole process.

Inclusion of the topics identified do not have to replace conventional knowledge but rather they should work together to engender a robust response with the possibility of significantly reducing the adverse effects of climate change on human livelihoods.

Table 7.2

Possible topics in CC adaptation and corresponding IK practices

Possible topics in CC Adaptation	**Topics in current curriculum**	**IK practices to be included**	**References**
Change in rainfall pattern	Rain formation and rainfall	- Predicts using local indicators - Harvest the tubers during excessive rainfall season - Proper timing of planting	(Nyadzi et al., 2021; Ozor et al., 2012)
Weather forecasting	Equipment and maintenance of standard meteorological stations	- Observing the leaves of trees, wind direction, heat, clouds - Behaviour of some birds and animals	(Nkuba et al., 2019; Nyakaisiki et al., 2019)
Floods	No corresponding topic in the curriculum	- Building drainage system - Enlarging the river path and placing sandbags at river bank - Planting living barriers (Vertiver grass) - Early harvesting	(Blankenberg & Skarbøvik, 2020; Shao, 2010)
Responding to Drought	Temperature and heat	- *Ìdíhàn* (mulching), - *Àgbìnpò* (intercropping) - Planting early maturing variety - Replanting of yam seeds - Staking, - No weeding of cassava farm	(Anju et al., 2014; Makhado et al., 2014)
Whirlwinds	Wind evaporation and evapotranspiration	Reserve and plant trees	(Harvey et al., 2004; Smith & Jarvis, 1998)

Source: Olaniyan B. S. (2021)

Table 7.3

Possible topics in root and tuber production and their corresponding IK practices

Possible topics in root crops production	**Topics in current curriculum at University level**	**IK practices to be included**	**Topics in current curriculum at secondary school level**
Site selection	Basic principles of soil classification	- *Àjùbà* (virgin land) - *Akíntọ̀lá* (Siam weed) and dark green colour grasses, - Shifting cultivation - *Gbada pe* for yam - *Lámùrè* (tiny black ants)	Pre-planting operations: Choice of site Nursery and nursery practices
Land preparation	Production practices for root crops	- Slash and burn - Mounds (*ebè*) or ridges - Planting on flat ground	Clearing Stumping Tilling
Seed selection	Seed production and certification	- Head of big yams - *Egùn* (yam milking) -Yams that sprouted in storage	Planting operations: Seed treatment Spacing and planting
Pest and diseases	Crop disease management Safety handling and application of fungicides	- Traditional herbs - Palm fronds - Black core of battery - Crop rotation - Rainwater	Post-planting operations: Thinning Supplying Mulching/fertilizer application Harvesting Effect of timely harvesting versus late harvesting
Processing and storage	Processing of root crops Changes in crops during storage	- Traditional processing methods - In ground storage - Wood ash and sponge - Barn	Post-harvest operations: Processing of crops into useable forms Storage
Soil fertility Management	Soil fertility and water conservation methods	- Incorporate crop residue - Home waste as compost - Animal dung as manure - Mounding - Mulching - Crop rotation	
Animals and Thieves	No corresponding topic in the curriculum	- *Aṣọ́komásùn* (scarecrow) - *Pàkúté* (trap) - *Agogo* (bell) - Charms	No corresponding topic in the curriculum
Herdsmen	No corresponding topic in the curriculum	- Centipede powder - Potash and beans mixture - *Ọmúajá leaves* (*Ancistrocarpus densispinosus*) - Charms	No corresponding topic in the curriculum

Source: Olaniyan B.S. (2021)

Most of these topics need to be taught in a hands-on fashion so the students can understand them. Hence it is suggested that they be taught on the school farm with an IK holder as the instructor or the students being taken to villages either on an excursion or for a short stay like community-based experience and service that the researcher had been involved in, as mentioned in Chapter 1. The logistics of bringing an IK holder to the school farm may be more cost effective than transporting the students to the villages, although the immersion into village life may help them absorb more indigenous practices as then the IK holder would not be constrained by time. A more effective approach would be a blend of both; that is both bringing the IK holder to the university and immersing the students into the cultures around them to learn traditional agricultural practices. These practices may later be the only real option available to them because of the high cost inherent in commercial agriculture. The practical application of IK to solve problems on the farm can then be transposed to other aspects of life and merged with the regular use of scientific knowledge in daily living.

Data from the study have shown that IK practices are not included in CC adaptation strategies and general agricultural intervention programmes, hence the ways taught in these laudable programmes are not readily adopted by the farmers because of the antipathy to anything foreign to their culture. The importance of IK in their daily living and agricultural production cannot be overemphasized. Accordingly, I argue that effective adaptation to CC and continued production of root and tuber crops to combat food insecurity, which may arise from increasing temperatures, urgently requires inclusion of IK into mainstream CC adaptation strategies. This merger should be an equitable one, with the two knowledge systems both playing significant roles in the ensuing collaborative programmes. IK from various cultures that grow root and tubers should be further explored, documented, verified, validated and included in adaptation programmes.

It is suggested that this amalgamated strategy should be included in the agricultural curriculum from secondary school through to tertiary institutions. This adaptation strategy should also be taught as a general course that is compulsory for all students at the tertiary level because climate change arising from global warming is becoming a major source of concern as many countries are running out of potable water and food. So, a concerted effort is needed to combat it by educating the general populace on the dangers of CC, the ways to adapt to it and minimize the adverse effects on livelihoods. Collaborating with the local people would engender acceptance of the strategy and subsequent dissemination of such would occur within the villages organically. A note of caution needs to be sounded that it is essential that the process be collaborative. Collaborative so that the views of the indigenous people are held in equal regard to those of the scientists, allowing easily accessible and affordable local resources to be incorporated into the proposed intervention measures to encourage the local people.

7.4 Summary

This chapter began by providing answers to the third research question: **Why do Nigerian root and tuber farmers respond to climate change in the way that they do?** The researcher confirmed that the farmers continue to use IK in their farming system and responses to climate change because it is effective, inexpensive, easily accessible and the antipathy to the top-down approach of science in solving problems that concern the indigenous people without taking into consideration their knowledge systems or way of life.

Then some answers were then given to the overarching question of the study, which was: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** The researcher reported that the nature of IK employed by root and tuber farmers in adapting to climate change is all encompassing. Hence it is dynamic, evolving, ingenious, sustainability-driven and holistic. A note of concern was also raised about the uneven spread of IK.

Finally, the implication of the study for agricultural education was also addressed and ideas regarding possible areas for including documented IK in the curriculum and methods of teaching such were given. An argument was made for the collaboration between indigenous and western knowledge in formulating adaptation strategies and policies, which are to be disseminated at the village level, included in the agricultural science scheme of work at secondary school level, and taught as a general course at tertiary level, to ensure all stakeholders are involved in adapting to climate change.

The next chapter gives a summary of the research findings, conclusion and recommendations.

CHAPTER EIGHT: SUMMARY AND CONCLUSION

8.0 Introduction

The previous chapter explored why root and tuber farmers respond to climate change using their indigenous knowledge and explained the nature of the knowledge so deployed as deduced from the data. Some topics were proposed for inclusion in the agricultural curriculum at both secondary and tertiary levels. Then possible areas where IK could be included in mainstream climate change adaptation programmes were also proposed.

This chapter gives a synopsis of the study, reiterating its purpose followed by a summary of the research findings and analysis, the implications for agricultural education and climate change adaptation. The chapter is completed by a final conclusion, recommendations, delineation of the study and direction for further studies.

8.1 Reiterating the Purpose of the Study

The purpose of the study was to explore the role of indigenous knowledge in Nigerian root and tuber farmers' responses to climate change. The farmers' experiences of climate change were documented as well as the IK employed in responding to it. One of the main strands revealed by the study is that the farmers deploy their IK primarily in root and tuber production with minimal influence from scientific knowledge. Thus the process needs to be studied to examine its effectiveness or otherwise and to identify potential areas where it can be integrated into mainstream climate change adaptation strategies, because community-based adaptation has a major role to play in the global response to climate change. The underlying principle of the study was that indigenous knowledge has a diverse repertoire of useful strategies in adapting to climate change that needed to be enhanced by scientific knowledge because of some shortcomings identified, for example the laborious task of clearing weeds manually which could be tackled with herbicides or machines. To build resilience to the impact of climate change, community-based adaptation needs to be empowered. This necessitates the study of day-to-day adaptation at the local level in order to formulate strategies that are culturally relevant and adapted to their locality. These strategies should be formulated in a collaborative manner and introduced to the society by the various custodians of knowledge that is teachers, agricultural extension officers, community leaders etc. to engender acceptance by the populace. The study had three objectives, as follows:

- To explore how root-tubers farmers experience climate change.
- To identify the responses of Nigerian root-tuber farmers to climate change using indigenous knowledge.
- To examine root-tuber farmers' reasons for responding to climate change using indigenous knowledge.

A summary of the findings is presented in the next section in the form of answers to each research question.

8.2 Summary of the findings

The study sought answer to an overarching question, which was: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** This was then segmented into three sub-questions, which were:

1. What are Nigerian root and tuber farmers' experiences of climate change?
2. How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?
3. Why do Nigerian root and tuber farmers respond to climate change in the way that they do?

Answers to these questions are the fulcrum for the study.

A conceptual literature review was conducted, which portrayed the important role that root and tuber production plays amongst the rural people becasue production of these crops are primarily in the hands of smallholder farmers located in the rural areas of Nigeria. The review espoused the usage of indigenous knowledge at all levels of production, from selection of farmland to storage of harvested farm produce, including some of the practices that are carried out to prevent damage to the crops from the effects of climate change, such as unpredictability of rainfall and prolonged dry seasons, which is, in essence, responding to climate change. The review also indicated the effects of climate change on the crops under study. It was shown that while root and tuber crops of cassava and sweet potato are drought tolerant and can grow on degraded soils, others like yam and cocoyam need very fertile soil and are adversely affected by a prolonged dry season or excessive rainfall and so they need to be protected from such by making mounds, mulching and early harvesting in desperate situations. The current adaptation strategies such as the use of agrochemicals against increased incidences of pests and diseases were found to be expensive and thus not adopted by the rural farmers, while the prolonged use of agrochemicals has led to acidic soils in the developed countries. These challenges, coupled with lack of support from the government, has resulted in farmers resorting to their indigenous knowledge in responding to the phenomenon of CC (Kolawole, 2006). It was shown that there had been insufficient documentation of indigenous knowledge used in root and tuber production, nor had the various root and tuber crops been studied separately, previous studies had relegated indigenous knowledge by not exploring the key role it plays in root and tuber production and climate change adaptation. These were the gaps noted in literature that the study sought to fill.

The philosophical leaning of the study involved unpacking indigenous knowledge by looking critically at its subjugation by western knowledge (WK) using the lens of post-colonialism. Situated learning theory was employed in eliciting and documenting the indigenous knowledge because IK is learnt by doing and is location-specific. The methodology adopted for this study was participatory phenomenology, which is a combination of relevant aspects of phenomenology and participatory research methodology, to ensure a culturally responsive methodology.

The study employed a qualitative approach in exploring the farmers' use of indigenous knowledge in their farming practices and responding to climate change. The study was done in collaboration with the participants using participatory methods of focus group discussion (*ìjíròrò egbé*), interviews (*ìfòròjomitoroòrò*), and participant observations (*àkíyèsí alabaṣe*) with storytelling (*ìtàn síso*) being the overarching theme with conscious efforts being made concerning decisions that would fit the ethical criteria of the university institution and cultural values of the participants. Data were collected in form of audio recordings and pictures across six villages in Kwara state, Nigeria. The data were subjected to an inductive thematic analysis and the findings were presented per village, as there were slight variations in IK employed at each. The findings of the study were presented in Chapters 5, 6 and 7, as answers to Research Questions 1, 2 and 3, respectively. In this way, the reporting was less cumbersome and more explicit.

Chapter 5 gave a detailed presentation of the farmers' experiences of climate change. A brief description of each village was provided to show the context of the study, before recounting the experiences of climate change. Answers to RQ 1 were elicited using focus group discussion to get a panoramic view of the experiences of CC in each community under study. Chapter 6 gave a detailed presentation of specific indigenous knowledge employed in root and tuber production from site selection to storage of harvested produce, with emphasis on techniques used in responding to different aspects and/or expressions of CC. Answers to RQs 2 and 3 were elicited using personal interviews and participant observations. Chapter 7 gave a detailed explanation of the farmers' reasons for using indigenous knowledge in responding to climate change, as deduced from the data. As such, it described the nature of indigenous knowledge deployed in responding to climate change. The conclusions are presented in the next section.

8.3 Conclusion

The conclusions presented here are based on the discussions given in Chapters 5, 6 and 7 concerning the research questions.

Research question 1: What are Nigerian root and tuber farmers' experiences of climate change? This question sought to garner the lived experiences of the root and tuber farmers on climate change, and how it had affected their livelihood and production.

Conclusion 1: The farmers in Kwara state were able to articulate the changes they had noticed in the weather pattern over the past 30 years of being resident in that location. They identified an altered rainfall pattern as a major change they had experienced over the years. This was articulated varying ways: early or late onset of rainfall, reduction in the amount, intensity and duration of rainfall, early or late cessation of rainfall, which all affected their crops in different ways, from stunted growth to spoilage during harvest, as explained in the respective chapters. The other indicators of climate change they identified were prolonged dry season or drought, floods, whirlwinds, increased prevalence of pests and diseases, and destruction of farm produce by cattle. The cattle were owned by herdsmen who were driven by deforestation in the northern part of the country due to climate change to migrate southward in search of green pasture for their animals. This influx had led to clashes, sometimes violent, between the farmers and the herdsmen. A composite representation of the findings was given in in Figure 5.14 in Chapter 5.

Research question 2: How do Nigerian root and tuber farmers use indigenous knowledge to respond to climate change?

This question sought to find out how the farmer deployed their IK in their efforts to respond to the changes they had noticed in the weather pattern.

Conclusion 2: The study found that the farmers make mounds and mulch them as a method of conserving water for their crops; they use compost made from domestic waste in lieu of fertilizers; they practice crop rotation to conserve soil fertility and pest control; they prepare their own pesticides from chosen plants; they plant crops with differing maturity dates and nutrient requirements on the same plot or mound to reduce the cost of labour, maximize land use and suppress weed; they constructed drainage systems and barriers at riverbanks to prevent flooding; they preserve and plant trees to serve as windbreaks, they use charms, dogs, bells, or scarecrows to protect their farms from thieves and animals, and plant animal repellent plants to keep cows away from their farms.

Research question 3: Why do Nigerian root and tuber farmers respond to climate change in the way that they do?

Conclusion 3: The farmers employ indigenous knowledge in responding to climate change rather than western knowledge. The reasons for this preference as deduced from the data were that indigenous knowledge is effective, easily accessible, inexpensive and there is antipathy towards the top-down approach of science, in which the scientists identify the problem, formulate solutions and offer them to the farmers without taking into consideration their economic capacity, cultural values, views and beliefs, leading to their non-adoption by the local farmers. The study concluded that although indigenous knowledge is effective, its effectiveness is usually for a short duration as most of the materials used are biodegradable hence need constant renewal. Access to indigenous knowledge does not necessarily translate to usage, as one needs to be conversant with the method of usage for it to be successful. In this regard, some of the indigenous practices, although not costly in monetary terms, requires a lot of labour which makes them laborious.

The overarching question for the study is: **What is the nature of indigenous knowledge of root-tuber farmers in adapting to climate change in Kwara state, Nigeria?** Answers to this question were shown in Figure 7.1 in Chapter 7.

Main Conclusion

The nature of indigenous knowledge employed by the root and tubers farmers in adapting to climate change, as identified from the data, showed six characteristics, namely:

- Dynamic
- Ingenious
- Evolving
- Sustainability-driven
- Holistic
- Uneven spread

Firstly, inferences drawn from the data showed that the IK employed by the farmers is *dynamic* as they made changes to the knowledge passed to them by their forebears. For instance, in an attempt to boost production, they had adopting yam varieties indigenous to the northern part of the country and changed their planting system accordingly for those varieties; they had also begun to plant millet on flat ground, which they learnt from Hausa farmers from the northern part of Nigeria.

Secondly, their IK is *evolving* as the farmers interact with people from different cultures within the region and the country at large and they imbibe aspects of that IK that they had found useful for their farming business into theirs.

Thirdly, their IK was found to be *ingenious* as they have resourceful ways of treating their seeds before planting to prevent insets and birds feeding on them while protecting the environment from the harmful effects of agrochemicals and saving money at the same time.

Fourthly, their IK is *sustainability-driven,* which is evident in the outcomes of their responses to climate change. For example, intercropping ensures the farmer has something to harvest and can make some money at the end of the farming season despite the climatic challenges. Their IK use reduces the cost of labour while also protecting the environment through weed suppression by the cover crops and prevention of soil run off due to erosion. Hence using IK protects their land for future use.

Fifthly, their IK was found to be *holistic* as they deal with issues that arise during the farming season in a broad all-encompassing manner; looking at how it affects all components of production and ensuring that the end goal of production is attained.

Finally, the study also identified the asymmetric spread of IK, especially amongst people of the same tribe who reside in different locations across the region.

8.4 Contribution of the Study and Theoretical Implications

This study provides empirical evidence of the usefulness of indigenous knowledge in adapting to climate change and has suggested ways in which it could be deployed by policy makers and included in secondary and tertiary agricultural science curricula in Nigeria. Indigenous knowledge does not currently feature in the curricula so this would be a means of teaching the next generation a blended way of coping with the effects of climate change. See Table 8.1 for a synopsis of the possible areas of inclusion of indigenous knowledge in adaptation and in agricultural science curricula. The study also extensively documented indigenous knowledge used in root and tuber production. This provides a resource for training of agricultural extension agents, students, pre-service and in-service teachers on indigenous knowledge, and could form the basis for its inclusion in mainstream adaptation strategies, especially those for the community-based programmes. This is essentially a means of preserving the knowledge for posterity.

The study adopted situated learning theory (SLT) in identifying indigenous knowledge in the study area, as indigenous knowledge is socially constructed and shared within a society, so learning *in situ* helped the documentation process. Also, SLT emphasizes interdependency among the learner, community, activity, assigning meaning, and learning and knowing that happens when people are engaged in activities arising within their social and cultural context. This collaboration helped to document indigenous knowledge at the different sites of the study. Participatory phenomenology has previously been mostly used in medical research, but the study showed that it can be employed in educational research and is culturally adaptable to the study area. Participatory phenomenology is best suited for the collaborative processes of this study. This method can be useful for future researchers and policy makers in identifying and documenting indigenous knowledge in other parts of the world, for similar purposes of education. This study agrees with the recommendation by previous researchers (Ifeanyi-Obi et al., 2012a; Ifeanyi–Obi & Nnadi, 2014; Kalu & Egbe, 2011; Kolawole, 2005; Kolawole, 2006) that indigenous knowledge should be identified, documented and incorporated into CC adaptation strategies and introduced into the educational system.

Table 8.1

Synopsis of possible topics

Possible Topics in climate change Adaptation and Agricultural science curriculum	IK practices
Change in Rainfall pattern	- Harvest the tubers during excessive rainfall season - Proper timing of planting
Weather forecasting	- Observing the leaves of trees, wind direction, heat, clouds - Behaviour of some birds To predict the rains
Floods	- Building Drainage system - Enlarging the river path and placing sandbags at river bank - Planting living barriers (Vertiver grass) - Early harvesting
Drought	- *Ìdíhàn* (mulching), - *Àgbìnpò* (intercropping) - Planting early maturing variety - Replanting of yam seeds - Staking, - No weeding of cassava farm
Whirlwinds	Reserve and plant trees
Site selection	- *Àjùbà* (virgin land) - *Akíntọ̀lá* (Siam weed) and dark green colour grasses, - Shifting cultivation - *Gbada pe* for yam - *Lámùrè* (tiny black ants)
Land preparation	- Slash and burn - Mounds (*ebè)* or ridges - Planting on flat ground
Seed selection	- Head of big yams - *Egùn* (yam milking) -Yams that sprouted in storage
Pest and diseases	- Traditional herbs - Palm fronds - Black core of battery - Crop rotation - Rainwater
Animals and Thieves	- *Aṣọ́komásùn* (scarecrow) - *Pàkúté* (trap) - *Agogo* (bell) - Charms
Herdsmen	- Centipede powder - Potash and beans mixture - *Ọmúajá leaves* (*Ancistrocarpus densispinosus*) - Charms

Source: Olaniyan B. S. (2021)

8.5 Recommendations

The researcher desires to see more people in her generation and younger take pride in their local knowledge being a component of a composite effort to combat climate change. She hence recommends the following:

- Inclusion of indigenous knowledge in mainstream adaptation strategies in Nigeria
- Engaging indigenous knowledge custodians in teaching students, both in classroom settings and in the villages.
- Community based experience and service should be a core part of university education for all courses, involving sustained engagement with the rural people and learning the indigenous ways of solving problems.
- Training and retraining of agricultural extension agents on blending indigenous knowledge with science to use resources available in the villages, rather than being advocates only of purely scientific innovations.
- Development of a blended agricultural curriculum featuring indigenous knowledge from different areas of Nigeria across various aspects of agriculture. This could be extended to other courses/subjects as well.

8.6 Directions for Further Study

This study has documented the role that indigenous knowledge plays in root and tuber production (as a group) and in adapting to climate change across six villages in Kwara state, Nigeria. Further studies could explore indigenous knowledge in root and tuber production in other states of the country. Indigenous knowledge deployed for other groups of crops like cereals and legumes (collectively) could be documented, alongside the ways in which the farmers respond to climate change using indigenous knowledge. The study could also be extended to explore how indigenous knowledge is deployed in animal production; researching its use by animal owners in responding to climate change and helping the animals cope with the phenomenon. A study could be made into how indigenous knowledge is used for crop protection purposes as well as forestry management in response to climate change.

REFERENCES

Abah, J., Mashebe, P., & Denuga, D. (2015). Prospect of integrating African indigenous knowledge systems into the teaching of sciences in Africa. *American Journal of Educational Research*, *3*(6), 668-673. https://doi.org/10.12691/education-3-6-1

Abdulrahman, S., Yusuf, O., & Suleiman, A. (2015). Profit efficiency of cocoyam production in Kaduna State, Nigeria. *Journal of Experimental Agriculture International*, 231-241. https://doi.org/10.9734/AJEA/2015/16219

Abdulrashid, L. (2020). The use of Indigenous Knowledge in flood disaster forecasting for flood disaster risk reduction in northern Katsina state. *Fudma Journal of Sciences*, *4*(4), 469-476. https://doi.org/10.33003/FJS-2020-0404-534

Acharya, A. S., Prakash, A., Saxena, P., & Nigam, A. (2013). Sampling: Why and how of it. *Indian Journal of Medical Specialties*, *4*(2), 330-333. https://doi.org/10.7713/ijms.2013.0032

Adebayo, A., Onu, J., Adebayo, E., & Anyanwu, S. (2012). Farmers' awareness, vulnerability and adaptation to climate change in Adamawa State, Nigeria. *British Journal of Arts and Social sciences*, *9*(2), 104-115.

Adebisi, A. (2016). Yoruba traditional education philosophy in the evolution of a 'total man'. *International Journal of Humanities and Cultural Studies (IJHCS) ISSN 2356-5926*, *2*(2), 33-45. http://ijhcschiefeditor.wix.com/ijhcs

Adedeji, T., Ewebiyi, I., & Olawumi, A. (2014). Farmers' perception of the effect of climate change on yam production in Kajola local government area of Oyo state, Nigeria. *Journal of Agriculture, Forestry and the Social Sciences*, *12*(1), 269-274. https://doi.org/10.4314/joafss.v12i1.29

Adegbite, A., Saka, J., Agbaje, G., Owolade, O., Lawal, G. O. A., & Ojo, S. (2006). Survey of plant-parasitic nematodes associated with yams in Edo, Ekiti and Oyo states of Nigeria. *African Journal of Agricultural Research*, *1*(4), 125-130. https://doi.org/10.5897/AJAR.9000664

Adejuwon, J. O. (2005). Food crop production in Nigeria. I. Present effects of climate variability. *Climate research*, *30*(1), 53-60. https://doi.org/10.3354/cr030053

Adejuwon, J. O. (2006). Food crop production in Nigeria. II. Potential effects of climate change. *Climate research*, *32*(3), 229-245. https://doi.org/10.3354/cr032229

Adekunle, O., Oladele, O., & Olukaiyeja, T. (2002). Indigenous control methods for pests and diseases of cattle in Northern Nigeria. *Livestock Research for Rural Development*, *14*(2), 1-10. https://lrrd.cipav.org.co/lrrd14/2/adek142.htm

Adeniyan, B., Ojeniyi, S., & Awodun, M. (2008). Relative effect of weed mulch types on soil properties and yield of yam in Southwest Nigeria. *J. Soil Nature*, *2*, 1-5. https://www.researchgate.net/publication/313189923

Adeoti, A., Coster, A., & Akanni, T. (2016). Analysis of farmers' vulnerability, perception adaptation to climate change in Kwara State, Nigeria. *International Journal of Climate Research*, *1*(1), 1-16. https://doi.org/10.18488/journal.112/2016.1.1/112.1.1.16

Adeoye, N., Ayanlade, A., & Babatimehin, O. (2009). Climate change and menace of floods in Nigerian cities: socio-economic implications. *Advances in Natural and Applied Sciences*, *3*(3), 369-377.

Adeoye, N. O. (2017). Land use conflict between farmers and herdsmen in parts of Kano, Yobe and Borno States of Nigeria: Nomads' viewpoints. *Ghana Journal of Geography*, *9*(1), 127-151.

Adesiji, G., Matanmi, B., Onikoyi, M., & Saka, M. (2012). Farmers Perception of Climate Change in Kwara State, Nigeria. *World Rural Observations*, *4* (2), 46-54.

Adesina, F. A., & Odekunle, T. O. (2011). Climate change and adaptation in Nigeria: Some background to Nigeria's response–III. International Conference on Environmental and Agriculture Engineering,

Adesoji, S. A. (2016). Eating today and tomorrow: exploring indigenous farming systems of smallholder arable crop farmers in the age of climate change in Nigeria. *Agriculture & Forestry/Poljoprivreda i Sumarstvo*, *62*(1), 349-358. https://doi.org/10.17707/AgricultForest.62.1.37

Adewumi, M. O., & Adebayo, F. (2008). Profitability and technical efficiency of sweet potato production in Nigeria. *Journal of Rural Development/Nongchon-Gyeongje*, *31*(1071-2016-86900), 105-120. https://doi.org/10.22004/ag.econ.45686

Adewumi, M. O., & Adebayo, F. (2008). Profitability and technical efficiency of sweet potato production in Nigeria. *Journal of Rural Development/Nongchon-Gyeongje*, *31*(5), 105-120.

Adewuyi, S., Folorunso, B., Okojie, L., & Akerele, D. (2015). Effect of climate change on food crop production and vulnerability assessment in Oyo State. *Journal of Economics and International Finance*, *7*(1), 18-24. https://doi.org/10.5897/JEIF2013.0516

Adeyemi, M. B., & Adeyinka, A. A. (2003). The principles and content of African traditional education. *Educational Philosophy and Theory*, *35*(4), 425-440. https://doi.org/10.1111/1469-5812.00039

Adeyonu, A. G., Balogun, O. L., Ajiboye, B. O., Oluwatayo, I. B., & Otunaiya, A. O. (2019). Sweet potato production efficiency in Nigeria: Application of data envelopment analysis. *AIMS Agriculture and Food*, *4*(3), 672-684. http://www.aimspress.com/journal/agriculture

Adhikari, U., Nejadhashemi, A. P., & Woznicki, S. A. (2015). Climate change and eastern Africa: a review of impact on major crops. *Food and Energy Security*, *4*(2), 110-132. https://doi.org/10.1002/fes3.61

Adipala, E., Byabakama, B. A., Ogenga-Latigo, M. W., & Otim-Nape, G. W. (1998). Effect of planting date and varietal resistance on the development of cassava mosaic virus disease in Uganda. *African Plant Protection*, *4*(2), 71-79. https://doi.org/10520/AJA10233121_163

Adisa, R. S., Adefalu, L. L., Olatinwo, L. K., Balogun, K. S., & Ogunmadeko, O. O. (2015). Determinants of post-harvest losses of yam among yam farmers in Ekiti State, Nigeria. *Bulletin of the Institute of Tropical Agriculture, Kyushu University*, *38*(1), 073-078. https://doi.org/10.11189/bita.38.073

Aduo, B., & Nwadili, C. O. (2019). A Survey Of Indigenous Farming Systems And Practices In Ebonyi State Nigeria: In Search Of Sustainable Plant Disease Management Options. *International Journal of Bio-Science and Bio-Technology*, *11*(9), 76-82. http://www.globalscientificjournal.com/

Afek, U., & Kays, S. J. (2004). Postharvest physiology and storage of widely used root and tuber crops. *Horticultural Review*, *30*, 253-316. https://doi.org/10.1002/9780470650837.ch7

Afolabi, B. O., Adejumo, A. O., & Jokanola, O. O. (2015). Comparative Assessment of Two Methods in the Production of Fermented Cassava Flour (Láfún) on Manual Energy Expended Retting Time and the Product Quality. *Food Science and Quality Management*, *42*, 20-28.

Agbede, T. (2006). Effect of tillage on soil properties and yam yield on an Alfisol in southwestern Nigeria. *Soil and Tillage Research*, *86*(1), 1-8. https://doi.org/10.1016/j.still.2005.01.012

Agbelemoge, A. (2013). Utilization of cocoyam in rural households in southwestern Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *13*(4), 7944-7956. http://hdl.handle.net/1807/56050

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, *26*(3), 413-439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Agrawal, A. (2002). Indigenous knowledge and the politics of classification. *International Social Science Journal*, *54*(173), 287-297. https://doi.org/10.1111/1468-2451.00382

Agrawal, A. (2014). Indigenous and scientific knowledge: some critical comments. *Antropologi Indonesia*(55). https://doi.org/10.7454/ai.v0i55.3331

Ahmed, M. N. Q., & Haq, S. M. A. (2019). Indigenous people's perceptions about climate change, forest resource management, and coping strategies: a comparative study in Bangladesh. *Environment, Development and Sustainability*, *21*(2), 679-708. https://doi.org/10.1007/s10668-017-0055-1

Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural Studies of Science Education*, *2*(3), 539-620. https://doi.org/10.1007/s11422-007-9067-8

Ajala, A., Oyawoye, E., Bamiro, O., Alabi, O., & Ajayi, B. (2016). Effectiveness of Indigenous Knowledge Practices among Sheep and Goat Farmers in Igbomina Land in Osun and Kwara States, Nigeria. *Journal of Forestry Research and Management*, *13*, 1-13. https://eprints.lmu.edu.ng/id/eprint/1093

Ajani, E., Mgbenka, R., & Okeke, M. (2013). Use of indigenous knowledge as a strategy for climate change adaptation among farmers in sub-Saharan Africa: Implications for policy. *Asian Journal of Agricultural Extension, Economics & Sociology*, *2*(1), 23-40. https://doi.org/10.9734/AJAEES/2013/1856

Ajetomobi, J., Abiodun, A., & Hassan, R. (2011). Impacts of climate change on rice agriculture in Nigeria. *Tropical and Subtropical Agroecosystems*, *14*(2), 613-622. https://www.researchgate.net/publication/286573706

Ajibade, L. T., & Shokemi, O. (2003). Indigenous approach to weather forecasting in ASA LGA, Kwara State, Nigeria. *Indilinga African Journal of Indigenous Knowledge Systems*, *2*(1), 37-44. https://hdl.handle.net/10520/EJC61414

Ajibefun, M. (2018). Social and economic effects of the menace of Fulani herdsmen crises in Nigeria. *Journal of Educational and Social Research*, *8*(2), 133. https://doi.org/10.2478/jesr-2018-0024

Ajiboye, T. O., Edagbo, D. E., Alowonle, A., Michael, C., Oyewole, F., Adegboye, S., . . . Olaniyan, A. O. (2021). Current Status of Yam (Dioscorea Sp) Genetic Resources-Case Study of Selected Locations in South-West Nigeria. *Sumerianz Journal of Agriculture and Veterinary*, *4* (1), 7-12. https://doi.org/10.47752/sjav.41.7.12

Akangbe, J., Oloruntoba, O., Ayanda, I., & Komolafe, S. (2012). An analysis of yam storage strategy to promote food security in Asa local government area of Kwara state, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *5*(4), 550-558. https://doi.org/10.4314/ejesm.v5i4.S15

Akena, F. A. (2012). Critical analysis of the production of Western knowledge and its implications for Indigenous knowledge and decolonization. *Journal of Black Studies*, *43*(6), 599-619. https://doi.org/10.1177%2F0021934712440448

Akinbo, O. (2019). Pre and post harvest studies of yam diseases and their control measure in south eastern Nigeria. *Nigeria Agricultural Journal*, *50*(2), 193-197. http://www.ajol.info/index.php/naj

Akinola, A., Oke, J., Adesiyan, A., & Famuyini, C. (2019, September 23-29). *Climate Change and Economic Efficiency of Yam Farmers in Ekiti State, Nigeria* 6th African
Conference of Agricultural Economists, Abuja, Nigeria.

Akinwale, A. R. (2013). Yoruba traditional education system: A veritable tool for salvaging the crisis laden education system in Nigeria. *Academic Journal of Interdisciplinary Studies*, *2*(6), 141-141. https://doi.org/10.5901/ajis.2013.v2n6p141

Akoroda, M. (1993). Yams: Dioscorea spp. In *Genetic improvement of vegetable crops* (pp. 717-733). Elsevier.

Akpodiogaga-a, P., & Odjugo, O. (2010). General overview of climate change impacts in Nigeria. *Journal of Human Ecology*, *29*(1), 47-55. https://doi.org/10.1080/09709274.2010.11906248

Akullo, D., Kanzikwera, R., Birungi, P., Alum, W., Aliguma, L., & Barwogeza, M. (2007). Indigenous knowledge in agriculture: A case study of the challenges in sharing knowledge of past generations in a globalized context in Uganda. World Library and Information Congress: 73rd IFLA General Conference and Council, Durban, South Africa.

Akwee, P., Netondo, G., Kataka, J., & Palapala, V. A. (2015). A critical review of the role of taro Colocasia esculenta L.(Schott) to food security: A comparative analysis of Kenya and Pacific Island taro germplasm. *Scientia Agriculturae*, *9*(2), 101-108. http://erepo.usiu.ac.ke/11732/5807

Alase, A. (2017). The interpretative phenomenological analysis (IPA): A guide to a good qualitative research approach. *International Journal of Education and Literacy Studies*, *5*(2), 9-19. https://doi.org/10.7575/aiac.ijels.v.5n.2p.9

Alexander, C., Bynum, N., Johnson, E., King, U., Mustonen, T., Neofotis, P., . . . Shadrin, V. (2011). Linking indigenous and scientific knowledge of climate change. *BioScience*, *61*(6), 477-484. https://doi.org/10.1525/bio.2011.61.6.10

Allemann, J., Laurie, S., Thiart, S., Vorster, H., & Bornman, C. (2004). Sustainable production of root and tuber crops (potato, sweet potato, indigenous potato, cassava) in southern Africa. *South African Journal of Botany*, *70*(1), 60-66. https://doi.org/10.1016/S0254-6299(15)30307-0

Aluko, Y. A. (2018). Women's use of indigenous knowledge for environmental security and sustainable development in Southwest Nigeria. *International Indigenous Policy Journal*, *9*(3). https://doi.org/10.18584/iipj.2018.9.3.2

Amanze, N., Agbo, N., Eke-Okoro, O., & Njoku, D. (2011). Selection of yam seeds from open pollination for adoption in yam (Dioscorea rotundata Poir) production zones in Nigeria. *Journal of Plant Breeding and Crop Science*, *3*(4), 68-73. https://doi.org/10.5897/JPBCS.9000121

Amusa, N., Adigbite, A., Muhammed, S., & Baiyewu, R. (2003). Yam diseases and its management in Nigeria. *African Journal of Biotechnology*, *2*(12), 497-502. https://doi.org/10.5897/AJB2003.000-1099

Ande, O., Adediran, J., Ayoola, O., & Akinlosotu, T. (2008). Effects of land quality, management and cropping systems on cassava production in southern western Nigeria. *African Journal of Biotechnology*, *7*(14). http://www.academicjournals.org/AJB

Angba, C. W., Baines, R. N., & Butler, A. J. (2020). Examining Yam Production in Response to Climate Change in Nigeria: A Co-Integration Model Approach. *Social Sciences*, *9*(4), 42. https://doi.org/10.3390/socsci9040042

Anikwe, M. A., & Ikenganyia, E. E. (2018). Ecophysiology and production principles of cassava (Manihot species) in Southeastern Nigeria. *Cassava. Sidney, Australian College of Business Technology*, 105-122.

Anju, L., Ambily, P., Gopikrishna, V., & Amalraj, M. (2014). A study on the scope and importance of tuber crops with special reference to cassava as resilient crop towards climate change. *Journal of Earth Science & Climatic Change*, *5*(6). https://doi.org/10.4172/2157-7617.1000202

Apple, J., Lemus, J., & Semken, S. (2014). Teaching geoscience in the context of culture and place. *Journal of Geoscience Education 62*(1), 1-4. https://doi.org/10.5408/1089-9995-62.1.1

Archer, E. R., Oettlé, N., Louw, R., & Tadross, M. (2008). 'Farming on the edge'in arid western South Africa: climate change and agriculture in marginal environments. *Geography*, *93*(2), 98-107. https://doi.org/10.1080/00167487.2008.12094227

Asante, S., Mensah, G., & Wahaga, E. (2008). Farmers' knowledge and perceptions of insect pests of yam (Dioscorea spp.) and their indigenous control practices in northern Ghana. *Ghana Journal of Agricultural Science*, *40*(2), 185-192. https://doi.org/10.4314/gjas.v40i2.2169

Ashcroft, B., Griffiths, G., & Tiffin, H. (2006). *The post-colonial studies reader*. Taylor & Francis.

Asiedu, R., & Sartie, A. (2010). Crops that feed the world 1. Yams. *Food Security*, *2*(4), 305-315. https://doi.org/10.1007/s12571-010-0085-0

Aspers, P. (2009). Empirical phenomenology: A qualitative research approach (The Cologne Seminars). *Indo-pacific Journal of Phenomenology*, *9*(2), 1-12. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1445-73772009000200002&lng=en&tlng=en

Asrat, P., & Simane, B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes*, *7*(1), 1-13. https://doi.org/10.1186/s13717-018-0118-8

Aswani, S. (1998). Patterns of marine harvest effort in southwestern New Georgia, Solomon Islands: resource management or optimal foraging? *Ocean & Coastal Management*, *40*(2-3), 207-235. https://doi.org/10.1016/S0964-5691(98)00047-7

Avoseh, M. B. (2013). Proverbs as theoretical frameworks for lifelong learning in indigenous African education. *Adult Education Quarterly*, *63*(3), 236-250. https://doi.org/10.1177/0741713612462601

Ayanlade, A., Odekunle, T. O., Orinmogunje, O. I., & Adeoye, N. O. (2009). Inter-annual climate variability and crop yields anomalies in the middle belt of Nigeria. *Adv Nat Appl Sci*, *3*(3), 452-465. https://www.researchgate.net/publication/228428377

Ayanlade, A., Radeny, M., & Akin-Onigbinde, A. I. (2018). Climate variability/change and attitude to adaptation technologies: a pilot study among selected rural farmers' communities in Nigeria. *GeoJournal*, *83*(2), 319-331. https://doi.org/10.1007/s10708-017-9771-1

Ayanlade, A., Radeny, M., & Morton, J. F. (2017). Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather and Climate Extremes*, *15*, 24-33. https://doi.org/10.1016/j.wace.2016.12.001

Ayanwuyi, E., Kuponiyi, F., Ogunlade, I., & Oyetoro, J. (2010). Farmers' perception of impact of climate changes on food crop production in Ogbomosho Agricultural Zone of Oyo State, Nigeria. *Global Journal of Human Social Science*, *10*(7), 33-39. https://www.researchgate.net/publication/265354065_

Ayeni, A., & Olorunfemi, F. (2014). Reflections on environmental security, indigenous knowledge and the implications for sustainable development in Nigeria. *J. Res. Natl. Dev*, *12*(1), 46-57. https://ir.unilag.edu.ng/handle/123456789/9622

Ayinde, O., Muchie, M., & Olatunji, G. (2011). Effect of climate change on agricultural productivity in Nigeria: a co-integration model approach. *Journal of Human Ecology*, *35*(3), 189-194. https://doi.org/10.1080/09709274.2011.11906406

Ayinde, O. E., Ajewole, O., Adeyemi, U., & Salami, M. (2018). Vulnerability analysis of maize farmers to climate risk in Kwara State, Nigeria. *Agrosearch*, *18*(1), 25-39. https://doi.org/10.4314/agrosh.v18i1.3

Babajide, J., Babajide, S., & Oyewole, O. (2007). Survey of traditional dry-yam slices (Gbodo) processing operations in Southwest, Nigeria. *American-Eurasian Journal of Sustainable Agriculture*, *1*(1), 45-49. http://www.aensiweb.net/AENSIWEB/aejsa/aejsa/2007/45-49.pdf

Babatolu, J., & Akinnubi, R. (2016). Smallholder farmers' perception of climate change and variability impact and their adaptation strategies in the upper and lower Niger river basin development authority areas, Nigeria. *Journal of Petroleum & Environmental Biotechnology*, *7*(3), 279. https://doi.org/10.4172/2157-7463.1000279

Bamidele, S. (2018). 'Land bandits'or 'land grabbers': Fulani herdsmen and local farmers incessant bloody clashes in Nigeria. *Revista Brasileira de Estudos Africanos= Brazilian Journal of African Studies*, *3*(6), 163-181. https://doi.org/10.22456/2448-3923.81671

Bamigboye, E. (2015). Utilization of Indigenous Knowledge Systems for Sustainable Vegetable Production under Tropical Conditions. *Scholarly Journal of Agricultural Science 5*(2), 63-66. http://www.scholarly-journals.com/SJAS

Bamigboye, E., & Kuponiyi, F. (2010). The characteristics of Indigenous Knowledge Systems (IKS) influencing their use in rice production by farmers in Ekiti State, Nigeria. *Agricultural Journal*, *5*(2), 74-79. https://doi.org/10.3923/aj.2010.74.79

Bamigboye, E. O. (2016). Utilisation of indigenous knowledge systems for sustainable vegetable production in Ekiti State: implications for sustainable agricultural development in Nigeria. *Poljoprivreda i Sumarstvo*, *62*(1), 91. https://doi.org/10.17707/AgricultForest.62.1.11

Bapfakurera, E. N., & Nduwamungu, J. (2020). The Role of Indigenous Knowledge Systems on Soil and Water Conservation in Musanze and Nyabihu Districts, North-Western of Rwanda. *Journal Agricultural and Biological Sciences*, *6*(2), 72-79. http://www.aiscience.org/journal/absj

Barbier, E. (2013). Environmental Sustainability and Poverty Eradication in Developing Countries. In *Getting Development Right* (pp. 173-194). Springer.

Barnhardt, R., & Oscar Kawagley, A. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology & Education Quarterly*, *36*(1), 8-23. https://doi.org/10.1525/aeq.2005.36.1.008

Baruwa, O., & Oke, J. (2012). Analysis of the Technical Efficiency of Small-holder Cocoyam Farms in Ondo State, Nigeria. *Tropicultura*, *30*(1).

Bassett, T. J., & Fogelman, C. J. G. (2013). Déjà vu or something new? The adaptation concept in the climate change literature. *48*, 42-53.

Bathiany, S., Dakos, V., Scheffer, M., & Lenton, T. M. J. S. a. (2018). Climate models predict increasing temperature variability in poor countries. *4*(5), eaar5809.

Battiste, M. (2005). Indigenous knowledge: Foundations for first nations. *WINHEC: International Journal of Indigenous Education Scholarship*(1), 1-17. https://doi.org/
Beach, K. (1995). Activity as a mediator of sociocultural change and individual development: The case of school-work transition in Nepal. *Mind, Culture, and Activity*, *2*(4), 285-302. https://doi.org/10.1080/10749039509524707
Becker, H., & Geer, B. (1957). Participant observation and interviewing: A comparison. *Human organization*, *16*(3), 28-32. https://doi.org/10.17730/humo.16.3.k687822132323013
Bello, O., Ganiyu, O., Wahab, M., Afolabi, M., Oluleye, F., Mahmud, J., . . . Abdulmaliq, S. (2012). Evidence of climate change impacts on agriculture and food security in Nigeria. *International Journal of Agriculture and Forestry*, *2*(2), 49-55. https://doi.org/10.5923/j.ijaf.20120202.08
Below, T., Artner, A., Siebert, R., & Sieber, S. (2010). Micro-level practices to adapt to climate change for African small-scale farmers. In *A review of selected literature* (Vol. 953).
Bergh, K., Orozco, P., Gugerty, M. K., & Anderson, C. L. (2019). Yam value chain: Nigeria. *Gates Open Res*, *3*. https://doi.org/10.21955/gatesopenres.1115542.1
Berkes, F., & Berkes, M. K. (2009). Ecological complexity, fuzzy logic, and holism in indigenous knowledge. *Futures*, *41*(1), 6-12. https://doi.org/10.1016/j.futures.2008.07.003
Best, A., Stokols, D., Green, L. W., Leischow, S., Holmes, B., & Buchholz, K. (2003). An integrative framework for community partnering to translate theory into effective health promotion strategy. *American Journal of Health Promotion*, *18*(2), 168-176. https://doi.org/10.4278%2F0890-1171-18.2.168
Bevan, M. T. (2014). A method of phenomenological interviewing. *Qualitative Health Research*, *24*(1), 136-144. https://doi.org/10.1177%2F1049732313519710
Bhabha, H. (1988). The commitment to theory. *New formations*, *5*(1), 5-23.
Bhabha, H. K. (1983). The other question…. *Screen*, *24*(6), 18-36. https://doi.org/10.1093/screen/24.6.18
Biermann, F. (2001). Big science, small impacts—in the South? The influence of global environmental assessments on expert communities in India. *Global Environmental Change*, *11*(4), 297-309. https://doi.org/10.1016/S0959-3780(01)00008-5
Blair, N. (2015). Researched to death: Indigenous peoples talkin'up our experiences of research. *International Review of Qualitative Research*, *8*(4), 463-478. https://doi.org/10.1525/irqr.2015.8.4.463
Blankenberg, A.-G. B., & Skarbøvik, E. (2020). Phosphorus retention, erosion protection and farmers' perceptions of riparian buffer zones with grass and natural vegetation: Case studies from South-Eastern Norway. *Ambio*, *49*(11), 1838-1849. https://doi.org/10.1007/s13280-020-01361-5
Boakye, A. A., Wireko-Manu, F. D., Oduro, I., Ellis, W. O., Gudjónsdóttir, M., & Chronakis, I. S. (2018). Utilizing cocoyam (Xanthosoma sagittifolium) for food and nutrition security: A review. *Food Science & Nutrition*, *6*(4), 703-713. https://doi.org/10.1002/fsn3.602
Boddy, C. (2005). A rose by any other name may smell as sweet but "group discussion" is not another name for a "focus group" nor should it be. *Qualitative Market Research: An International Journal*, *8* (3), 248-255. https://doi.org/10.1108/13522750510603325
Boillat, S., & Berkes, F. (2013). Perception and interpretation of climate change among Quechua farmers of Bolivia: indigenous knowledge as a resource for adaptive capacity. *Ecology and Society*, *18*(4). https://doi.org/10.5751/ES-05894-180421

Boissière, M., Locatelli, B., Sheil, D., Padmanaba, M., & Sadjudin, E. (2013). Local perceptions of climate variability and change in tropical forests of Papua, Indonesia. *Ecology and Society*, *18*(4). https://doi.org/10.5751/ES-05822-180413

Bokanga, M. (1999). Cassava: Post-harvest operations. *Information Network on Post-Harvest Operations. In Post-Harvest Compendium*, 1-26.

Boss, P., Dahl, C. M., & Kaplan, L. (1996). The use of phenomenology for family therapy research: The search for meaning. In D. H. Sprenkle & S. M. Moon (Eds.), *Research Methods in Family Therapy* (pp. 83-106). The Guilford Press.

Bragin, M., Akesson, B., Ahmady, M., Akbari, S., Ayubi, B., Faqiri, R., . . . Rasooli, M. H. (2021). Peace, love, and justice: A participatory phenomenological study of psychosocial well-being in Afghanistan. *International Social Work*, 1-23. https://doi.org/10.1177/0020872820969781

Braimah, H., Anchirinah, V., & Adu-Mensah, J. (2007). Yam pests in the Ashanti and Brong Ahafo regions of Ghana: A study of farmers' indigenous technical knowledge and control practices. *Ghana Journal of Agricultural Science*, *40*(1), 33-42. https://doi.org/10.4314/gjas.v40i1.2152

Brayboy, B. M., Gough, H. R., Leonard, B., Roehl, R. F., & Solyom, J. A. (2012). *Reclaiming scholarship: Critical Indigenous Research Methodologies*. Jossey-Bass.

Buchanan, L. (1943). Notes on Rain Stopping in Nyasaland. *Journal of the Royal African Society*, *42*(166), 34-37. https://www.jstor.org/stable/717462

Busari, D. A., Owojuyigbe, M. A., Okunola, R. A., & Mekoa, I. (2017). Cultural concepts employed in child discipline within rural Yorùbá households: the Ayetoro-Oke African community. *Rural Society*, *26*(2), 161-177. https://doi.org/10.1080/10371656.2017.1340142

Bush, E. J., Singh, R. L., & Kooienga, S. (2019). Lived experiences of a community: Merging interpretive phenomenology and community-based participatory research. *International Journal of Qualitative Methods*, *18*, 1-12. https://doi.org/10.1177/1609406919875891

Buthelezi, M. N., & Ngobeni, N. D. (2015). A survey of farming practices and cassava pests and diseases: a case study for Mseleni Village, KwaZulu-Natal in South Africa. *Indilinga African Journal of Indigenous Knowledge Systems*, *14*(2), 262-271. https://hdl.handle.net/10520/EJC183442

Camacho, L. D., Gevaña, D. T., Carandang, A. P., & Camacho, S. C. (2016). Indigenous knowledge and practices for the sustainable management of Ifugao forests in Cordillera, Philippines. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *12*(1-2), 5-13. https://doi.org/10.1080/21513732.2015.1124453

Cameron, J. (2005). *Focusing on the focus group* (2 ed., Vol. 2). Oxford University Press.

Cargo, M., Grams, G. D., Ottoson, J. M., Ward, P., & Green, L. W. (2003). Empowerment as fostering positive youth development and citizenship. *American Journal of Health Behavior*, *27*(1), S66-S79. https://doi.org/10.5993/ajhb.27.1.s1.7.

Cargo, M., & Mercer, S. L. (2008). The value and challenges of participatory research: strengthening its practice. *Annu. Rev. Public Health*, *29*, 325-350. https://doi.org/10.1146/annurev.publhealth.29.091307.083824

Carstensen, M. B. (2011). Paradigm man vs. the bricoleur: bricolage as an alternative vision of agency in ideational change. *European Political Science Review*, *3*(1), 147-167. https://doi.org/10.1017/S1755773910000342

Ceci, L. (1978). Watchers of the Pleiades: Ethnoastronomy among native cultivators in northeastern North America. *Ethnohistory*, *25*(4), 301-317. https://www.jstor.org/stable/481683
Challinor, A., Wheeler, T., Garforth, C., Craufurd, P., & Kassam, A. (2007). Assessing the vulnerability of food crop systems in Africa to climate change. *Climatic Change*, *83*(3), 381-399. https://doi.org/10.1007/s10584-007-9249-0
Chambers, R. (1992). *Rural apprasial: rapid, relaxed and participatory*. Institute of Development Studies (UK). https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/774
Chandra, S. (1984, 21-26 February). Tropical root crop statistics: a world perspective. Sixth Symposium of the International Society for Tropical Root Crops / hosted by in, Lima, Peru.
Chandrasekara, A., & Josheph Kumar, T. (2016a). Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits. *International Journal of Food Science*, *2016*, 3631647. https://doi.org/10.1155/2016/3631647
Chilisa, B. (2011). *Indigenous research methodologies*. Sage Publications, Incorporated.
Chilisa, B., Major, T. E., Gaotlhobogwe, M., & Mokgolodi, H. (2015). Decolonizing and indigenizing evaluation practice in Africa: Toward African relational evaluation approaches. *Canadian Journal of Program Evaluation*, *30*(3). https://doi.org/10.3138/cjpe.30.3.05
Chinn, P. W. (2007). Decolonizing methodologies and indigenous knowledge: The role of culture, place and personal experience in professional development. *Journal of Research in Science Teaching*, *44*(9), 1247-1268. https://doi.org/ 10.1002/tea.20192
Chughtai, H., & Myers, M. D. (2017). Entering the field in qualitative field research: A rite of passage into a complex practice world. *Information Systems Journal*, *27*(6), 795-817. https://doi.org/10.1111/isj.12124
Clune, W. H., & Zehnder, A. J. (2018). The three pillars of sustainability framework: approaches for laws and governance. *Journal of Environmental Protection*, *9*(3), 211-240. https://doi.org/10.4236/jep.2018.93015
Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher*, *28*(2), 4-15. https://doi.org/10.3102/0013189X028002004
Cobern, W. W., & Loving, C. C. (2001). Defining "science" in a multicultural world: Implications for science education. *Science Education*, *85*(1), 50-67. https://doi.org/10.1002/1098-237X(200101)85:1%3C50::AID-SCE5%3E3.0.CO;2-G
Cochran, P. A., Marshall, C. A., Garcia-Downing, C., Kendall, E., Cook, D., McCubbin, L., & Gover, R. M. S. (2008). Indigenous ways of knowing: Implications for participatory research and community. *American Journal of Public Health*, *98*(1), 22-27. https://doi.org/10.2105/AJPH.2006.093641
Cock, J. H. (1982). Cassava: a basic energy source in the tropics. *Science*, *218*(4574), 755-762.
Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.
Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8 ed.). Routledge.
Conroy, S. A. (2003). A pathway for interpretive phenomenology. *International journal of qualitative methods*, *2*(3), 36-62. https://doi.org/10.1177%2F160940690300200304
Cook, I. (2005). *Participant observation* (2nd ed.). Pearson Education. (1997)
Córdoba Vargas, C. A., Hortúa Romero, S., & León-Sicard, T. (2020). Resilience to climate variability: the role of perceptions and traditional knowledge in the Colombian Andes.

Agroecology and Sustainable Food Systems, *44*(4), 419-445. https://doi.org/10.1080/21683565.2019.1649782

Cornwall, A., & Jewkes, R. (1995). What is participatory research? *Social science & medicine*, *41*(12), 1667-1676. https://doi.org/10.1016/0277-9536(95)00127-S

Coursey, & Coursey, C. K. (1971). The new yam festivals of West Africa. *Anthropos*, *3*(H. 3./4), 444-484. https://www.jstor.org/stable/40457684

Coursey, D. (1984). Potential utilization of major root crops, with special emphasis on human, animal, and industrial uses. Tropical root crops: production and uses in Africa: proceedings of the Second Triennial Symposium of the International Society for Tropical Root Crops-Africa Branch held in Douala, Cameroon, 14-19 Aug. 1983,

Couto, R. A. (1987). Participatory research: Methodology and critique. *Clinical Sociology Review*, *5*(1), 9. http://digitalcommons.wayne.edu/csr/vol5/iss1/9

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Daryanto, S., Wang, L., & Jacinthe, P.-A. (2016a). Drought effects on root and tuber production: A meta-analysis. *Agricultural Water Management*, *176*, 122-131. https://doi.org/10.1016/j.agwat.2016.05.019

Daryanto, S., Wang, L., & Jacinthe, P.-A. (2016b). Drought effects on root and tuber production: A meta-analysis. *Agricultural Water Management*, *176*, 122-131.

Davidson, L., Stayner, D. A., Lambert, S., Smith, P., & Sledge, W. H. (2001). Phenomenological and participatory research on schizophrenia. *Journal of Social Issues*, *53*(4), 767-784. https://psycnet.apa.org/doi/10.1111/0022-4537.00048

Davis, B., & Sumara, D. (2008). Complexity as a theory of education. *TCI (Transnational Curriculum Inquiry)*, *5*(2), 33-44. https://doi.org/10.14288/tci.v5i2.75

De Bruijn, G., & Fresco, L. (1989). The importance of cassava in world food production. *NJAS Wageningen Journal of Life Sciences*, *37*(1), 21-34. https://doi.org/10.18174/njas.v37i1.16651

Degebasa, A. C. (2020). Prospects and Challenges of Postharvest Losses of Potato (Solanum Tuberosum L.) in Ethiopia. *Global Journal of Nutrition & Food Science*, *2*(5), 1.

Dei, G. J. (1993). Sustainable development in the African context: Revisiting some theoretical and methodological issues. *Africa Development/Afrique et Développement*, 97-110. https://www.jstor.org/stable/43657925

Dei, G. J. S. (2000). Rethinking the role of indigenous knowledges in the academy. *International Journal of Inclusive Education*, *4*(2), 111-132. https://doi.org/10.1080/136031100284849

Demeritt, D. (2001). The construction of global warming and the politics of science. *Annals of the Association of American Geographers*, *91*(2), 307-337. https://doi.org/10.1111/0004-5608.00245

Denton, F., O'Neill, M., & Stone, J. M. (2008). Adapting To Climate Change In Africa: The role of research and capacity development. *Development Outreach*, *10*(1), 38-40. https://doi.org/10.1596/1020-797X-10-1_38

Devers, K. J., & Frankel, R. M. (2000). Study design in qualitative research--2: Sampling and data collection strategies. *Education for health*, *13*(2), 263. https://doi.org/13576280050074543

Dimelu, M., Edoka, M., & Emodi, A. (2014). Challenges in building climate change mitigation and adaptation capacity of extension professionals in Nigeria. *PAT*, *10*(1), 110-122. http://www.patnsukjournal.net/currentissue

Dimelu, M. U., Salifu, E. D., & Igbokwe, E. M. (2016). Resource use conflict in agrarian communities, management and challenges: A case of farmer-herdsmen conflict in Kogi State, Nigeria. *Journal of Rural Studies*, *46*, 147-154.

Doebel, R. (2000). Oral traditions and scientific knowledge: some remarks on the epistemological validity of the indigenous perspective. *Asian Journal of Social Science*, *28*(1), 171-184. https://doi.org/10.1163/030382400X00217

Doku, E. (1981). Strategies for progress in cocoyam research. Tropical root crops: research strategies for the 1980s: proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops-Africa Branch, 8-12 Sept. 1980, Ibadan, Nigeria, Ibadan, Nigeria.

Donaldson, T., Fore, G., Filippelli, G. M., & Hess, J. (2020). A systematic review of the literature on situated learning in the geosciences: beyond the classroom. *International Journal of Science Education*, 1-22. https://doi.org/10.1080/09500693.2020.1727060

Doody, O., Slevin, E., & Taggart, L. (2013). Preparing for and conducting focus groups in nursing research: part 2. *British Journal of Nursing*, *22*(3), 170-173. https://doi.org/10.12968/bjon.2013.22.3.170

Drawson, A. S., Toombs, E., & Mushquash, C. J. (2017). Indigenous research methods: A systematic review. *The International Indigenous Policy Journal*, *8*(2), 5. https://doi.org/10.18584/iipj.2017.8.2.5

Dudgeon, P., Scrine, C., Cox, A., & Walker, R. (2017). Facilitating empowerment and self-determination through participatory action research: Findings from the National Empowerment Project. *International Journal of Qualitative Methods*, *16*(1), 1609406917699515. https://doi.org/10.1177/1609406917699515

Dweba, T., & Mearns, M. A. (2011). Conserving indigenous knowledge as the key to the current and future use of traditional vegetables. *International Journal of Information Management*, *31*(6), 564-571. https://doi.org/10.1016/j.ijinfomgt.2011.02.009

Echebiri, R., & Edaba, M. (2008). Production and utilization of cassava in Nigeria: Prospects for food security and infant nutrition. *PAT*, *4*(1), 38-52. http://www.patnsukjournal.com/currentissue

Edoga, R. N. (2007). Determination of length of growing season in Samaru using different potential evapotranspiration models. *AU JT*, *11*(1), 28-35. https://www.researchgate.net/publication/266609077

Egesi, C. N., Onyeka, T., & Asiedu, R. (2007). Severity of anthracnose and virus diseases of water yam (Dioscorea alata L.) in Nigeria I: effects of yam genotype and date of planting. *Crop Protection*, *26*(8), 1259-1265. https://doi.org/10.1016/j.cropro.2006.10.025

Elkatawneh, H. (2016). The Five Qualitative Approaches: Problem, Purpose, and Questions/The Role of Theory in the Five Qualitative Approaches/Comparative Case Study. SSRN Electronic Journal, 1–17. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2761327

Enete, A. A., & Amusa, T. A. (2010). Challenges of agricultural adaptation to climate change in Nigeria: A synthesis from the literature. *Field Actions Science Reports. The Journal of Field Actions*, *4*. https://www.researchgate.net/publication/277110058_

Enete, A. A., Madu, I. I., Mojekwu, J. C., Onyekuru, A. N., Onwubuya, E. A., & Eze, F. (2011). *Indigenous agricultural adaptation to climate change: Study of Imo and Enugu states in Southeast Nigeria*. African Technology Policy Studies Network.

Ennin, S., Issaka, R., Acheampong, P., Numafo, M., & Danquah, E. O. (2014). Mechanization, fertilization and staking options for environmentally sound yam production. *African Journal of Agricultural Research*, *9*(29), 2222-2230. https://doi.org/10.5897/AJAR2014.8487

Eruola, A., Bello, N., Ufoegbune, G., & Makinde, A. (2012). Effect of variety selection on growth, development and yield of white yam in southwestern Nigeria. *International Journal of Agriculture and Forestry*, *2*(3), 101-104. https://doi.org/10.5923/j.ijaf.20120203.04

Etejere, E. O., & Bhat, R. B. (1985). Traditional preparation and uses of cassava in Nigeria. *Economic Botany*, *39*(2), 157-164. https://doi.org/10.1007/BF02907839

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1-4. https://doi.org/10.11648/j.ajtas.20160501.11

Ezeanya-Esiobu, C. (2019). *Indigenous Knowledge and Education in Africa*. Springer Nature.

Ezeonwuka, I.-F., & Igwe, A. U. (2016). Emerging challenges in Nigeria's national security in the twenty-first century: The Fulani herdsmen menace. *Asian Journal of Multidisciplinary Studies*, *4*(5), 204-215. http://www.ajms.co.in/

Fabiyi, O. O., & Oloukoi, J. (2013). Indigenous knowledge system and local adaptation strategies to flooding in coastal rural communities of Nigeria. *Journal of Indigenous Social Development*, *2*(1). http://scholarspace.manoa.hawaii.edu/handle/10125/29811

Fafunwa, A. B. (2018). *History of education in Nigeria*. Routledge. https://doi.org/10.4324/9780429454905 (1974)

Falade, K. O., & Akingbala, J. O. (2010). Utilization of cassava for food. *Food Reviews International*, *27*(1), 51-83. https://doi.org/10.1080/87559129.2010.518296

Falaki, A., Akangbe, J., & Ayinde, O. (2013a). Analysis of climate change and rural farmers' perception in North Central Nigeria. *Journal of Human Ecology*, *43*(2), 133-140.

Falaki, A., Akangbe, J., & Ayinde, O. E. (2013b). Analysis of climate change and rural farmers' perception in North Central Nigeria. *Journal of Human Ecology*, *43*(2), 133-140. https://doi.org/10.1080/09709274.2013.11906619

Fanon, F. (1967). *Black skin, white masks*. Grove press. (1986).

FAO. (2002, December 3-6). Importance of root crops in Africa. Expert Consultation on Root Crop Statistics, Harare, Zimbabwe.

FAO. (2003, 3-6 December 2002). Expert Consultation on Root Crop Statistics. Expert Consultation on Root Crop Statistics, Harare, Zimbabwe.

Fasona, M., Fabusoro, E., Sodiya, C., Adedayo, V., Olorunfemi, F., Elias, P., & Oyedepo, J. (2015, 17-18 April 2015). *Some dimensions of farmers-pastoralists conflicts in the Nigerian Savanna* 5th International Conflict Management Conference: : Livelihoods, Sustainability and Conflict, Kennesaw State University Campus, Kennesaw, Atlanta Suburb, Georgia, USA,.

Fasona, M. J., & Omojola, A. (2005). Climate change, human security and communal clashes in Nigeria. International Workshop on Human Security and Climate Change, Oslo, Norway. June,

Fawole, O. (2007). Constraints to production, processing and marketing of Sweet-Potato in selected communities in Offa local government Area, Kwara State Nigeria. *Journal of Human Ecology*, *22*(1), 23-25. https://doi.org/10.1080/09709274.2007.11905994

Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*, 2069-2094. https://doi.org/10.1007/s10311-020-01059-w

Ferraro, V., Piccirillo, C., Tomlins, K., & Pintado, M. E. (2016). Cassava (Manihot esculenta Crantz) and yam (Dioscorea spp.) crops and their derived foodstuffs: safety, security and nutritional value. *Critical Reviews in Food Science and Nutrition*, *56*(16), 2714-2727. https://doi.org/10.1080/10408398.2014.922045

Fetuga, G. O., Tomlins, K., Bechoff, A., Henshaw, F. O., Idowu, M. A., & Westby, A. (2013). A survey of traditional processing of sweet potato flour for amala, consumption pattern of sweet potato amala and awareness of orange-fleshed sweet potato (OFSP) in South West Nigeria. *Journal of Food, Agriculture and Environment*, *11*(3-4), 67-71. https://doi.org/10.1234/4.2013.4604

Fitchett, J. M., & Ebhuoma, E. (2018). Phenological cues intrinsic in indigenous knowledge systems for forecasting seasonal climate in the Delta State of Nigeria. *International Journal of Biometeorology*, *62*(6), 1115-1119. https://doi.org/10.1007/s00484-017-1495-x

Folch-Lyon, E., & Trost, J. F. (1981). Conducting focus group sessions. *Studies in family planning*, 443-449. https://doi.org/10.2307/1965656

Fox, S. (1997). Situated learning theory versus traditional cognitive learning theory: Why management education should not ignore management learning. *Systems Practice*, *10*(6), 727-747. https://doi.org/10.1007/BF02557922

Francesca, C. (2016). *The traditional knowledge advantage: Indigenous peoples' knowledge in climate change adaptation and mitigation strategies* (IFAD Advantage Series, Issue.

Frauenberger, C., Good, J., & Keay-Bright, W. (2010). Phenomenology, a framework for participatory design. Proceedings of the 11th Biennial Participatory Design Conference, Sydney Australia

Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio*, *22* (2/3), 151-156. www.jstor.org/stable/4314060

Gibbs, A. (1997). Focus groups. *Social research update*, *19*(8), 1-8.

Gobbi, M. (2005). Nursing practice as bricoleur activity: a concept explored. *Nursing inquiry*, *12*(2), 117-125. https://doi.org/10.1111/j.1440-1800.2005.00261.x

Gómez-Baggethun, E., Corbera, E., & Reyes-García, V. (2013). Traditional ecological knowledge and global environmental change: research findings and policy implications. *Ecology and society: a journal of integrative science for resilience and sustainability*, *18*(4). https://doi.org/10.5751/ES-06288-180472.

Goodman, A., Morgan, R., Kuehlke, R., Kastor, S., Fleming, K., & Boyd, J. (2018). "We've Been Researched to Death": Exploring the Research Experiences of Urban Indigenous Peoples in Vancouver, Canada. *International Indigenous Policy Journal*, *9*(2). https://doi.org/10.18584/iipj.2018.9.2.3

Gould, R. K., & Lincoln, N. K. (2017). Expanding the suite of Cultural Ecosystem Services to include ingenuity, perspective, and life teaching. *Ecosystem services*, *25*, 117-127. https://doi.org/10.1016/j.ecoser.2017.04.002

Govender, N. (2012). Educational implications of applying the complexity approach to Indigenous Knowledge Systems (IKS). *Alternation*, *19*(2), 112-137. http://alternation.ukzn.ac.za/Files/docs/19.2/07%20Gov.pdf

Grossoehme, D. H. (2014). Research Methodology Overview of Qualitative Research. *J Health Care Chaplain*, *20*(3), 109-122. https://doi.org/10.1080/08854726.2014.925660

Hall, B. L. (1992). From margins to center? The development and purpose of participatory research. *The American Sociologist*, *23*(4), 15-28. https://www.jstor.org/stable/27698620
Hart, M. A. (2010). Indigenous worldviews, knowledge, and research: The development of an indigenous research paradigm. *Journal of Indigenous Social Development*, *1*(1A). http://hdl.handle.net/10125/12527
Hartmann, P. (2007). Root and tuber crops and economic growth: The case of Sub-Saharan Africa. Tropical root and tuber crops: Opportunities for poverty alleviation and sustainable livelihoods in developing countries. Proceedings of the Thirteenth Triennial Symposium of the International Society for Tropical Root Crops (ISTRC),
Harvey, C. A., Tucker, N. I., & Estrada, A. (2004). Live fences, isolated trees, and windbreaks: tools for conserving biodiversity in fragmented tropical landscapes. *Agroforestry and biodiversity conservation in tropical landscapes*, 261-289. https://www.researchgate.net/publication/325128589
Hasnat, G. T., Kabir, M. A., & Hossain, M. A. (2018). Major environmental issues and problems of South Asia, particularly Bangladesh. *Handbook of Environmental Materials Management*, 1-40.
Hassan, Z. A., Schattner, P., & Mazza, D. (2006). Doing a pilot study: why is it essential? *Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia*, *1*(2-3), 70. http://www.ejournal.afpm.org.my/
Henry, G. T. (2009). *Practical sampling* (Vol. 2). https://doi.org/10.4135/9781412985451.n2
Hoffmann, V., Probst, K., & Christinck, A. (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values*, *24*(3), 355-368. https://doi.org/10.1007/s10460-007-9072-2
Howeler, R. H., Ezumah, H. C., & Midmore, D. J. (1993). Tillage systems for root and tuber crops in the tropics. *Soil and Tillage Research*, *27*(1-4), 211-240. https://doi.org/10.1016/0167-1987(93)90069-2
Huberman, M. (1990). Linkage between researchers and practitioners: A qualitative study. *American educational research journal*, *27*(2), 363-391. https://doi.org/10.3102%2F00028312027002363
Husain, A. S., & Sundaramari, M. (2011). Scientific rationality and perceived effectiveness of indigenous technical knowledge on coconut (Cocos nucifera L.) cultivation in Kerala. *Journal of Tropical Agriculture*, *49*, 78-87. https://www.researchgate.net/publication/298114250
Hydén, L.-C., & Bülow, P. H. (2003). Who's talking: drawing conclusions from focus groups—some methodological considerations. *Int. J. Social Research Methodology*, *6*(4), 305-321. https://doi.org/10.1080/13645570210124865
Idowu, A. A., Ayoola, S., Opele, A., & Ikenweiwe, N. (2011). Impact of climate change in Nigeria. *Iranica Journal of Energy & Environment*, *2*(2), 145-152. https://ir.unilag.edu.ng/handle/123456789/6309
Idusogie, E., & Olayide, S. (1977). *Role of roots and tubers in Nigerian nutrition and agricultural development*. Joint FAO-WHO-OAU Regional Food and Nutrition Commission for Africa.
Ifeanyi-Obi, C., Etuk, U., & Jike-Wai, O. (2012a). Climate change, effects and adaptation strategies; implication for agricultural extension system in Nigeria. *Greener Journal of Agricultural Sciences*, *2*(2), 53-60. https://doi.org/10.15580/GJAS.2013.3.1234

Ifeanyi-obi, C., Etuk, U., & Jike-wai, O. (2012b). Climate Change, Effects and Adaptation Strategies; Implication for Agricultural Extension System in Nigeria. *Greener Journal of Agricultural Sciences*, *2* (2), 053-060.
Ifeanyi–Obi, C., & Nnadi, F. (2014). Climate change adaptation measure used by farmers in south-south Nigeria. *Journal of Environmental Science*, *8*(4), 01-06. https://doi.org/10.9790/2402-08410106
Igboin, B. O. (2012). The Semiotic of Greetings in Yoruba Culture. *Cultura*, *9*(2), 123-142. https://doi.org/10.5840/cultura2012929
Ike, P. C., & Inoni, O. E. (2006). Determinants of yam production and economic efficiency among small-holder farmers in southeastern Nigeria. *Journal of Central European Agriculture*, *7*(2), 337-342. https://hrcak.srce.hr/17367
Ikeorgu, J., & Nwokocha, H. (2001). Development of the yam minituber technique for seed yam production. *Nigeria Agricultural Journal*, *32*. https://doi.org/10.4314/naj.v32i1.49372
Ikezue, C. E., & Ezeah, P. (2017). Recurrent Conflicts among Migrant Fulani Herdsmen and Indigenous Communities of Southern Nigeria: A Review of Literature. *International Journal of Health and Social Inquiry*, *3*(1). https://journals.aphriapub.com/index.php/IJHSI/article/view/331
IPCC, I. P. O. C. C. (2007). Climate change 2007: Impacts, adaptation and vulnerability. *Genebra, Suíça*.
Irizarry, H., & Rivera, E. (1993). Yield of two yam (Dioscorea alata) cultivars with three planting dates and two planting systems. *The Journal of Agriculture of the University of Puerto Rico*, *77*(3-4), 161-166. https://doi.org/10.46429/jaupr.v77i3-4.4204
Ishak, N. M., Bakar, A., & Yazid, A. (2014). Developing Sampling Frame for Case Study: Challenges and Conditions. *World Journal of Education*, *4*(3), 29-35. https://doi.org/10.5430/wje.v4n3p29
Ishaya, S., & Abaje, I. (2008). Indigenous people's perception on climate change and adaptation strategies in Jema'a local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning*, *1*(8), 138. https://doi.org/10.5897/JGRP.9000080
Israel, B. A., Schulz, A. J., Parker, E. A., & Becker, A. B. (1998). Review of community-based research: assessing partnership approaches to improve public health. *Annual Review of Public Health*, *19*(1), 173-202. https://doi.org/10.1146/annurev.publhealth.19.1.173
Itam, K. O., Ajah, E. A., & Agbachom, E. E. (2014). Analysis of determinants of cassava production and profitability in Akpabuyo Local Government Area of Cross River State, Nigeria. *International Business Research*, *7*(12), 128. https://doi.org/10.5539/ibr.v7n12p128
Iwuoha, C. I., & Eke, O. S. (1996). Nigerian indigenous fermented foods: their traditional process operation, inherent problems, improvements and current status. *Food Research International*, *29*(5-6), 527-540. https://doi.org/10.1016/0963-9969(95)00045-3
Jiri, O., Mafongoya, P., Mubaya, C., & Mafongoya, O. (2015). Seasonal climate prediction and adaptation using indigenous knowledge systems in agriculture systems in Southern Africa: a review. *Journal of Agricultural Science* *8*(5). https://doi.org/10.5539/jas.v8n5p156
Johnson, C. (2012). Bricoleur and bricolage: From metaphor to universal concept. *Paragraph*, *35*(3), 355-372. https://doi.org/10.3366/para.2012.0064
Kadiri, M., Ojewumi, A., Aniola, T., & Musa, A. H. (2014). Ethno-botanical survey of plants commonly used for ceremonial activities among Yoruba tribe of south West Nigeria. *Direct Res. J. Health Pharmacol*, *2*, 1-5. https://doi.org/10.26765/DRJA17087745

Kaivo-oja, J. (2017). Towards better participatory processes in technology foresight: How to link participatory foresight research to the methodological machinery of qualitative research and phenomenology? *Futures*, *86*, 94-106. https://doi.org/10.1016/j.futures.2016.07.004

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing*, *72*(12), 2954-2965. https://doi.org/10.1111/jan.13031

Kalu, B., & Egbe, O. (2011). Climate change and crop vulnerability in Nigeria. *Agro-science*, *10*(1). https://doi.org/10.4314/as.v10i1.68719

Kamalkumaran, P., Anand, M., & Nanthakumar, S. (2020). Tuber Crops in Ensuring Nutritional Security among the Rural Population. *Biotica Research Today*, *2*(5 Spl.), 180-183.

Kaniki, A. M., & Mphahlele, M. K. (2002). Indigenous knowledge for the benefit of all: can knowledge management principles be used effectively? *South African Journal of Libraries and Information Science*, *68*(1), 1-15. https://hdl.handle.net/10520/EJC61125

Kassali, R. (2011). Economics of sweet potato production. *International Journal of Vegetable Science*, *17*(4), 313-321. https://doi.org/10.1080/19315260.2011.553212

Kates, R. W. (1997). Climate change 1995: impacts, adaptations, and mitigation. *Environment: Science and Policy for Sustainable Development*, *39*(9), 29-33. https://doi.org/10.1080/00139159709604767

Kawulich, B. B. (2005). Participant observation as a data collection method. Forum qualitative sozialforschung/forum: Qualitative social research,

Kelly, P. J. (2005). Practical suggestions for community interventions using participatory action research. *Public Health Nursing*, *22*(1), 65-73. https://doi.org/10.1111/j.0737-1209.2005.22110.x

Kettle, N. P., Dow, K., Tuler, S., Webler, T., Whitehead, J., & Miller, K. M. (2014). Integrating scientific and local knowledge to inform risk-based management approaches for climate adaptation. *Climate Risk Management*, *4*, 17-31. https://doi.org/10.1016/j.crm.2014.07.001

Kibet Rono, P., Rahman, S., & Benaissa, C. (2017). An Analysis of Demand for Roots and Tubers in Kenya using the Linear Approximation Almost Ideal Demand System (LA-AIDS). 2017 Annual Meeting, February 4-7, 2017, Mobile, Alabama,

Kincheloe, J. L. (2011). Describing the bricolage: Conceptualizing a new rigor in qualitative research. In *Key Works in Critical Pedagogy* (pp. 177-189). Brill Sense.

Kio, P. (1972). Shifting cultivation and multiple use of forest land in Nigeria. *The Commonwealth Forestry Review*, 144-148. https://www.jstor.org/stable/42605108

Klein, R. J., Schipper, E. L. F., & Dessai, S. (2005). Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science & Policy*, *8*(6), 579-588. https://doi.org/10.1016/j.envsci.2005.06.010

Klopper, H. (2008). The qualitative research proposal. *Curationis*, *31*(4), 62-72. https://doi.org/10.4102/curationis.v31i4.1062

Knipscheer, H., & Wilson, J. (1981). Cocoyam farming systems in Nigeria. Tropical root crops: research strategies for the 1980s: proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops-Africa Branch, 8-12 Sept. 1980, Ibadan, Nigeria,

Kolawole, O. (2005). Introducing indigenous education to university undergraduate students: Feelers from Obafemi Awolowo University, Nigeria. *South African Journal of Higher Education*, *19*(Special Edition 1), 1189-1196. https://hdl.handle.net/10520/EJC37216

Kolawole, O. (2013). Soil science, indigenous knowledge and sustainable intensification: Implications for smallholder farming systems. Knowledge for Development, Technical Centre for Agriculture and Rural Cooperation. *Soil-science-indigenousknowledge-and-sustainable-intensification-Implications-for-smallholder-farming-systems (07/10/2013)*. https://www.researchgate.net/publication/258149992_

Kolawole, O. D. (2001). Local knowledge utilisation and sustainable rural development in the 21st century. *Indigenous Knowledge and Development Monitor*, *9*(3), 13-15. https://www.researchgate.net/publication/236679790

Kolawole, O. D. (2006). Local farmers' approach to soil conservation: lessons from Nigeria. *Indilinga African Journal of Indigenous Knowledge Systems*, *5*(1), 75-86. https://hdl.handle.net/10520/EJC61500

Kolawole, O. D. (2012). Intersecting western and local knowledge: critical issues for development research in Africa. *Journal of Knowledge Globalization*, *5*(2). http://hdl.handle.net/10311/1313

Kolawole, O. D., Motsholapheko, M. R., Ngwenya, B. N., Thakadu, O., Mmopelwa, G., & Kgathi, D. L. (2016). Climate variability and rural livelihoods: How households perceive and adapt to climatic shocks in the Okavango Delta, Botswana. *Weather, Climate, and Society*, *8*(2), 131-145. https://doi.org/10.1175/WCAS-D-15-0019.1

Kolawole, O. D., Wolski, P., Ngwenya, B., & Mmopelwa, G. (2014). Ethno-meteorology and scientific weather forecasting: Small farmers and scientists' perspectives on climate variability in the Okavango Delta, Botswana. *Climate Risk Management*, *4*, 43-58. https://doi.org/10.1016/j.crm.2014.08.002

Kolawole, P. O., Agbetoye, L., & Ogunlowo, S. A. (2010). Sustaining world food security with improved cassava processing technology: The Nigeria experience. *Sustainability*, *2*(12), 3681-3694. https://doi.org/10.3390/su2123681

Koocheki, A. A. (2003). Indigenous knowledge in agriculture with particular reference to saffron production in Iran. I International Symposium on Saffron Biology and Biotechnology 650,

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Kovach, M. (2010). Conversation method in Indigenous research. *First Peoples Child & Family Review: An interdisciplinary Journal honouring the voices, perspectives, and knowledges of first peoples through research, critical analyses, stories, standpoints and media reviews*, *5*(1), 40-48. https://doi.org/10.7202/1069060ar

Kumar, K. (1989). *Conducting key informant interviews in developing countries*. United States. Agency for International, Development.

Kumar, V. (2014). Role of indigenous knowledge in climate change adaptation strategies: A study with special reference to North-Western India. *Journal of Geography & Natural Disasters*, *5*(1), 1-5. https://doi.org/2167-0587.1000131

Kumar, V. (2014). Role of Indigenous knowledge in climate change adaptation strategies: A study with special reference to North-Western India. *Geography & Natural Disasters*, *5*(131), 2167-0587.1000131.

Kusi, F., Asante, S., Adjebeng-Danquah, J., Nutsugah, S., Buah, S., Owusu, R., . . . Zakaria, M. (2013). Participatory integrated pest management strategy for improving shelf-life of yam (Dioscorea spp.). *International Journal of Advance Agricultural Research*, *1*, 124-132. http://hdl.handle.net/123456789/333

Ladan, S. I. (2014). An appraisal of climate change and agriculture in Nigeria. *Journal of geography and regional planning*, *7*(9), 176-184. https://doi.org/10.5897/JGRP2013.0405

Lal, R., & Hahn, S. (1973). Effects of methods of seedbed preparation, mulching and time of planting on yam in Western Nigeria. 3rd International Symposium on Tropical Root Crops, Ibadan, Nigeria,

Lalonde, A. (1991a, September 26-29). African indigenous knowledge and its relevance to environment and development activities. The Common Property Conference, Winnipeg, Manitoba.

Lalonde, A. (1991b). African indigenous knowledge and its relevance to environment and development activities. *Canadian International Development Agency*.

Lancaster, G. A., Dodd, S., & Williamson, P. R. (2004). Design and analysis of pilot studies: recommendations for good practice. *Journal of Evaluation in Clinical Practice*, *10*(2), 307-312. https://doi.org/10.1111/j..2002.384.doc.x

Lancaster, P. A., Ingram, J. S., Lim, M., & Coursey, D. (1982). Traditional cassava-based foods: survey of processing techniques. *Economic Botany*, *36*(1), 12-45. https://www.jstor.org/stable/4254349

Lannbrecht, F. L. (1976). The pastoral nomads of Nigeria. *Expedition*.

Lapan, S. D., Quartaroli, M. T., & Riemer, F. J. (2012). *Qualitative research: An introduction to methods and designs*. Jossey-Bass.

Lasker, R. D., Weiss, E. S., & Miller, R. (2001). Partnership synergy: a practical framework for studying and strengthening the collaborative advantage. *The Milbank Quarterly*, *79*(2), 179-205. https://doi.org/10.1111/1468-0009.00203

Lauer, M., & Aswani, S. (2009). Indigenous ecological knowledge as situated practices: understanding fishers' knowledge in the western Solomon Islands. *American Anthropologist*, *111*(3), 317-329. https://doi.org/10.1111/j.1548-1433.2009.01135.x

Lauer, M., & Matera, J. (2016). Who detects ecological change after catastrophic events? Indigenous knowledge, social networks, and situated practices. *Human Ecology*, *44*(1), 33-46. https://doi.org/10.1007/s 10745-016-9811 -3

Laurier, E. (2010). *Participant observation* (2nd ed., Vol. 133). Sage Publications.

Lave, J. (1991). Situating learning in communities of practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspective on Socially Shared Cognition* (pp. 63-82). American Psychological Association. https://doi.org/10.1037/10096-003

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Lebot, V. (2009). *Tropical root and tuber crops* (Vol. 2). CABI.

Lokot, M. (2021). Whose voices? Whose knowledge? A feminist analysis of the value of key informant interviews. *International Journal of Qualitative Methods*, *20*, 1609406920948775.

Lopez, V., & Whitehead, D. (2013). Sampling data and data collection in qualitative research. *Nursing & Midwifery Research: Methods and Appraisal for Evidence-based Practice*, 123-140.

Louis, R. P. (2007). Can you hear us now? Voices from the margin: Using indigenous methodologies in geographic research. *Geographical Research*, *45*(2), 130-139. https://doi.org/10.1111/j.1745-5871.2007.00443.x

Luka, E. G., & Yahaya, H. (2012). Perceived constraints to use of indigenous soil management practices among yam producers in Nasarawa state, Nigeria. *Journal of Sustainable Development in Africa*, *14*(2), 115-124.

Lunt, P., & Livingstone, S. (1996). Rethinking the focus group in media and communications research. *Journal of Communication*, *46*(2), 79-98. https://doi.org/10.1111/j.1460-2466.1996.tb01475.x

Macaulay, A. C., Commanda, L. E., Freeman, W. L., Gibson, N., McCabe, M. L., Robbins, C. M., & Twohig, P. L. (1999). Participatory research maximises community and lay involvement. *British Medical Journal*, *319*(7212), 774-778. https://doi.org/10.1136/bmj.319.7212.774

MacDonald, C. (2012). Understanding participatory action research: A qualitative research methodology option. *The Canadian Journal of Action Research*, *13*(2), 34-50. https://doi.org/10.33524/cjar.v13i2.37

Madukwe, M. (1995). Obstacles to the adoption of yam minisett technology by small-scale farmers of Southeastern Nigeria. *Agrosearch*, *1*(1), 1-6. https://africaneditors.org/journal/AGROSH/abstract/04020-30487

Madzivhandila, T. (2014). Discourses of climate change and sustainable development in the third world countries: for who's benefit is it? *Journal of Public Administration*, *49*(1), 92-103. https://doi.org/https://hdl.handle.net/10520/EJC153635

Madzivhandila, T. S., Niyimbanira, F., & Nkuna, N. (2021). Sustainable Adaptation Measures to climate change: a need of a balancing act between developed and developing countries. *African Renaissance*, *2021*(si1), 87-107. https://doi.org/https://hdl.handle.net/10520/ejc-aa_afren-v2021-nsi1-a5

Maguire, P. (1987). *Doing participatory research: A feminist approach*. Center for International Education, School of Education, University of Massachusetts. https://doi.org/http://scholarworks.umass.edu/cie_participatoryresearchpractice/1

Maila, M. W., & Loubser, C. P. (2003). Emancipatory indigenous knowledge systems: Implications for environmental education in South Africa. *South African Journal of Education*, *23*(4), 276-280. https://doi.org/https://hdl.handle.net/10520/EJC31963

Mairiga, N. M., & Ibrahim, M. (2021). Assessment of Indigenous Knowledge in Managing Environmental Challenges: A Case Study of Ringim Local Government Area of Jigawa State, Nigeria. *International Journal of Scientific Advances*, *2*(4), 606-611. https://doi.org/10.51542/ijscia.v2i4.25

Makhado, R. A., Saidi, A. T., & Tshikhudo, P. P. (2014). Optimising drought adaptation by small-scale farmers in southern Africa through integration of indigenous and technologically-driven practices. *African Journal of Science, Technology, Innovation and Development*, *6*(4), 265-273. https://doi.org/https://hdl.handle.net/10520/EJC163661

Makondo, C. C., & Thomas, D. S. (2018). Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation. *Environmental science & policy*, *88*, 83-91. https://doi.org/https://doi.org/10.1016/j.envsci.2018.06.014

Makwara, E. C. (2013). Indigenous knowledge systems and modern weather forecasting: exploring the linkages. *Journal of Agriculture and Sustainability*, *2*(2).

Makwara, E. C. (2019). Unpacking the Functionality of Indigenous Knowledge Systems (IKSs) in Weather Forecasting in Turwi Basin, Zimbabwe. *Journal of Agriculture and Sustainability*, *13*.

Malcolm, S., Marshall, E., Aillery, M., Heisey, P., Livingston, M., & Day-Rubenstein, K. (2012). *Agricultural adaptation to a changing climate: economic and environmental implications vary by US region* (USDA-ERS Economic Research Report, Issue. https://ssrn.com/abstract=2112045

Mapara, J. (2009). Indigenous knowledge systems in Zimbabwe: Juxtaposing postcolonial theory. *Journal of Pan African Studies*, *3*(1). https://doi.org/http://ir.gzu.ac.zw:8080/xmlui/handle/123456789/130

Marcos, J., Cornet, D., Bussière, F., & Sierra, J. (2011). Water yam (Dioscorea alata L.) growth and yield as affected by the planting date: Experiment and modelling. *European Journal of Agronomy*, *34*(4), 247-256. https://doi.org/10.1016/j.eja.2011.02.002

Martínez-Mesa, J., González-Chica, D. A., Duquia, R. P., Bonamigo, R. R., & Bastos, J. L. (2016). Sampling: how to select participants in my research study? *Anais Brasileiros de Dermatologia*, *91*, 326-330. https://doi.org/10.1590/abd1806-4841.20165254

Mavhura, E., Manyena, S. B., Collins, A. E., & Manatsa, D. (2013). Indigenous knowledge, coping strategies and resilience to floods in Muzarabani, Zimbabwe. *International Journal of Disaster Risk Reduction*, *5*, 38-48. https://doi.org/10.1016/j.ijdrr.2013.07.001

Mbanali, U., Chukwu, M., & Iwuagwu, M. (2018). Variation in the functional properties of blends of heat-treated local thickening seeds and cocoyam flour. *Research Journal of Food Science and Nutrition*. https://ssrn.com/abstract=3517541

McLafferty, I. (2004). Focus group interviews as a data collecting strategy. *Journal of Advanced Nursing*, *48*(2), 187-194. https://doi.org/10.1111/j.1365-2648.2004.03186.x

McLennan, M. R., Hyeroba, D., Asiimwe, C., Reynolds, V., & Wallis, J. (2012). Chimpanzees in mantraps: lethal crop protection and conservation in Uganda. *Fauna & Flora International, Oryx*, *46*(4), 598-603. https://doi.org/10.1017/S0030605312000592

Melifonwu, A. (1994). Weeds and their control in cassava. *African Crop Science Journal*, *2*(4), 519-530.

Mendelsohn, R. J. C. C. (2000). Efficient adaptation to climate change. *45*(3), 583-600.

Mercer, J., Kelman, I., Lloyd, K., & Suchet-Pearson, S. (2008). Reflections on use of participatory research for disaster risk reduction. *Area*, *40*(2), 172-183. https://doi.org/10.1111/j.1475-4762.2008.00797.x

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management*, *43*(5), 804-816. https://doi.org/10.1007/s00267-008-9197-0

Mignouna, D. B., Abdoulaye, T., Akinola, A. A., Alene, A., & Nweke, F. (2015). Factors influencing the use of selected inputs in yam production in Nigeria and Ghana. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, *116*(2), 131-142. http://nbn-resolving.de/urn:nbn:de:hebis:34-2015061048499

Mishra, L. (2016). Focus group discussion in qualitative research. *Techno Learn*, *6*(1), 1-5. https://doi.org/10.5958/2249-5223.2016.00001.2

Mistry, J., & Berardi, A. (2016). Bridging indigenous and scientific knowledge. *Science*, *352*(6291), 1274-1275. https://doi.org/10.1126/science.aaf1160

Mombo, S., Dumat, C., Shahid, M., & Schreck, E. (2017). A socio-scientific analysis of the environmental and health benefits as well as potential risks of cassava production and consumption. *Environmental Science and Pollution Research*, *24*(6), 5207-5221. https://doi.org/10.1007/s11356-016-8190-z

Montagnac, J. A., Davis, C. R., & Tanumihardjo, S. A. (2009). Nutritional value of cassava for use as a staple food and recent advances for improvement. *Comprehensive Reviews in Food Science and Food Safety*, *8*(3), 181-194. https://doi.org/10.1111/j.1541-4337.2009.00077.x

Morgan, G. A., & Harmon, R. J. (2001). Data collection techniques. *Journal-American Academy Of Child And Adolescent Psychiatry*, *40*(8), 973-976. https://doi.org/10.1097/00004583-200108000-00020

Morse, S. (2018). Analysis of yam minisett technique adoption in Nigeria. *Journal of Crop Improvement*, *32*(4), 511-531. https://doi.org/10.1080/15427528.2018.1458365

Mortimore, M. (2010). Adapting to drought in the Sahel: lessons for climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(1), 134-143. https://doi.org/10.1002/wcc.25

Muguti, T., & Maposa, R. S. (2012a). Indigenous weather forecasting: A phenomenological study engaging the Shona of Zimbabwe. *The Journal of Pan African Studies*, *4*(9), 102-112.

Mugwisi, T. (2017). Applying indigenous knowledge in agricultural extension: the case of Agritex workers in Zimbabwe. *Indilinga African Journal of Indigenous Knowledge Systems*, *16*(1), 160-177. https://doi.org/https://hdl.handle.net/10520/EJC-8fae7149b

Murray Li, T. (2000). Locating indigenous environmental knowledge in Indonesia. In A. Bicker, R. Ellen, & P. Parkes (Eds.), *Indigenous Enviromental Knowledge and its Transformations: Critical Anthropological Perspectives* (Vol. 120, pp. 121-149). Routledge. https://doi.org/https://doi.org/10.4324/9780203479568

Mutekwa, V. (2009). Climate change impacts and adaptation in the agricultural sector: The case of smallholder farmers in Zimbabwe. *Journal of Sustainable Development in Africa*, *11*(2), 237-256. https://www.researchgate.net/publication/254951714

Nakashima, D., McLean, K. G., Thulstrup, H. D., Castillo, A. R., & Rubis, J. T. (2012). Weathering uncertainty: traditional knowledge for climate change assessment and adaptation. In: United Nations Educational, Scientific and Cultural Organization.

Nanbol, K., & Namo, O. (2019). The Contribution of Root and Tuber Crops to Food Security: A Review. *Journal Of Agricultural Science And Technology B*, *9*(4). https://doi.org/10.17265/2161-6264/2019.04.001

Narayan, D., & Mundial, B. (1996). *Toward participatory research*. World Bank Washington, DC. https://doi.org/10.1596/0-8213-3473-5

Nawrotzki, R., & Kadatska, P. (2010). Addressing climate change with indigenous knowledge. *Int J Clim Chang Impacts Responses*, *2*(1), 33-48. https://doi.org/http://dx.doi.org/10.18848/1835-7156/CGP/v02i01/37290

Nayar, N. (2014). The contribution of tropical tuber crops towards food security. *Journal of Root Crops*, *40*(1), 3-14. https://doi.org/https://journal.isrc.in/index.php/jrc/article/view/225

Ndlovu, C., James, A., & Govender, N. (2020). Can IK and Western Science Be Complementary in an IK-SCIE Agricultural Curriculum? Theorising for an Appropriate Agricultural Curriculum. In K. G. Fomunyam & S. B. Khoza (Eds.), *Curriculum Theory, Curriculum Theorising, and the Theoriser* (pp. 106-130). Brill Sense. https://doi.org/https://doi.org/10.1163/9789004447943

Nedunchezhiyan, M., Ravindran, C., & Velumani, R. (2014). Weed management in root and tuber crops in India: Critical analysis. *Journal of Root Crops*, *39*(2), 13-20. https://journal.isrc.in/index.php/jrc/article/view/87

Neela, S., Fanta, S. W. J. F. s., & nutrition. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *7*(6), 1920-1945.

Neina, D. (2021). Ecological and Edaphic Drivers of Yam Production in West Africa. *Applied and Environmental Soil Science*, *2021*. https://doi.org/10.1155/2021/5019481

Neubauer, B. E., Witkop, C. T., & Varpio, L. (2019). How phenomenology can help us learn from the experiences of others. *Perspectives on Medical Education*, *8*(2), 90-97. https://doi.org/10.1007%2Fs40037-019-0509-2

Nkeme, K. K., Ekanem, J. T., & Nse, V. A. (2021). Capacity Building Needs of Small-Holder Cocoyam (Xanthosoma Sagittifoliuu) Farmers in Selected Rural Communities of Akwa Ibom State, Nigeria. *Journal of Agricultural Extension*, *25*(2), 32-42. https://doi.org/10.4314/jae.v25i2.3

Nkomwa, E. C., Joshua, M. K., Ngongondo, C., Monjerezi, M., & Chipungu, F. (2014). Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, Southern Malawi. *Physics and Chemistry of the Earth, Parts A/B/C*, *67*, 164-172. https://doi.org/https://doi.org/10.1016/j.pce.2013.10.002

Nkuba, M. R., Chanda, R., Mmopelwa, G., Adedoyin, A., Mangheni, M. N., Lesolle, D., & Kato, E. (2019). Do indigenous forecasts and scientific forecasts influence arable farmers' and agro-pastoralists' estimation of onset and cessation of rains? Empirical evidence from Rwenzori region, Western Uganda. *Agricultural and Forest Meteorology*, *278*, 107667. https://doi.org/https://doi.org/10.1016/j.agrformet.2019.107667

Novikov, A. M., & Novikov, D. A. (2019). *Research methodology: From philosophy of science to research design*. CRC Press.

Noyoo, N. (2007). Indigenous knowledge systems and their relevance for sustainable development: A case of Southern Africa. *Tribes and Tribals*, *1*, 167-172. https://doi.org/https://www.researchgate.net/publication/228799155_

Nwaiwu, I., Ohajianya, D., Orebiyi, J., Eze, C., & Ibekwe, U. (2013). Determinants of Agricultural Sustainability in Southeast Nigeria—The Climate Change Debacle. *Global Journal of Agricultural Research*, *1*(2), 1-13.

Nweke, F. I., Ugwu, B., Asadu, C. L. A., & Ay, P. (1991). Production costs in the yam-based cropping systems of southeastern Nigeria. *RCMP Research Monograph*(6). http://hdl.handle.net/10625/11174

Nyadzi, E., Werners, S. E., Biesbroek, R., & Ludwig, F. (2021). Techniques and skills of indigenous weather and seasonal climate forecast in Northern Ghana. *Climate and Development*, *13*(6), 551-562. https://doi.org/https://doi.org/10.1080/17565529.2020.1831429

Nyakaisiki, K., Mugume, I., Ngailo, T., & Nakabugo, R. (2019). The Use of Indigenous Knowledge in Predicting Changes in Seasonal Rainfall by Smallholder Farmers of Ruteete Subcounty, Kabarole District. *Journal of Geoscience and Environment Protection*, *7*(1), 13-22. https://doi.org/https://doi.org/10.4236/gep.2019.71002

Nyantakyi-Frimpong, H. (2013). Indigenous knowledge and climate adaptation policy in Northern Ghana. *Africa Portal, Backgrounder*, *48*. https://www.researchgate.net/publication/335840663

Nyikahadzoi, K., Adekunle, A., Fatunbi, O., & Zamasiya, B. (2017). Promoting production and marketing of root crops in Southern Africa in a changing climate using integrated Agricultural Research for Development (IAR4d) pathway. *African Journal of Food, Agriculture, Nutrition and Development*, *17*(1), 11787-11802. https://doi.org/10.18697/ajfand.77.13765

Nyong, A., Adesina, F., & Elasha, B. O. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and*

Adaptation Strategies for Global Change, *12*(5), 787-797. https://doi.org/DOI 10.1007/s11027-007-9099-0

Nyong, E., & Bassey, D. (2019). Analysis of adaptation of climate smart agricultural (CSA) practices of yam farmers in Akwa Ibom state, Nigeria. *Journal of Agriculture, Environmental Resource & Management*, *3*(1), 26-36.

Nyumba, T. O., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, *9*(1), 20-32. https://doi.org/10.1111/2041-210X.12860

Obayelu, O. A., Adepoju, A. O., & Idowu, T. (2014). Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. *Journal of Agriculture and Environment for International Development (JAEID)*, *108*(1), 3-16. https://doi.org/10.12895/jaeid.20141.140

Obermeister, N. (2017). From dichotomy to duality: Addressing interdisciplinary epistemological barriers to inclusive knowledge governance in global environmental assessments. *Environmental Science & Policy*, *68*, 80-86. https://doi.org/https://doi.org/10.1016/j.envsci.2016.11.010

Obidiegwu, J. E., & Akpabio, E. M. (2017). The geography of yam cultivation in southern Nigeria: Exploring its social meanings and cultural functions. *Journal of Ethnic Foods*, *4*(1), 28-35.

Obisesan, A. (2013). Credit accessibility and poverty among smallholder cassava farming households in South West, Nigeria. *Greener Journal of Agricultural Sciences*, *3*(2), 120-127. https://doi.org/10.15580/GJAS.2013.2.112712295

Odebode, S., Egeonu, N., & Akoroda, M. (2008). Promotion of sweet potato for the food industry in Nigeria. *Bulgarian Journal of Agricultural Science*, *14*(3), 300-308. https://www.researchgate.net/publication/267193944

Odjugo, P. (2008). The effect of tillage systems and mulching on soil microclimate, growth and yield of yellow yam (Dioscorea cayenensis) in Midwestern Nigeria. *African Journal of Biotechnology*, *7*(24). https://www.researchgate.net/publication/279651237

Odoemelam, L., & Ajuka, P. (2015). Indigenous farm management practices among rural farmers: Implications for sustainable environment in South-East Agro-Ecological Zone, Nigeria. *Discourse Journal of Agriculture and Food Sciences*, *3*(1), 7-14. http://www.resjournals.org/JAFS

Ofem, O. O., & Inyang, B. (2014). Livelihood and conflict dimension among crop farmers and fulani herdsmen in Yakurr region of Cross River State. *Mediterranean Journal of Social Sciences*, *5*(8), 512. https://doi.org/10.5901/mjss.2014.v5n8p512

Ogbeibu, A., & Uyigue, E. (2008). Climate Change and Poverty: Sustainable Approach in the Niger Delta Region of Nigeria.

Ogbo, A., Lauretta, N. E., & Ukpere, W. (2013). Risk management and challenges of climate change in Nigeria. *Journal of Human Ecology*, *41*(3), 221-235. https://doi.org/10.1080/09709274.2013.11906570

Ogen, O. (2006). Traditional farming and indigenous knowledge systems in Africa: perspective from the Ikale-yoruba experience. *Indilinga African Journal of Indigenous Knowledge Systems*, *5*(2), 157-166. https://doi.org/https://hdl.handle.net/10520/EJC61510

Oguamanam, C. (2016). *International Law and Indigenous Knowledge*. University of Toronto Press. https://doi.org/https://doi.org/10.3138/9781442676244

Ogunlade, I., Adesiji, G., Adebayo, S., Orisagbemi, S., & Aderinoye-Abdulwahab, S. (2010, 18-22 October 2010). Rice Farmers' Knowledge & Attitude to Climate Change in Kwara State, Nigeria. . Proceeding 44th Annual Conference of Agricultural Society of Nigeria LAUTECH.

Ogunniyi, L. (2008). Profit efficiency among cocoyam producers in Osun State, Nigeria. *International Journal of Agricultural Economics and Rural Development*, *1*(1), 38-46. https://www.researchgate.net/publication/299476190

Ojiako, I., Asumugha, G., Ezedinma, C., & Uzokwe, V. N. (2007). Analysis of production trends in the major root and tuber crops in Nigeria, 1961-2005. *Research on Crops*, *8*(2), 371-380. https://doi.org/https://hdl.handle.net/20.500.12478/1320

Ojokoh, A., & Gabriel, R. (2010). A comparative study on the storage of yam chips (gbodo) and yam flour (elubo). *African Journal of Biotechnology*, *9*(21), 3175-3177. https://www.researchgate.net/publication/316607072

Okeke, A. M., Tor, I. E., & Iheanacho, A. C. (2017). Determinants of Choice of Storage Systems for Root and Tuber Crops in Benue State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, *2*(6), 3039-3044. https://doi.org/10.3923/pjn.2008.365.376

Okeke, E., Eneobong, H., Uzuegbunam, A., Ozioko, A., & Kuhnlein, H. (2008). Igbo traditional food system: Documentation, uses and research needs. *Pakistan Journal of Nutrition*, *7*(2), 365-376.

Okigbo, B. (1989a). New crops for food and industry: the roots and tubers in tropical Africa. *New Crops for Food Industry. GE Weekens et al., Chapman and Wall, London*, 123-134.

Okigbo, B. (1989b). *New crops for food industry: The roots and tuber in tropical Africa*. Springer Science & Business Media.

Okonya, J. S., & Kroschel, J. (2013). Indigenous knowledge of seasonal weather forecasting: A case study in six regions of Uganda. *Agricultural Sciences*, *2013*. https://doi.org/10.4236/as.2013.412086

Okonya, J. S., Petsakos, A., Suarez, V., Nduwayezu, A., Kantungeko, D., Blomme, G., . . . Kroschel, J. (2019). Pesticide use practices in root, tuber, and banana crops by smallholder farmers in Rwanda and Burundi. *International Journal of Environmental Research and Public Health*, *16*(3), 400. https://doi.org/10.3390/ijerph16030400

Olagunju, F., Fakayode, S., Babatunde, R., & Ogunwole-Olapade, F. (2013). Gender analysis of sweet potato production in Osun State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, 1-13. https://doi.org/10.9734/AJAEES/2013/2194

Olaniyi, O., Olutimehin, I., & Funmilayo, O. (2019). Review of climate change and its effect on Nigeria ecosystem. *International Journal of Rural Development, Environment and Health Research*, *3*(3). http://www.eajournals.org/

Olasantan, F. (1999). Effect of time of mulching on soil temperature and moisture regime and emergence, growth and yield of white yam in western Nigeria. *Soil and Tillage Research*, *50*(3-4), 215-221. https://doi.org/10.1016/S0167-1987(98)00192-5

Olotu, P., Olotu, I., Kambasha, M. B., Ahmed, A., Ajima, U., Ohemu, T., . . . Ameh, E. (2017). Culture and traditional medicine practice among the Idoma people of Otukpo Local Government Area of Benue State, Nigeria. *International Research Journal of Pharmacy*, *8*(11), 33-39.

Olukoshi, A. (2006). African scholars and African studies. *Development in Practice*, *16*(6), 533-544. https://doi.org/10.1080/09614520600958116

Oluwaseyi, A. B. (2017). Plant genetic resources (PGR) in Nigeria and the reality of climate change-A review. *Asian Journal of Environment & Ecology*, 1-24. https://doi.org/10.9734/AJEE/2017/31855

Oluwasusi, J., & Tijani, S. (2013). Farmers adaptation strategies to the effect of climate variation on yam production: a case study in Ekiti state, Nigeria. *Agrosearch*, *13*(2), 20-31. https://doi.org/10.4314/agrosh.v13i2.3

Oluwatayo, I. B., & Ojo, A. O. (2016). Awareness and adaptation to climate change among yam-based farmers in rural Oyo state, Nigeria. *The Journal of Developing Areas*, 97-108. https://www.jstor.org/stable/24737382

Onayemi, O. (1986). Some chemical factors affecting the quality of processed yam. *Journal of Food Science*, *51*(1), 161-164. https://doi.org/10.1111/j.1365-2621.1986.tb10860.x

Oniang'o, R., Allotey, J., & Malaba, S. J. (2004). Contribution of indigenous knowledge and practices in food technology to the attainment of food security in Africa. *Journal of Food Science*, *69*(3), CRH87-CRH91. https://doi.org/https://ift.onlinelibrary.wiley.com/doi/epdf/10.1111/j.1365-2621.2004.tb13346.x

Onipede, K. (2017). Festival, identity and social integration: A study of the new yam festival in Otun-Ekiti, southwest Nigeria. *Fieldwork in Religion*, *12*(1), 78-102. https://doi.org/10.1558/firn.28640

Onwubuya, E., & Ajani, E. (2012). Strategies for improving production and processing of cocoyam among women farmers in Anambra State, Nigeria. *Universal Journal of Education and General Studies*, *1*(5). http://www.universalresearchjournals.org/ujegs

Onyenwoke, C. A., & Simonyan, K. J. (2014). Cassava post-harvest processing and storage in Nigeria: A review. *African Journal of Agricultural Research*, *9*(53), 3853-3863. https://doi.org/10.5897/AJAR2013.8261

Opara, L. U. (2003). Yams: Post Harvest Operation. *Massey University, Palmerston North, New Zealand (Edited by Mejia D, AGST/FAO) www. fao. org/inpho/content/compend/text/ch24. htm (last modified Aug. 2003)*.

Orb, A., Eisenhauer, L., & Wynaden, D. (2001). Ethics in qualitative research. *Journal of Nursing Scholarship*, *33*(1), 93-96. https://doi.org/10.1111/j.1547-5069.2001.00093.x

Osahon, E. E., & Ekwe, K. (2020). Utilization of Cocoyam Production Technologies Among Rural Households in South East, Nigeria. *JCCR| Journal of Community & Communication Research*, *5*(2), 122-129. https://sccdr.org.ng/jccr/index.php/jccr/article/view/67

Osunde, Z. (2008). Minimizing postharvest losses in yam (Dioscorea spp.): treatments and techniques. In G. L. Robertson & J. R. Lupien (Eds.), *Using food science and technology to improve nutrition and promote national development: selected case studies*. International Union of Food Science & Technology. https://www.researchgate.net/publication/259999490

Otegbayo, B. O., Asiedu, R., & Bokanga, M. (2012). Effects of storage on the chemical composition and food quality of yam. *Journal of Food Processing and Preservation*, *36*(5), 438-445. https://doi.org/10.1111/j.1745-4549.2011.00600.x

Owusu-Ansah, F. E., & Mji, G. (2013). African indigenous knowledge and research. *African Journal of Disability*, *2*(1), 1-5. https://doi.org/https://hdl.handle.net/10520/EJC131362

Owusu-Darko, P. G., Paterson, A., & Omenyo, E. L. (2014). Cocoyam (corms and cormels)—An underexploited food and feed resource. *Journal of Agricultural Chemistry and*

Environment, *3*(01), 22. http://www.scirp.org/journal/PaperInformation.aspx?PaperID=43369&#abstract

Oyekale, A., & Oladele, O. (2012). Determinants of climate change adaptation among cocoa farmers in southwest Nigeria. *ARPN Journal of Science and Technology*, *2*(1), 154-168. http://www.ejournalofscience.org/

Ozor, N., Madukwe, M., Enete, A., & Amaechina, E. (2012). A framework for agricultural adaptation to climate change in Southern Nigeria. *International Journal of Agriculture Sciences*, *4*(5), 243-252. http://www.bioinfo.in/journalcontent.php?vol_id=924&id=26&month=6&year=2012

Ozor, N., Madukwe, M., Enete, A., Amaechina, E., & Onokala, P. (2010). Barriers to climate change adaptation among farming households of Southern Nigeria. *Journal of Agricultural Extension*, *14*(1). https://doi.org/10.4314/jae.v14i1.64079

Ozor, N., & Nnaji, C. (2011). The role of extension in agricultural adaptation to climate change in Enugu State, Nigeria. *Journal of Agricultural Extension and Rural Development*, *3*(3), 42-50. https://doi.org/10.5897/JAERD.9000074

Page, P. (2008). Impact of climate change mitigation measures on indigenous peoples and on their territories and lands. R*enewable Energy*, *31*(40), 12.

Pain, R., & Francis, P. (2003). Reflections on participatory research. *Area*, *35*(1), 46-54. https://doi.org/10.1111/1475-4762.00109

Panda, S. K., & Ray, R. C. (2016). Fermented foods and beverages from tropical roots and tubers. In H. K. Sharma, N. Y. Njintang, R. S. Singhal, & P. Kaushal (Eds.), *Tropical Roots and Tubers: Production, Processing and Technology* (pp. 225-252). John Wiley & Sons, Ltd.

Parmar, A., Fikre, A., Sturm, B., & Hensel, O. (2018). Post-harvest management and associated food losses and by-products of cassava in southern Ethiopia. *Food Security*, *10*(2), 419-435.

Parry, M., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (2007a). *Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

Parry, M., Canziani, O., Palutikof, J., van der Linden, P. J., & Hanson, C. E. (2007b). *Climate change 2007: impacts, adaptation and vulnerability* (Vol. 4). Cambridge University Press Cambridge.

Petsakos, A., Prager, S. D., Gonzalez, C. E., Gama, A. C., Sulser, T. B., Gbegbelegbe, S., . . . Hareau, G. (2019). Understanding the consequences of changes in the production frontiers for roots, tubers and bananas. *Global Food Security*, *20*, 180-188. https://doi.org/10.1016/j.gfs.2018.12.005

Petty, N. J., Thomson, O. P., & Stew, G. (2012). Ready for a paradigm shift? Part 2: Introducing qualitative research methodologies and methods. *Manual therapy*, *17*(5), 378-384. https://doi.org/10.1016/j.math.2012.03.004

Poggenpoel, M., & Myburgh, C. (2003). The researcher as research instrument in educational research: A possible threat to trustworthiness?(A: research_instrument). *Education*, *124*(2), 418-423.

Polkinghorne, D. E. (2005). Language and meaning: Data collection in qualitative research. *Journal of Counseling Psychology*, *52*(2), 137. https://doi.org/10.1037/0022-0167.52.2.137

Poubom, C., Awah, E., Tchuanyo, M., & Tengoua, F. (2005). Farmers' perceptions of cassava pests and indigenous control methods in Cameroon. *International Journal of Pest Management*, *51*(2), 157-164. https://doi.org/10.1080/09670870500131863

Pradyawong, S., Juneja, A., Sadiq, M. B., Noomhorm, A., & Singh, V. (2018). Comparison of cassava starch with corn as a feedstock for bioethanol production. *Energies*, *11*(12), 3476. https://doi.org/10.3390/en11123476

Prusty, S. R., & Tripathy, S. (2015). Changing agro-climate: Tropical tubers and roots as a challenge for sustainable livelihood in India. *Journal of Experimental Agriculture International*, 118-123. https://doi.org/10.9734/AJEA/2015/10224

Raheem, D., & Chukwuma, C. (2001). Foods from cassava and their relevance to Nigeria and other African countries. *Agriculture and Human Values*, *18*(4), 383-390. https://doi.org/10.1023/A:1015233606665

Rahman, M. (1985). Theory and practice of participatory action research. In O. F. Borda (Ed.), *The Challenge of Social Change* (pp. 107-132). Sage.

Rankoana, S. A. (2017). The Use of Indigenous Knowledge in Subsistence Farming: Implications for Sustainable Agricultural Production in Dikgale Community in Limpopo Province, South Africa.

Ray, R. C., & Sivakumar, P. S. (2009). Traditional and novel fermented foods and beverages from tropical root and tuber crops. *International Journal of Food Science & Technology*, *44*(6), 1073-1087. https://doi.org/10.1111/j.1365-2621.2009.01933.x

Rhoades, R., & Bebbington, A. (1995). *Farmers who experiment: an untapped resource for agricultural research and development*. Intermediate Technology Publications Ltd (ITP).

Riggs, E. M. (2005). Field-based education and indigenous knowledge: Essential components of geoscience education for Native American communities. *Science Education*, *89*(2), 296-313. https://doi.org/10.1002/sce.20032

Rigney, L.-I. (1999). Internationalization of an Indigenous anticolonial cultural critique of research methodologies: A guide to Indigenist research methodology and its principles. *Wicazo sa Review*, *14*(2), 109-121. https://doi.org/10.2307/1409555

Roberts, L. D. (2015). Ethical issues in conducting qualitative research in online communities. *Qualitative Research in Psychology*, *12*(3), 314-325. https://doi.org/10.1080/14780887.2015.1008909

Rodney, W. (1973). *How Europe Underdeveloped Africa*. Tanzanian Publishing House.

Rowan, J. (2001). *The humanistic approach to action research*. Sage. (2006)

Roy, A. (2016). Who's afraid of postcolonial theory? *International Journal of Urban and Regional Research*, *40*(1), 200-209. https://doi.org/10.1111/1468-2427.12274

Rukundwa, L. S., & Van Aarde, A. G. (2007). The formation of postcolonial theory. *HTS Teologiese Studies/Theological Studies*, *63*(3), 1171-1194. https://doi.org/10.4102/hts.v63i3.237

Ryser, R. C. (2011a). Indigenous peoples and traditional knowledge. In *Berkshire encyclopedia of sustainability* (Vol. 5): Berkshire Publishing Company.

Said, E. W. (1979). *Orientalism*. Vintage.

Said, E. W. (1985). Orientalism reconsidered. *Cultural Critique*, *1 (Autumn, 1985)*(2), 89-107. https://doi.org/10.1177%2F030639688502700201

Samuel, T., Ogonna, O., & Samuel, E. (2018). Effects of climate change on yam production in Cross River State, Nigeria. *International Journal of Agriculture and Forestry*, *8*(2), 104-111. https://doi.org/10.5923/j.ijaf.20180802.09

Sanginga, N., & Mbabu, A. (2015). Root and tuber crops (Cassava, yam, potato and sweet potato). Proceedings of the An Action Plan for African Agricultural Transformation Conference, Dakar, Senegal,

Scarcelli, N., Tostain, S., Vigouroux, Y., Agbangla, C., Daïnou, O., & Pham, J. L. (2006). Farmers' use of wild relative and sexual reproduction in a vegetatively propagated crop. The case of yam in Benin. *Molecular ecology*, *15*(9), 2421-2431. https://doi.org/10.1111/j.1365-294X.2006.02958.x

Schiemann, G. (2014). One cognitive style among others: Towards a phenomenology of the lifeworld and of other experiences. In B. B. & G. D. (Eds.), *The Multidimensionality of Hermeneutic Phenomenology* (pp. 31-48). Springer. https://doi.org/10.1007/978-3-319-01707-5_3

Schipper, E. L. F. (2006). Conceptual history of adaptation in the UNFCCC process. *Review of European Community & International Environmental Law*, *15*(1), 82-92. https://doi.org/https://doi.org/10.1111/j.1467-9388.2006.00501.x

Scott, G. J., Rosegrant, M. W., & Ringler, C. (2000a). Global projections for root and tuber crops to the year 2020. *Food policy*, *25*(5), 561-597. https://doi.org/10.1016/S0306-9192(99)00087-1

Scott, G. J., Rosegrant, M. W., & Ringler, C. (2000b). *Roots and tubers for the 21st century: Trends, projections, and policy options* (Vol. 31). Intl Food Policy Res Inst.

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences*. Teachers college press.

Sekelemani, A., Mogomotsi, P. K., Stone, L. S., Mogomotsi, G. E., & Lekhane, O. (2020). Farmers' perceptions of climate change and their adaptation strategies: The case of Ngamiland East, Botswana. *Transactions of the Royal Society of South Africa*, *75*(2), 213-221. https://doi.org/10.1080/0035919X.2020.1748749

Semali, L. M., & Asino, T. I. (2013). Decolonizing cultural heritage of Indigenous people and their knowledge from images in global films. *Decolonization: Indigeneity, Education & Society*, *2*(2).

Semali, L. M., & Kincheloe, J. L. (2002). *What is indigenous knowledge?: Voices from the academy*. Routledge.

Senanayake, S. (2006). Indigenous knowledge as a key to sustainable development. *The Journal of Agricultural Sciences- Sri Lanka*, *2*(1), 87-94. http://repo.lib.sab.ac.lk:8080/xmlui/handle/123456789/812

Sesay, L., Norman, P., Massaquoi, A., Kobba, F., Allieu, A., Gboku, M., & Fomba, S. (2013). Assessment of farmers' indigenous knowledge and selection criteria of yam in Sierra Leone. *Sky Journal of Agricultural Research*, *2*(1), 1-6. http://www.skyjournals.org/SJAR

Shao, W.-y. (2010). Critical rainfall intensity for safe evacuation from underground spaces with flood prevention measures. *Journal of Zhejiang University-Science A*, *11*(9), 668-676. https://doi.org/10.1631/jzus.A1000137

Sharma, H. K., & Kaushal, P. (2016). Introduction to tropical roots and tubers. In H. K. Sharma, N. Y. Njintang, R. S. Singhal, & P. Kaushal (Eds.), *Tropical Roots and Tubers-production, Processing and Technology.* (pp. 1-33). John Wiley & Sons Ltd.

Shrestha, R. P., Raut, N., Swe, L. M. M., & Tieng, T. (2018). Climate change adaptation strategies in agriculture: Cases from southeast Asia. *Sustainable Agriculture Research, 7*(526-2020-482), 39-51. https://doi.org/10.22004/ag.econ.301826

Sillitoe, P. (2006). Indigenous knowledge in development. *Anthropology in Action*, *13*(3), 1-12. https://doi.org/10.3167/aia.2006.130302
Smit, B., & Pilifosova, O. (2003a). Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development*, *8*(9), 9.
Smit, B., & Pilifosova, O. (2003b). From adaptation to adaptive capacity and vulnerability reduction. In *Climate Change, Adaptive Capacity and Development* (pp. 9-28). World Scientific.
Smith, D. M., & Jarvis, P. G. (1998). Physiological and environmental control of transpiration by trees in windbreaks. *Forest Ecology and Management*, *105*(1-3), 159-173. https://doi.org/10.1016/S0378-1127(97)00292-2
Smith, J. B., Schneider, S. H., Oppenheimer, M., Yohe, G. W., Hare, W., Mastrandrea, M. D., . . . Magadza, C. H. (2009). Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC)"reasons for concern". *Proceedings of the National Academy of Sciences*, *106*(11), 4133-4137. https://doi.org/10.1073/pnas.0812355106
Songok, C. K., Kipkorir, E. C., & Mugalavai, E. M. (2011). Integration of indigenous knowledge systems into climate change adaptation and enhancing food security in Nandi and Keiyo districts, Kenya. In *Experiences of Climate Change Adaptation in Africa* (pp. 69-95). Springer. https://doi.org/10.1007/978-3-642-22315-0_5
Sparke, M. (2007). Everywhere but always somewhere: Critical geographies of the Global South. *The Global South*, *1*(1), 117-126. https://doi.org/https://muse.jhu.edu/article/398234
Speranza, C. I., Kiteme, B., Ambenje, P., Wiesmann, U., & Makali, S. (2010). Indigenous knowledge related to climate variability and change: insights from droughts in semi-arid areas of former Makueni District, Kenya. *Climatic Change*, *100*(2), 295-315. https://doi.org/https://doi.org/10.1007/s10584-009-9713-0
Spivak, G. C. (1988). Can the subaltern speak? *Can the subaltern speak? Reflections on the history of an idea*, 21-78.
Stalmeijer, R. E., McNaughton, N., & Van Mook, W. N. (2014). Using focus groups in medical education research: AMEE Guide No. 91. *Medical Teacher*, *36*(11), 923-939. https://doi.org/10.3109/0142159X.2014.917165
Stern, N. (2008). The economics of climate change. *American Economic Review*, *98*(2), 1-37. https://doi.org/10.1257/aer.98.2.1
Taiwo, K. A. (2006). Utilization potentials of cassava in Nigeria: The domestic and industrial products. *Food Reviews International*, *22*(1), 29-42. https://doi.org/10.1080/87559120500379787
Talwana, H. A. L., Serem, A. K., Ndabikunze, B. K., Nandi, J. O. M., Tumuhimbise, R., Kaweesi, T., . . . Palapala, V. A. (2009). Production Status and Prospects of Cocoyam (Colocasia esculenta L. Schott.) in East Africa. *Journal of Root Crops*, *35*(1), 98-107. http://erepo.usiu.ac.ke/11732/4502
Tanyanyiwa, V. I., & Chikwanha, M. (2011). The role of indigenous knowledge systems in the management of forest resources in Mugabe area, Masvingo, Zimbabwe. *Journal of Sustainable Development in Africa*, *13*(3), 132-149. https://www.researchgate.net/publication/331167806
Tauli-Corpuz, V., & Lynge, A. (2008). Impact of climate change mitigation measures on indigenous peoples and on their territories and lands. *Economic and Social Council, Working paper E/C*, *19*(2008), 10.

Taylor-Powell, E., & Steele, S. (1996). Collecting evaluation data: Direct observation. *Program Development and Evaluation. Wiscounsin: University of Wisconsin-Extension*, 1-7. http://learningstore.uwex.edu/assets/pdfs/G3658-5.PDF

Taylor, G. A. J., & Blake, B. J. (2015). Key informant interviews and focus groups. In M. d. Chesnay (Ed.), *Nursing Research using Data Analysis, Qualitative Designs and Methods in Nursing* (pp. 153-165). Springer Publishing Company, LLC.

Teherani, A., Martimianakis, T., Stenfors-Hayes, T., Wadhwa, A., & Varpio, L. (2015). Choosing a qualitative research approach. *Journal of Graduate Medical Education*, *7*(4), 669. https://doi.org/10.4300/JGME-D-15-00414.1

Tella, R. D. (2007). Towards promotion and dissemination of indigenous knowledge: a case of NIRD. *The International Information & Library Review*, *39*(3-4), 185-193. https://doi.org/10.1016/j.iilr.2007.06.002

Terry, E. R., Doku, E., Arene, O., & Mahungu, N. (1984). *Tropical root crops: production and uses in Africa: proceedings of the Second Triennial Symposium of the International Society for Tropical Root Crops-Africa Branch held in Douala, Cameroon, 14-19 Aug. 1983*. IDRC, Ottawa, ON, CA.

Tewe, O., Ojeniyi, F., & Abu, O. (2003). *Sweet Potato Production, Utilisation and Marketing in Nigeria*.

Tikai, P., & Kama, A. (2010). A study of indigenous knowledge and its role to sustainable agriculture in Samoa. *Ozean journal of social sciences*, *3*(1), 65-79.

Tompkins, E. L., Adger, W. N., Boyd, E., Nicholson-Cole, S., Weatherhead, K., & Arnell, N. (2010). Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change*, *20*(4), 627-635.

Tor, I., Iheanacho, A., & Okeke, A. (2017). Analysis of Socio–economic Challenges of Using Local Storage Systems for Root and Tuber Crops in Benue State, Nigeria. *International Journal of Innovative Agriculture & Biology Research*, *5*(4), 30-37. https://doi.org/10.22161/ijeab/2.6.33

Tume, S. J. P., Kimengsi, J. N., & Fogwe, Z. N. (2019). Indigenous knowledge and farmer perceptions of climate and ecological changes in the bamenda highlands of Cameroon: insights from the Bui Plateau. *Climate*, *7*(12), 138. https://doi.org/10.3390/cli7120138

Tunde, A., & Ajadi, B. (2019). Indigenous understanding of climatechange, impacts and coping strategies in a rural setting of Kwara state, Nigeria. *GEOGRAPHY, ENVIRONMENT, SUSTAINABILITY*, *11*(4), 85-99.

Uarrota, V. G., de Bairros, A. d. F. M., Gindri, D., Leolato, L. S., de Andrade, G. C., Nerling, D., Stefen, D., Arijama, M., Razão, E. H. & Rocha, M. (2019). From neglected and underutilized crops to powerful sources of vitamin A: three case studies of Mozambican cultivated Tacca leontopetaloides, Cowpea, and Cassava. In *Vitamin A*. IntechOpen.

Ubalua, A. O., Ewa, F., & Okeagu, O. D. (2016). Potentials and challenges of sustainable taro (Colocasia esculenta) production in Nigeria. *Journal of Applied Biology and Biotechnology Vol*, *4*(01), 053-059. https://doi.org/10.7324/JABB.2016.40110

Uchechukwu-Agua, A. D., Caleb, O. J., & Opara, U. L. (2015). Postharvest handling and storage of fresh cassava root and products: a review. *Food and Bioprocess Technology*, *8*(4), 729-748. https://doi.org/10.1007/s11947-015-1478-z

Ukamaka, D. M., Danjuma, S. E., Mbolle, C. J., Achonam, E. I., & Mbadiwe, I. E. (2017). Livelihood issues in herdsmen-farmers conflict among farming communities in Kogi State, Nigeria. *African Journal of Agricultural Research*, *12*(24), 2105-2115. https://doi.org/10.5897/AJAR2017.12319

UNFCCC, C. (1992). United Nations framework convention on climate change. In: United Nations New York.

Unya, I. U. (2021). The transformation and significance of the new yam festival in contemporary Igbo society of Nigeria. *Uzu Journal*, *8*(3).

Uyigue, E., & Ogbeibu, A. E. (2007). Climate change and poverty: sustainable approach in the Niger Delta region of Nigeria. 2007 Amsterdam Conference on the Human Dimensions of Global Environmental Change, May,

Valenzuela, H. R., & DeFrank, J. (1995). Agroecology of tropical underground crops for small-scale agriculture. *Critical Reviews in Plant Sciences*, *14*(3), 213-238. https://doi.org/10.1080/07352689509701927

Verter, N., & Bečvářová, V. (2015). An analysis of yam production in Nigeria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *63*(2), 659-665. https://doi.org/10.11118/actaun201563020659

Wada, E., Asfaw, Z., Feyissa, T., & Tesfaye, K. (2017). Farmers perception of agromorphological traits and uses of cocoyam (Xanthosoma sagittifolium (L.) Schott) grown in Ethiopia. *African Journal of Agricultural Research*, *12*(35), 2681-2691. https://doi.org/10.5897/AJAR2017.12465

Wagai, J. N., Rhoda, D., Prier, M., Trimmer, M. K., Clary, C. B., Oteri, J., . . . Cutts, F. (2021). Implementing WHO guidance on conducting and analysing vaccination coverage cluster surveys: Two examples from Nigeria. *PLoS One*, *16*(2), e0247415. https://doi.org/10.1371/journal.pone.0247415

Wahab, B., & Ojolowo, S. (2012). Application of indigenous knowledge to flood prevention and management. *African Journal of Sustainable Development*, *2*(1), 79-116. http://ir.library.ui.edu.ng/handle/123456789/1189

Wallerstein, N., & Duran, B. (2017). *The theoretical, historical, and practice roots of CBPR*. John Wiley & Sons.

Warren, D. M., & Cashman, K. (1988). *Indigenous knowledge for sustainable agriculture and rural development* (Vol. 10). International Institute for Environment and Development.

Warren, D. M., Slikkerveer, L. J., & Brokensha, D. (1995). *The cultural dimension of development; indigenous knowledge systems*.

Weerarathne, L., Marambe, B., & Chauhan, B. S. (2017). Intercropping as an effective component of integrated weed management in tropical root and tuber crops: A review. *Crop Protection*, *95*, 89-100. https://doi.org/10.1016/j.cropro.2016.08.010

Wiggins, S., & Wiggins, T. (2006). Climate change and environment degradation: Risk and adaptation assessment. *Teddington, UK tear fund*.

Williams, C. (2007). Research methods. *Journal of Business & Economics Research (JBER)*, *5*(3). https://doi.org/10.19030/jber.v5i3.2532

Wilson, S. (2001). What is an indigenous research methodology? *CanadianJjournal of Native Education*, *25*(2), 175-179.

Wong, L. P. (2008). Focus group discussion: a tool for health and medical research. *Singapore Med J*, *49*(3), 256-260.

Wright, S., Lloyd, K., Suchet-Pearson, S., Burarrwanga, L., Tofa, M., & Country, B. (2012). Telling stories in, through and with Country: engaging with Indigenous and more-than-human methodologies at Bawaka, NE Australia. *Journal of Cultural Geography*, *29*(1), 39-60. https://doi.org/10.1080/08873631.2012.646890

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education*, *29*(1), 145-185. https://doi.org/10.1007/s11191-019-00100-x

Zięba, Z., Dąbrowska, J., Marschalko, M., Pinto, J., Mrówczyńska, M., Leśniak, A., Petrovski, A. & Kazak, J. K. (2020, 7-11 September). Built environment challenges due to climate change.*IOP Conference Series: Earth and Environmental Science* 6th World Multidisciplinary Earth Sciences Symposium, Prague, Czech Republic.

APPENDIX A Ethical Clearance Certificate

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

27 September 2018

Mrs Bolanle Susan Olaniyan (218086689)
School of Education
Edgewood Campus

Dear Mrs Olaniyan,

Protocol reference number: HSS/1316/018M
Project title: Nigerian root-tuber farmers' indigenous experiences and responses regarding Climate Change

Approval Notification – Expedited Application

In response to your application received 21 August 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

Dr Rosemary Sibanda (Deputy Chair)

/ms

Cc Supervisor: Professor Nadaraj Govender
Cc Academic Leader Research: Dr SB Khoza
Cc School Administrator: Ms Sheryl Jeenarain

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
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Website:

1910 - 2010
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Founding Campuses: Edgewood · Howard College · Medical School · Pietermaritzburg · Westville

APPENDIX B Change of Title

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

19 October 2018

Ms Bolanle S Olaniyan 218086689
School of Education
Pietermaritzburg Campus

Dear Ms Olaniyan

Reference number: HSS/1316/018M

Full approval - Change in project title

I wish to confirm that your application in connection with the above has now been granted full approval.

- **Change in project title** Nigerian root-tuber farmers' indigenous experiences and responses regarding Climate Change.
- **New project title:** Nigerian Root Tuber Farmers' Responses to Climate Change: The role of Indigenous Knowledge.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach/Methods must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. Please note: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

Best wishes for the successful completion of your research protocol.

Yours faithfully

[redacted]......................

Dr S Naidoo (Deputy Chair)

/px

cc Supervisor: Prof Nadaraj Govender
cc Academic Leader Research: Dr SB Khoza
cc School Administrator: Ms S Jeenarain, Ms M Ngcobo and Mr S Mthembu

Humanities & Social Sciences Research Ethics Committee
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Website: www.ukzn.ac.za

1910 - 2010
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APPENDIX C GATEKEEPER PERMISSION LETTER TO THE DIRECTOR
13 August 2018

Attention: The Director Extension Services, Kwara Agricultural Development Programme

Dear Sir,

I, Mrs. Bolanle Susan Olaniyan, am a student in the School of Education at the University of KwaZulu-Natal (Edgewood Campus). As part of my PhD thesis, I am conducting research on the responses of root-tuber farmers to Climate Change utilizing IKS. Therefore, I kindly seek your participation. The title of my research is:

Nigerian root and tuber farmers' responses to climate change: The role of Indigenous Knowledge

This study to examine the role indigenous knowledge plays in root-tuber farmers' response to climate change in Nigeria.

PLEASE TAKE NOTE THAT:

- All participants' responses will be treated with strict confidentiality.
- Fictitious names will be used to represent their name and the name of your institution.
- Participant and institutional identities will not be divulged under any circumstance/s, during and after the reporting process.
- There will be no financial benefits that participants may accrue as a result of their participation in this research project.
- Participation is voluntary; therefore, they are free to withdraw at any time without incurring any negative or undesirable consequences/penalty on your part.
- All information will be used for scholarly purposes only.

For further information on this research project, please feel free to contact me using the following contact details: Bolanle Olaniyan; Cell: +27655398066, +2347061572639; Email: b.solaniyan@gmail.com, or my supervisor: Prof. Nadaraj Govender; Cell: 074 373 3259; Email: Govendern37@ukzn.ac.za.

Your positive response in this regard will be highly appreciated.

Thanking you in advance

Yours sincerely

[redacted]

Bolanle Susan Olaniyan

APPENDIX D Informed Consent of Gatekeeper

Informed Consent

Declaration

I Adu Joseph Olorunsola (full names) the Director of Extension Services, Kwara Agricultural Development Programme hereby confirm that I understand the contents of this document and the nature of this research project and

I consent / do not consent to members of staff and farmers' participation in the study.

I understand that

- participation is voluntary
- that there is no remuneration for participation
- that the interview will be audio-taped with participants' permission
- and they are at liberty to withdraw from the project at any time, should they so desire.

SIGNATURE: DATE: 13/8/2018 [redacted]

APPENDIX E Informed Consent Form

13 August 2018

Dear Participant

I, Mrs Bolanle Susan Olaniyan, am a student in the School of Education at the University of KwaZulu-Natal (Edgewood Campus). As part of my PhD thesis, I am conducting research on the experiences and of root-tuber farmers to Climate Change utilising IKS. Therefore, I kindly seek your participation. The title of my research is:

"Nigerian root and tuber farmers' responses to climate change: The role of Indigenous Knowledge"

This study is to examine the role indigenous knowledge plays in root-tuber farmers' response to climate change in Nigeria.

PLEASE TAKE NOTE THAT:

- All your responses will be treated with strict confidentiality.
- Fictitious names will be used to represent your name and the name of your institution.
- Your identity will not be divulged under any circumstance/s, during and after the reporting process.
- There will be no financial benefits that participants may accrue as a result of their participation in this research project.
- Participation is voluntary; therefore, you are free to withdraw at any time you wish without incurring any negative or undesirable consequences/penalty on your part.
- All information will be used for scholarly purposes only
- With your permission the interview will be audio recorded.

	Willing	Not willing
Audio equipment		

For further information on this research project, please feel free to contact me using the following contact details: Bolanle Olaniyan; Cell: 07061572639; Email: b.solaniyan@gmail.com, or my supervisor: Prof. Nadaraj Govender; Cell: 074 373 3259; Email: Govendern37@ukzn.ac.za.

You may also contact the Research Office through: P. Mohun HSSREC Research Office, Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za. Thank you for your contribution to this research.

Your positive response in this regard will be highly appreciated.

Thanking you in advance

Yours sincerely

[redacted]

Bolanle Susan Olaniyan

APPENDIX F Sample of Participant’s Informed Consent

Consent Document

Dear Mrs OLANIYAN,

I, MUSA MUJIDAT FOLASHADE hereby consent / do not consent to participate in the study entitled:

“Nigerian root and tuber farmers’ responses to climate change: The role of Indigenous Knowledge”

I agree / do not agree to be interviewed

I agree / do not agree for the interview to be audio-taped

I understand that confidentiality will be maintained and that I have the right to withdraw from the study at any stage.

SIGNATURE: [redacted] DATE: 30/06/2019

Consent Document

Dear Mrs OLANIYAN,

I, Saka Ajadi, hereby consent / do not consent to participate in the study entitled:

“Nigerian root and tuber farmers’ responses to climate change: The role of Indigenous Knowledge”

I agree / do not agree to be interviewed

I agree / do not agree for the interview to be audio-taped

I understand that confidentiality will be maintained and that I have the right to withdraw from the study at any stage.

SIGNATURE [redacted] DATE: 12/07/2019

APPENDIX G Iwe ifowosi pelu alaye

Ọjọ Kẹtala Oṣù Kẹsan Ọdun 2018

Olufẹ Olukopa,

Èmi, Iyaafin Bolanle Susan Olaniyan, akeeko ni Ile-ẹkọ giga ti KwaZulu-Natal (Edgewood Campus). Gẹgẹbi apakan ti iwe-ẹkọ lati di Omowe mi, mo n ṣe iwadi lori awọn esi ti awọn agbe-root-tuber si Iyipada Afefe lilo imoye ibile wa. Nitorina, mo ṣafẹri ikopa yin. Akọle iwadi mi ni:

"Awọn idahun ti awọn agbe-root-tuber ti orile-ede Naijiria si iyipada ojo: Ipa ti Imọyẹ Ibilẹ"

Iwadii yii ni lati ṣayẹwo iru ipa ti awọn imọ abinibi ti o wa ninu awọn esi agbe-root-tuber si iyipada ojo ni orile-ede Naijiria.

Ejo e ṣe akiyesi pe

- Gbogbo awọn idahun rẹ yoo ni itọju pẹlu iṣeduro asiri.
- Orukọ inagije ni a o lo lati fi se akawe orukọ rẹ ati ti ile-iṣẹ rẹ
- A ko ni sọ idanimọ rẹ labẹ bo ti wu kori nigba ati lẹhin ilana iwadi yi.
- Ko si anfani ti owo ti awọn olukopa le ni nipase kikopa wọn ninu iṣẹ iwadi yi.
- Ikopa jẹ atinuwa; Nitorina, o ni ominira lati kuro nigbakugba ti o ba fẹ laisi ipalara eyikeyi odi tabi awọn ipalara ti ko yẹ tabi ijiya kankan.
- Gbogbo alaye ti e ba se ni a o lo fun iwadi ni Kankan soso
- Pẹlu igbanilaaye rẹ ijomitoro yoo jẹ igbasilẹ ohun

	Mo Gba	Mi o Gba
Ero igbohunsile		

Fun alaye siwaju sii lori iṣẹ iwadi yii, jọwọ kan si mi nipa lilo awọn alaye olubasọrọ wọnyi: Bolanle Olaniyan; ero ibanisoro: 07061572639: imeeli: b.solaniyan@gmail.com, tabi ke kan si Alabojuto mi: Ojogbon Nadaraj Govender lori ero ibanisoro: 074 373 3259: imeeli: Govendern37@ukzn.ac.za.

E tun le kan si Offisi Iwadi nipasẹ: P. Mohun HSSREC Research Office, ero ibanisoro: 031 2604557 imeeli: mohunp@ukzn.ac.za. E ṣeun fun lilowosi iwadi yii.

Mo dupe lopolopo fun idahun rere rẹ lori iwadi yi

E seun lopolopo

Emi ni ti yin nitoto

[redacted]

Bolanle Susan Olaniyan

APPENDIX H Guiding questions for focus group discussions

(This will be used only for farmers aged 40 and above who have stayed in the village for at least 30 years)

1 What kind of changes have you observed in the weather in recent years in your village?

2 How does the community explain those changes?

3 Please can you explain the causes of these observed changes?

4 What are the main disasters caused by these changes in the past 30 years in this village?

5 Please explain indigenous adaptation practices used by local communities to withstand drought condition, reduced rainfall, strong winds,

6 Please explain strategies used by local communities to control pests and diseases caused by climate change to crop.

7 Please explain indigenous knowledge practices on water resources management.

8 Do you think indigenous knowledge practices are helpful to adapt to climate change? If yes, how?

9 Do you think it is relevant to integrate indigenous knowledge with western knowledge to adapt to climate change? If yes, why?

10 Do you think it is relevant to integrate indigenous knowledge with existing government policies and programs to adapt to climate change? If yes, why?

11 What are the underlying challenges of using indigenous knowledge practices on climate change adaptation?

12 How can these challenges can be solved?

13 What are your suggestions on how to promote indigenous knowledge for effective climate change adaptation at local level?

APPENDIX I Semi-structured Interview Schedule

Sample Questions. (This will be asked in the indigenous languages: Yoruba, Baruba and Nupe)

Socio-economic characteristics

1. Age:
2. Educational Status: (a) No formal education (b) Adult education
   (c)Primary education (d) Secondary education
   (e)Others specify…………………………………………
3. Years of Farming:
4. Who taught you how to farm:
5. Are you originally from this village? (a) Yes (b) No
6. How long have you stayed here?
7. Access to Extension services:
8. Farm Size:
9. Root-tuber crops produced:

Type of crop	Tick
Yam	
Cassava	
Sweet Potato	
Potato	
Cocoyam	

10. Yield:

Type of crop	Yield in bags
Yam	
Cassava	
Sweet Potato	
Potato	
Cocoyam	

11. Is this the regular yield or there has been a change?
12. If no, why the change?
13. Access to media? (a) Yes (b) No
14. If yes, what type of media does your household have access to?

Research Question 1 Farmers' Experiences of Climate Change

1. How do you determine when to start planting?
2. Are there times you misread the weather?
3. What happened?
4. Are you aware of any change in the weather or season over the years?
5. What changes have you noticed?

6. What are the local markers/indicators that made you aware of the change?
7. Can you share your experiences about the changing weather (positive and negative)?
8. What happened to your crops during the time of little or no rainfall?

Research Question 2 IKS in Root-tuber production

1. What are the land preparation practices you do before planting?
2. How do you know which land is good to plant on?
3. How do you select the seeds to use?
4. What are the practices engaged in after planting?
5. How do you keep pest, animals and thieves away from your farm?
6. How do you know the crops are doing well since they are in the ground?
7. How do you know when to harvest?
8. What are those things you do during harvesting?

Research Question 3 Responses to Climate Change using IKS

1. How did you manage your crops during periods when the rains came earlier than usual?
2. How did you cope with late onset of rain or too much rain?
3. What measures did you take to save your crops during drought?
4. Did you get any support from the extension officer?
5. What informed these responses?

Question 4 Outcomes of responses to Climate Change

1. Where these responses to Climate Change helpful? How?
2. In what way(s) did the responses to Climate Change improve the farming process?
3. In what ways did they affect the farming process negatively? How?
4. What positive effect did your response to Climate Change have on your produce?
5. What negative effect did your response to Climate Change have on your produce?

APPENDIX J Participants Observation Guide

1. Farming system (mono cropping/intercropping)
2. Location of farm.
3. Types of crops grown
4. Farming implements and methods used
5. Weather patterns and coping strategies
6. Land preparation
7. Post planting activities
8. Harvesting
9. Storage
10. Knowledge applied per stage

APPENDIX K Weather Report

Year	Rainfall (MM)	Raining Days	Temperature (^{0}C) MAX	Temperature (^{0}C) MIN	Average Relative Humidity (%)
1991	N.A	N.A	31.70	22.70	-
1992	108.50	71	34.00	25.00	-
1993	1138.12	74	33.60	22.40	-
1994	1085.02	70	34.05	21.75	-
1995	1211.78	76	33.44	24.58	-
1996	N.A	N.A	32.70	26.20	-
1997	1704.18	85	32.86	24.25	-
1998	1104.50	72	35.61	21.30	-
1999	1292.30	80	34.82	21.89	-
2000	946.70	56	37.93	22.08	76.0
2001	907.60	57	40.06	19.79	76.0
2002	1028.50	66	36.40	20.30	77.0
2003	811.75	50	31.17	17.50	83.0
2004	1597.40	56	33.33	20.15	82.0
2005	1144.50	55	35.90	23.90	82.5
2006	1236.99	78	36.47	22.79	81.4
2007	1481.63	78	36.47	22.79	81.4

Year	Rainfall (MM)	Raining Days	Temperature (^{0}C) MAX	Temperature (^{0}C) MIN	Average Relative Humidity (%)
2008	1381.90	60	36.00	22.00	84.0
2009	1526.57	72	38.00	23.40	87.1
2010	1165.70	62	36.00	23.30	87.4
2011	1252.80	59	36.00	23.00	84.0
2012	1617.8	60	32.40	23.70	81.0
2013	900.00	54	35.50	22.80	85.9
2014	1016.00	55	37.70	21.40	92.6
2015	806.60	47	37.30	22.50	89.6
2016	1747.20	83	35.80	21.03	88.2

2017	1504.80	55	39.80	21.80	89.9
2018	1283.70	88	34.40	21.20	88.2

Source: PME Department. Kwara Agricultural Development Project Weather Survey (1991-2018)

APPENDIX L Editing certificate

Sheelagh Halstead
BSc (Natal) HED (UNISA) MSc (UKZN)

Independent Education Consultant

13 Denbigh Road
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South Africa, 2193

EDITING CERTIFICATE

Student's Name: Bolanle Susan Olaniyan

Student's Affiliation: School of Education, Science and Technology Education Cluster, University of KwaZulu-Natal

Thesis Title: Nigerian Root and Tuber Farmers' Responses to Climate Change: The role of Indigenous Knowledge

I confirm that for this draft thesis I have edited the preliminary pages and Chapters 1 to 8, but not the references nor the appendices. I have corrected grammatical errors and rearranged sentences for greater clarity or to shorted them. Where the meaning of the original writing was ambiguous, I offered some suggestions according to the possible meanings. I made a few suggestions concerning moving text around to make the academic argument clearer. I left the student to institute the suggested changes in consultation with her supervisor.

I did not consider the accuracy of intext citations, but, with few exceptions, they appeared to be formatted in accordance with academic conventions.

As an independent educational consultant, one of my specialisations is editing academic documents. I am a native English speaker. I was awarded a BSc at the University of Natal, with chemistry and applied mathematics majors. After graduation, I was a Research Officer in the Ministry of Roads and Road Traffic in, as was then, Rhodesia. My duties included writing reports and editing those by colleagues. Some years later I entered the teaching profession and studied with UNISA for my postgraduate Higher Education Diploma, achieving a distinction for the English language module. After 20 years of high school teaching, I took up an academic position at the University of KwaZulu-Natal, where I completed an MSc in chemistry education and wrote several research articles. Since retirement, I have edited numerous academic papers and over 20 theses or dissertations in science education or the pure sciences. Several of the dissertations were judged to be *cum laude*, or required no alterations from the examiners

Sheelagh Edith Halstead. [redacted] 7th February 2022

APPENDIX M TURNITIN REPORT