

## **CLIMATE-INDUCED CROP LOSSES: LESSONS FROM YAM TRADERS AND FARMERS' ADAPTIVE CAPACITIES AND BARRIERS**

<sup>1,2\*</sup>Razaq Abolaji Olaitan, <sup>1,3</sup>Isaac Ayo Oluwatimilehin, and <sup>1,4</sup>Ayansina Ayanlade

<sup>1</sup>Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria

<sup>2</sup>Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria

<sup>3</sup>Department of Geography, University of Kentucky, 817 Patterson Office Tower, Lexington, KY, 40508, USA

<sup>4</sup>Central European University, Vienna, Austria

\*Correspondence author email: olaitan.ra@unilorin.edu.ng

### **Abstract**

*Climate change poses significant threats to agricultural systems in Africa and this necessitates the need for comprehensive understanding of adaptation dynamics across various actors in the value chain. The study investigates the impact of temperature and rainfall on yam tuber losses in Kwara State, Nigeria, and evaluates the perceptions, adaptive capacities, and barriers faced by yam traders. A descriptive research method was used in the study as long-term (1982-2023) temperature and rainfall data of Kwara State was obtained through the National Aeronautic and Safety Administration archives. Semi-structured questionnaires, key informant interviews, and focus group discussions were administered to yam traders and farmers in the study area to investigate the yam traders' perception of climate and evaluate the adaptive capacity of yam traders towards climate change in the study area. Results indicate that 1987 and 2002 were among the hottest years on record, each with an annual maximum temperature of 32.03°C, while the coolest year was 2011 with an annual maximum temperature of 29.97°C. The result also revealed that the majority of yam traders believed that climate change is real and despite acknowledging climate change's impact on yam tuber losses, there was no consensus on its extent, with traders estimating it to be between 20% and 30%. The results also reveal a negative correlation between climate variability and yam preservation, and suggest limited use of adaptive technologies among yam traders. Furthermore, the study observes that climate change negatively affects yam, leading to all kinds of losses. The study, therefore, recommends that the injection of more sociocultural, financial, and physical capital should be considered to prevent future losses, as traditional technology is a promising adaptation for traders. The study concludes that climate change impacts negatively on yam losses but traditional technology is a promising adaptation practiced by a certain group of yam tubers traders in the study area. There is a need to factor sociocultural, financial and physical capital to prevent loss and waste of yam tubers in the nearest future.*

**Keywords:** Climate Change, Adaptation, Climate loss, Yam production, Farmers-traders

## **1.0 Introduction**

The impacts of climate change on agriculture in the last few decades have increasingly constituted a major global concern because of the continuous decline in crop production globally (Habib-ur-Rahman *et al.*, 2022). Yam tubers loss and wastages provide excellent examples of how climate change has negatively impacted agricultural loss of yam. This loss is fast assuming a worrisome dimension in Africa as it is already leading to rising poverty (Srivastava *et al.*, 2012). As yam farming is increasingly becoming a source of economic livelihood for many people in Africa. Yam loss and waste is a noticeable and unnoticeable change in the quantity and quality of yam production. The loss and waste of yam tubers have contributed to hundreds of thousands of deaths globally, with the largest proportion in Africa (Aighewi *et al.*, 2023). Climate change is intricately linked to yam loss and waste and the relationship has occurred at different geographical regions and coarse scales (Aighewi *et al.*, 2023). Temperature and rainfall are among the climatic variables responsible for climate impacts on yam losses and wastage and climate variability may negatively impact the yam quality and quantity (Magna *et al.*, 2018). Understanding the effects of climate change on yam production is crucial for the provision of necessary interventions that will reduce the general increase in the rate of yam spoilage, particularly in African urban and rural settings (Falade *et al.*, 2024). Adaptation to losses of yam is unevenly distributed at any levels subject to variation in susceptibility of a system to the effects of climate change as multiple drivers of adaptation work together to influence tuber crops production and supply.

Although adaptation interventions have been put in place to ensure that communities are able to cope with food losses and waste, the consensus among scholars is that there is a need to review the responses of individuals, communities, states, countries and international multilateral organizations to the increasing incidence of food insecurity in several parts of the world (Stringer *et al.*, 2020). Reviewing responses improves understanding of adaptation to the impact of climate change on yam production. Adequate consideration of the multiple human and natural factors within a given multi-sectional area in climate change studies may help to reduce uncertainties attributed to yam loss and waste estimation in Africa (Zakari *et al.*, 2018). Close to 13% of the world population living in Africa are worried about the increasing impacts of yam spoilage while most people in African households are at varied levels of food insecurity (Fovo Joseph *et al.*, 2022). There is, therefore, the need to review the current level of knowledge on climatic impacts of yam spoilage to be able to integrate diversity, flexibility and indigenous knowledge in subsequent planning for more efficient adaptation strategies (Adeyeye, 2017). Although African farmers depend exclusively on rainfall for yam production, the region is characterized by a lack of adequate data on yam losses and wastes and the general orientation of studies at only coarse social and spatial levels (Ansah *et al.*, 2017). Although 60% of yam is produced in West Africa, 40% of Nigerian children are suffering from poor nutrition (Verter, 2015). Climate change impacts, which include pests and diseases infestations, have limited the economic viability and the gross domestic product (GDP) of most African farmlands. Because of the dwindling GDP recorded for yam, many African governments have developed capacity-building programs for smallholder farmers to enhance yam production (Adamaagashi *et al.*, 2023).

Studies that focused mainly on the impacts of climate change on tuber crops and cereal crops have been carried out in the past (Alimagham *et al.*, 2024). For example, Alimagham *et al.* (2024) investigated the impacts of temperature and rainfall on the yam yield in the Savannah zone of West Africa and found that the continuous increase in temperature and reduction in rainfall have contributed to between 27% and 33% reduction in yam yields. Similarly, studies have examined the response of yam yields to climate change in Nigeria and noted that the increasing temperature

trends is negatively affecting the yields of yam tubers in Nigeria. However, most studies in Nigeria only focused on crop yields while not paying attention to tuber crop losses incurred in the production, transportation and distribution value chain. Interestingly, agriculture remains the mainstay of Nigeria's economy, employing at least 60% of the country's workforce and accounting for 35% of GDP (Immanuel *et al.*, 2024). There is the need to review the existing adaptation practices because of the recent increase in the number of extreme poverty-stricken populations by 25% out of the 60 million West African population that depend on yam tubers for food, medicine and socio-cultural needs (Immanuel *et al.*, 2024). Climate change has been linked to agricultural production, which is the mainstay of economic livelihood. Therefore, investigating the impacts of climate change adaptation to yam loss and waste in a heterogeneous society and redefining how it influences agricultural production across the multi-sectional society remain urgent research concerns (Habib-ur-Rahman *et al.*, 2022).

The present study assesses climate change impacts on yam tuber with attention paid to losses and wastes in Kwara State, Nigeria, based on the assumption that yam produced in Nigeria is planted and produced by agrarian communities in different ecological areas of the country and transported and sold to consumers in many locations all over the country. The Food and Agricultural Organization (FAO) recognizes every region in the country as the hotspot of agricultural practices. This study investigates the potential impacts of climate change adaptation, focusing on the effects of the rainy season (between April and October) on yam tubers and the effects of restricted access to storage facilities. The study is predicated on the assumption that coping with yam loss and waste is determined by the existing social, political and environmental infrastructure together with the highlights of social and ecological resilience that is affordable in a community. The definition of yam tubers consists of yam tubers in their raw forms immediately after harvest without considering processed yams in the business value chain. Although there are many yam species in Africa, the study limits its scope of yam tubers only to *Dioscorea rotundata*, popularly known as white yam, and *Dioscorea alata* popularly called water yam. The two species were chosen because they are the most common staple yam tuber crops in Nigeria. There have been many studies on the impacts of climate change on yam production but what is unique in the present study is the assessment of losses from the perspectives of farmers and traders which has been observed to be underexplored in the literature (Owusu Danquah *et al.*, 2022).

This study focused on Kwara State which is the meeting point of yam buyers in Nigeria and the study involves investigating the perception of climate change, yam trading experiences and how it has affected yam stock in the state. The study aimed at assessing the adaptation to the impacts of climate change on yam losses and wastes among traditional yam wholesale buyers in Nigeria. The study examines the impacts of variations in temperature and rainfall on yam tuber losses and wastes in Nigeria; investigates the perception of climate change among the farmers and traders; and evaluates the climate-induced yam losses and adaptive capacities of farmers and traders in the study area.

## **2.0 Methodology**

The study adopted a descriptive research design which included the use of a semi-structured questionnaire, focus group discussion and interview. The secondary data for the study is a native resolution daily temperature and rainfall data which was downloaded from the National Aeronautic and Space Administration (NASA).

The study was carried out in Kwara State, as shown in Figure 1, which bordered tropical rainforest to the south and guinea savannah to the North. Kwara State is situated between

latitudes 8° 24' N and 8° 36' N and longitudes 4° 10' E and 4° 36' E. The climate of Kwara State is largely controlled by two dominant air masses affecting the sub-region. These are the dry, dusty, tropical-continental (cT) air mass (which originates from the Sahara Desert), and the warm, tropical-maritime (mT) air mass (which originates from the Atlantic Ocean. The influence of both air masses on the region is determined largely by the movement of the Inter-Tropical Convergence Zone (ITCZ) (Immanuel *et al.*, 2024). The interplay of these two air masses gives rise to two distinct seasons within the sub-region. The wet season is associated with the tropical maritime air mass, while the dry season is a product of the tropical continental air mass. The influence and intensity of the wet season decreased from the West African coast northwards. The rainfall in the whole sub-region of West Africa depends on thunderstorm activity which occurs along disturbance lines called “line squalls” and, about 80 per cent of the total annual rainfall for most places is associated with line squall activities which are prevalent between June and September. The total annual rainfall of Kwara State is about 1200mm while the monthly temperature of the state ranges between 34°C to 35°C. The relative humidity at Ilorin in the wet season is between 75% and 80%, while in the dry season, it is about 65%. The elevation on the western side varies from 273 to 333m above sea level while on the eastern side it varies from 273 to 364m. The soils are easy to farm, which include loamy soil with sodium, having low fertility (Adedapo, 2020).

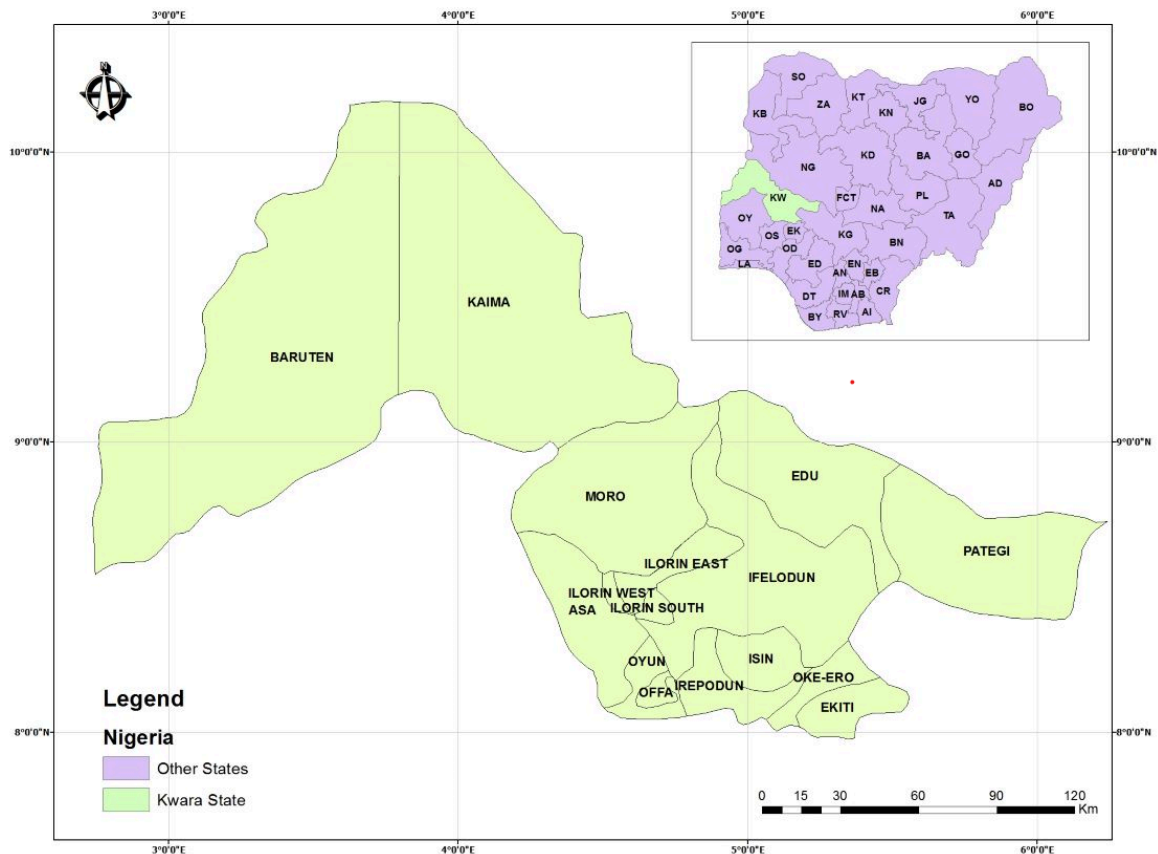


Figure 1: Map of Nigeria showing Kwara State

Because of the high seasonal rainfall coupled with the high temperature, there is the tendency for lateritic soil to constitute the major soil types due to the leaching of nutrient minerals (Kumar *et al.*, 2022a). The vegetation type comprises tall grass which is interspersed with scattered trees including shear butter, acacia and locust bean trees. Agricultural activities in Kwara State supports the growth of yam tuber crops, cereal crops and leguminous crops (Aluko, 2024). Boluyo is an informal agro-commodity organization that specializes in buying all agricultural farm produce on-farm and reselling them to consumers at unregulated prices. The organization with a membership of over 876 as of February 2024 comprises members that cut across the 36 states of the federation; many of whom are predominantly farmers and residents of Ilorin, Kwara State where the headquarters of the organization is located (Fovo Joseph *et al.*, 2022). Members of the organization which was established over five decades ago engage in the buying of yam tubers, both on the farmlands and in various community markets in Nigeria.

A descriptive research approach was used in the study involving primary and secondary data. The primary data consists of focus group discussion, content analysis and key informant interview (KII) while the secondary data consists of climate data which include rainfall and temperature data for thirty years (between 1991 and 2024) from the National Aeronautic and Safety Administration (NASA) archives. Climate change impacts on yam tubers data were collected through focus group discussion, content analysis and structured questionnaire administration. The respondents in this group consist of males and females above 35 years of age with wide experience in the yam tuber business.

Kwara State is made up of diverse ethnic groups that can be found in all parts of Nigeria and the yam tubers found in the selected markets in the Ilorin metropolis fairly represent yams found in all geo-political zones in Nigeria. Consideration of intersectional yam varieties is crucial in the current study to minimize important climatological information on the effects of climate change on agricultural practices among the communal population in different ecological zones of Nigeria. This includes tropical rainforest (RF), Derived Guinea Savannah (DGS), Guinea Savannah (GS), Sudan savannah (SS), and mountain vegetation belt (MV). Six (6) yam markets in Ilorin metropolis were purposively selected for the study; the locations are popular for the purchase of fresh yam tubers at reduced prices. The selected markets normally operate daily, however, every five consecutive market days attracts a large population of respondents, including retail sellers and consumers, who trade in yam tubers. Eighty-eight (88) respondents were sampled on the general market days in order to have a fair sample size of the population. Because of the general belief that Kwara State is a relatively peaceful State compared to many other parts of the country, some residents in various parts of the country have to relocate to Kwara State to keep themselves away from climate-induced crises, including farmers-herders conflicts. The high rate of population explosion in Kwara State made the demands for yam tubers exceed the supply by farmers in the state. In an attempt to balance the demands for yam, most of the yam tubers in the selected markets were brought from various parts of the country, which include Oyo State, Niger State, and Enugu State, to mention but a few.

Some traders export their yams to other countries instead of selling in the local markets. However, the present study focuses on the trading in yam tubers within Nigeria. The study adopts descriptive research design that incorporates both primary and secondary data. The primary data consists of semi-structured questionnaire key informant interviews, and focus group discussion administered to yam traders and farmers in the study area. This is to investigate the yam traders' perception of climate and evaluate the adaptive capacity of yam traders towards climate change in the study area. The secondary data are climatic data which include temperature and rainfall. Samples for primary data were collected using a purposive sampling method, as in Table 1.

**Table 1. Samples and Sampling locations of respondents in the Ilorin metropolis**

<b>Markets in Ilorin and date of sampling</b>	<b>Sources of Yam tubers</b>	<b>Latitude</b>	<b>Longitude</b>	<b>No of Respondents</b>	<b>% of Respondents</b>
Oja Oba, 16 <sup>th</sup> August, 2024	Oyo State (RF), Kwara State (DGS),, Ekiti State (RF) ,Kogi State (GS), Osun State (RF)	8.50	4.55	16	39
Okolowo, 14 <sup>th</sup> June, 2024	Oyo State (RF), Kwara State (DGS),, Kaduna State, Niger State, Abuja	8.48	4.53	22	48
Ganmo, 13 <sup>th</sup> march, 2024	Kwara State (DGS),, Osun State (RF), Enugu State, Benue State, Ondo State (RF)	8.43	4.60	23	28
Sango, 5 <sup>th</sup> July, 2024	Kwara State (DGS),, Niger State (GS), Kaduna State (SS)	8.51	4.58	12	21

Bode Saadu, 3 <sup>rd</sup> April, 2024	Kwara State (DGS),, Niger State (GS), Kaduna State (SS), Abuja (SS)	8.48	4.52	6	19
Jebba, May 13 <sup>th</sup> , 2024	Kwara State (DGS), Niger State (GS), , Abuja (GS), Plateau State (mv), Kaduna State (SS)	8.53	4.60	9	21
Total				88	

This study requires a large market size and yam-based market so as to be able to provide a fair sample size. Hence, a total of six different agrarian markets in Kwara State were selected for this study. Twelve (12) Key Informant Interviews (KII) and six (6) Focus Group Discussions (FGD) were used: The 12 KII consist of two (2) members of executives of the Boluyo Yam Traders' Association from each of the selected markets while the FGD was conducted among the members of the Boluyo Yam Traders' Association in each market.

Descriptive statistics was used to analyze the data collected. To ensure data quality, we ensured that data were selected from the most popular yam markets in the study area, and the respondents were traders above 45 years old. Daily maximum temperature and rainfall data between 1991 and 2024 were obtained from the archive of NASA. Yam losses and wastage data were collected through the observation checklist of three freshly harvested yam tubers. The study adopted the informal yam tuber classification system which regarded every three pieces of yam tuber as a unit of commercial transaction. However, the prices of each unit of tuber varies according to the size of the yam tubers. Such a traditional commercial unit system was developed by Boluyo Yam Flour Association as yam losses and wastages were estimated by simple observation of the number of losses and wastes from every three pieces of yam tubers packaged for selling to consumers by comparing the fraction of yams that were wasted between 1986 and 2015 in Table 2 below.

**Table 2: Different Types of Yam Tubers Grown in Kwara State**

Staple Yam species	Common names	Distribution	Market values
<i>Dioscorea rotundata</i>	White yam	Common in many parts of the country	very high
<i>Dioscorea alata</i>	Water yam	More prominent in the southern parts of the country, it is called <i>ewura</i> in Yoruba land	High
<i>Dioscorea cayennensis</i>		Less common in the country	Low
<i>Dioscorea bulbifera</i>	Aerial yam	Less common in the country	Low
<i>Dioscorea dumetorum</i>	Bitter yam	More prominent in the southern parts of the country, it is called <i>Esuru</i> in Yoruba land	Low
<i>Dioscorea esculenta</i>	Lesser yam	Less common in the country	Low

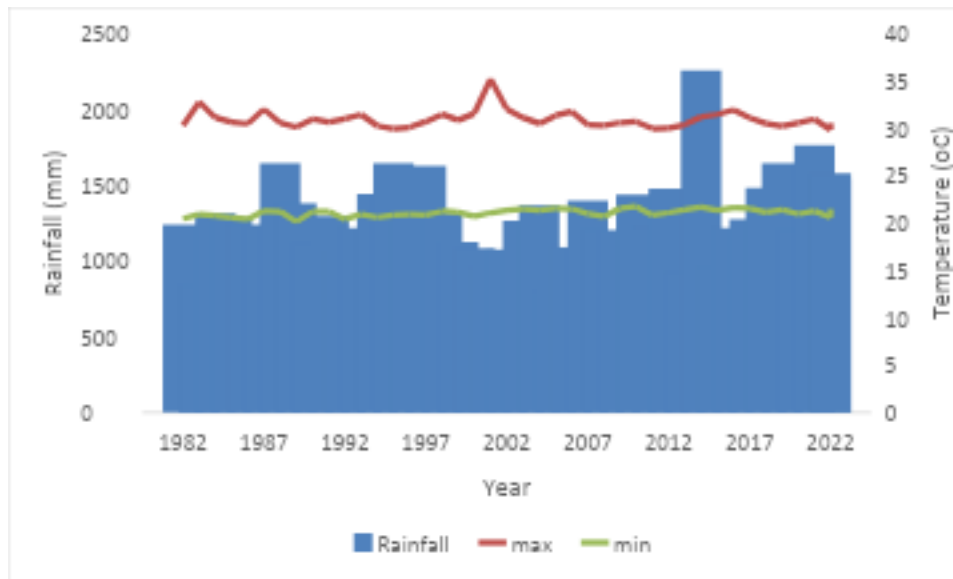
Data were analyzed as the average monthly temperature and annual average rainfall values were presented using charts prepared in Microsoft Excel. Descriptive statistics were also used in the presentation of other results.

### 3.0 Results and Discussion

#### 3.1 Temperature and Rainfall Variation

The findings from the study showed that the hottest years include 1987 and 2002, with annual maximum temperature values of 32.03°C in both 1987 and 2002 while the lowest annual maximum temperature of 29.97°C was obtained in the year 2011. There was a significant difference in the annual mean of the maximum temperature  $p$  value < 0.05. The maximum annual rainfall value of 2256.68mm was obtained in the year 2014 while the minimum annual rainfall value of 802.15mm and 836.86mm was obtained for the years 2005 and 1986, respectively (see Figure 2).





**Figure 2: Variability in annual rainfall, minimum and maximum temperature**

The result further showed the highest annual minimum temperature of 21.74°C, 21.68°C, 21.66°C, 21.58°C, 21.56°C, 21.54°C and 21.52°C in the years 2010, 2014, 2016, 2017, 2009, 2005, and 2006, respectively. On the other hand, the lowest annual minimum temperature of 20.14°C was obtained in 1989. However, there was no significant difference between the annual mean of the minimum temperature at 95 level of significance  $p$  value  $< 0.05$ . Although both the temperature and rainfall showed variability in the annual distribution, the magnitude of changes in temperature is not proportional to changes in rainfall.

Increase in temperature is usually favorable to the tuber crops particularly while they are still in the soil at the farmlands. However, the continuous sharp drop in the temperature may have had a negative effect on the yam tuber crops. The continuous change in temperature may favor the rotting of the yam tubers due to pest infestation. Similarly, yam tubers thrive better under the influence of rainfall, however, the continuous exposure of yam tubers to the disproportionate changes in temperature and rainfall may contribute to loss and wastes of yam tubers. Temperature and rainfall are important climate change variables adopted by many climate scholars. The choice of temperature and rainfall have been useful in marking the spatial distribution of the pests and diseases in the farmlands (Yeleliere *et al.*, 2023). Several studies have attributed the global increase in pest and diseases to annual temperature increase. However, many scholars differed as to the patterns of changes in rainfall (Lahlali *et al.*, 2024). Some research findings reveal that temperature in the tropics is increasing as the rainfall is decreasing.

For example, Lahlali *et al.* (2024), analyzed changes in light rainfall and heavy rainfall intensity in the global tropics using satellite data between 1998 and 2019 and noted a 9% reduction in rainfall intensity but increase in light rainfall intensity by 13%. However, assessing the rainfall intensity and seasonal variability in rainfall distribution over southeastern United States between 1985 and 2014, using data obtained from the global historical climatological networks found that extreme rainfall intensity increased by 53% while the temperature also increased. This result corroborates the present study which shows that annual maximum temperature values of 32.03°C was obtained in 1987 and 2002, while the maximum annual rainfall value was 2256.68mm (1241.38mm in 1982, 1579.65mm in 2023). Notwithstanding the different results outlined above,

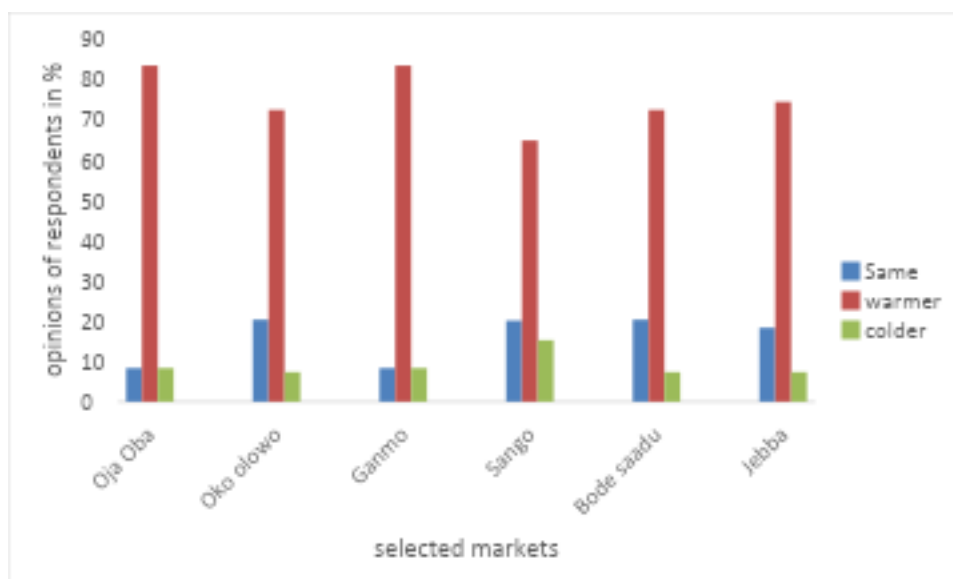
what may be deduced is that the increasing temperature and rainfall influences on climate change is not measured by mere increase or decrease, but by its variability over a few decades.

### *3.2 Traders and Farmers Perception of Climate Change*

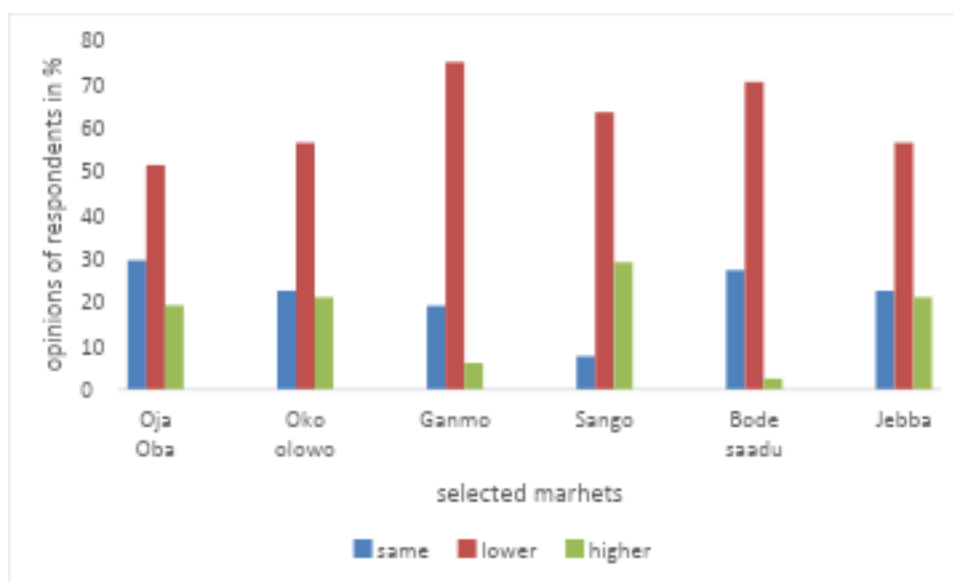
The results of the study showed that 75.07% of the total number of respondents admitted that the temperature had been warmer over the last three decades, 15.96% of the total number of respondents admitted that the temperature had been the same over the last three decades, but 8.97% of the total number of respondents showed that the temperature was relatively colder over the same period. The market-to-market result showed that 83.34% of the respondents in Oja Oba and Ganmo admitted that the temperature was warmer; 74.34% of the respondents in Jebba admitted that the temperature was warmer; 72.34% of the respondents in Oko Olowo and Bode Saadu admitted that the temperature was warmer and; 64.76% of the respondents in Sango admitted that the temperature was warmer. The lowest number of respondents who opined that the temperature was colder was recorded across the six selected markets. Similarly, the result showed that 62.13% of the total respondents admitted that the rainfall quantity was reducing, 21.41% of the total respondents admitted that the rainfall quantity was the same, and 16.46% of the total respondents admitted that the rainfall quantity had increased. This included 74.87% of the respondents in Ganmo, 70.33% of the respondents in Bode Saadu, 63.4% of the respondents in Sango, 56.42% of the respondents in both Oko Olowo and Jebba, and 51.3% of the respondents in Oja Oba, all of whom believed that rainfall had reduced over the last three decades.

However, apart from the 29.05% of the respondents in Sango who posited that rainfall volume was higher as against the 7.55% of the respondents who maintained that the rainfall volume was the same, the lowest number of respondents claimed that rainfall volume was higher in all the other five selected markets. In terms of awareness of climate change, 75.98% of the total respondents were aware of climate change, while 24.02% of the total respondents were not aware of climate change. However, the distribution of respondents who admitted that there was climate change included 78.12% of the respondents in Oko Olowo; 76.55% of the respondents in Oja Oba; 76.23% of the respondents in Ganmo; 76.05% of the respondents in Jebba; 75.56% of the respondents in Bode Saadu and; 73.35% of the respondents in Sango, respectively (see Figures 3,4 and 5).

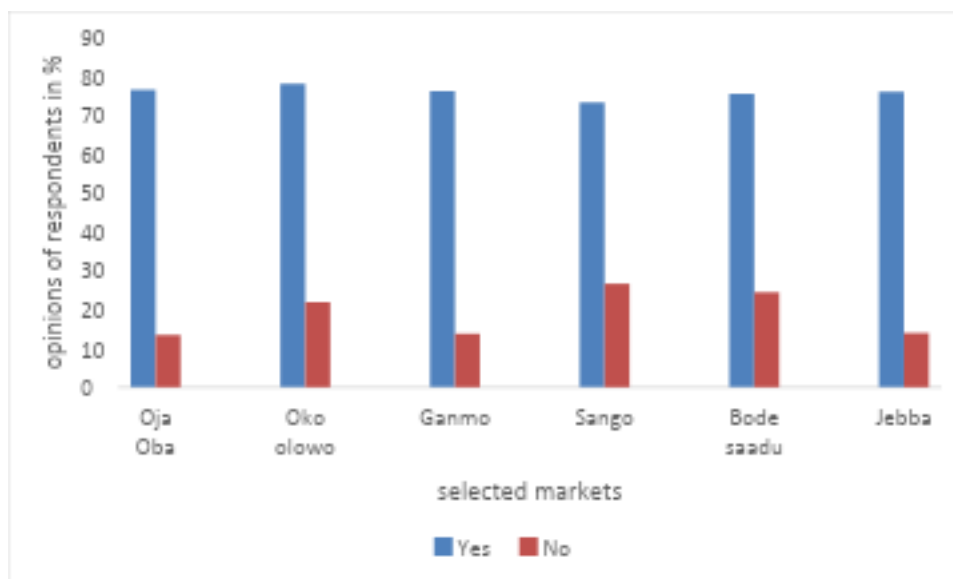
Majority of the respondents in the six selected markets believed that there has been a delay in the onset of rainfall over the last three decades. Most of the respondents also opined that temperature generally had increased during the same study period, including the awareness of climate change (Figures 3,4 and 5). The climatic data, however, shows that September recorded the highest rainfall amount out of the different variations in rainfall values, yet the amount of rainfall has slightly reduced generally as the rainy season becomes shorter and the dry season becomes longer in duration. Temperature has also shown variation in annual distribution, but there is an increasing trend in annual temperature, thus the study agreed with the climatic data. The annual increase in temperature and reduction in annual rainfall distribution also corroborate the findings that there is a significant climate change awareness in Nigeria. In addition, most of the respondents also believed that extreme floods and extreme drought were becoming more frequent. The perception of climate change may not provide accurate climatic information as climatic data, variabilities in climate data that may negatively impact yam tubers. Climate perception is subjective, depending on the individual, or and compounding vulnerability to climate change. Recent study in southern Brazil evaluated climate perception as an element of community adaptation strategies through the use of qualitative approach. The result of the study



**Figure 3** General perception of temperature



**Figure 4** General perception of rainfall



**Figure 5** General perception of climate change

shows that despite the equal severity of the impacts of climate in the two selected communities of southern Brazil, there was variation in climate perception.

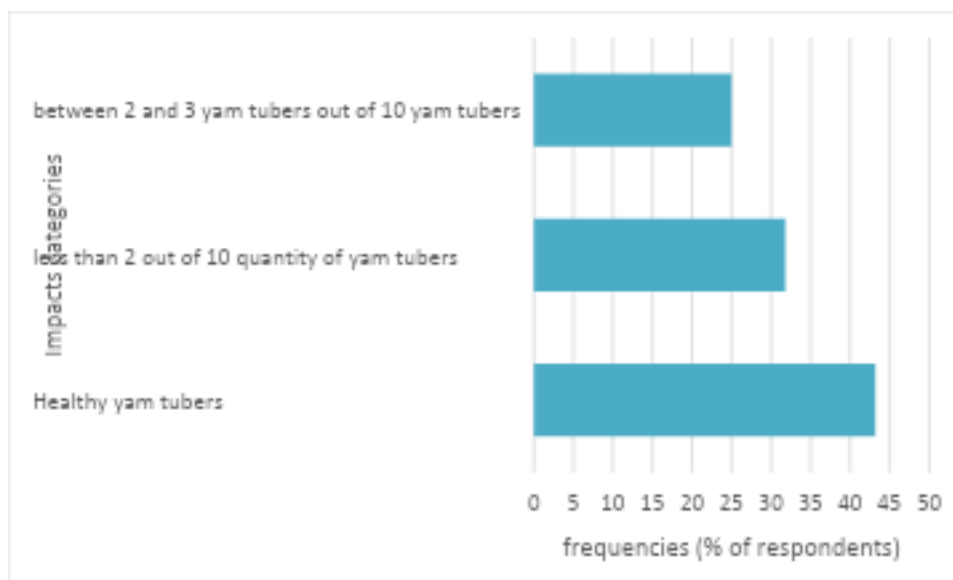
The variation in climate perception in selected communities may be attributed to a different context in which climate events were understood instead of assigning meaning to climate. Climate perception is also contiguous with people's lived experience. For example, analyzed factors influencing climatic-hazard induced stress in a coastal community in Bangladesh using key informant interview and focus group discussion and perceived floods among the main climate-hazard affecting the coastal community. (Shehab *et al.*, 2025). The present study corroborates this last finding as farmers and traders readily admitted that climate change was real because they were experiencing the direct effects of bush-burning and cutting down of trees during and after tuber harvests. This study showed that 75.07% of the total number of respondents admitted that the temperature had been warmer over the last three decades. Several studies have noted that direct solar radiation may not only affect the soil through deforestation but also expose humans to heat (Shehab *et al.*, 2025; Sarangi *et al.*, 2024). Thus, traders from Northern Nigeria expected to perceive climate change differently from traders from the south.

### 3.3 Climate-induced Yam Losses and Wastes

Even though yam sellers in the six selected markets agreed that the temperature was generally warmer, including the temperature of the coldest season, most of the respondents attributed climate change to natural causes. The belief that climate change is a natural phenomenon is also in line with the perception of the temperature of the hottest season which the majority opined to be the same. Thus, the result of FGD and content analysis revealed that most farmers and traders in the six selected markets observed no impacts of climate change in the yam tuber losses and wastes. However, a few of the respondents believed that climate change significantly impacted yam tuber losses and waste. The result of the studies showed that 43.19% of the respondents admitted that climate change did not impact yam tuber losses and wastes, 31.81% of the respondents showed that less than 20% of the yam tuber losses and wastes was insignificantly affected and 25% of the respondents showed that between 20% and 30% of the yam tuber losses

and wastes were significantly affected. However, in a separate interview with a yam tuber trader at the Oja Oba market, an old trader in her early 60s stated that the duration of the hot and wet weather conditions had nothing to do with yam tuber losses and waste.

Traders in the study area attributed the loss and wastes of yam tubers to lack of silos for preserving yams throughout the year. Some traders opined that heat or rainfall cannot damage yam tubers when they are correctly buried in the soil. The traders attributed the loss and wastes to certain yams in the markets that were grown through the indiscriminate addition of fertilizers, and many inexperienced traders may not be able to recognize them until they start to rot. However, floods and droughts are among the most frequent extreme events affecting Kwara State in recent times, ravaging farmlands and leading to the losses of many farmlands. The consequences of the extreme events is the loss and wastes of yam tubers as traders were unable to access farmlands and markets due to the flood. Furthermore, the increase in the frequency of extreme events is contributing to the unbearable cost of yam in the markets. Thus, the high cost, coupled with increasing trends in population growth informed the mass supplies of yam tubers from other parts of the country such as Abuja, Minna and Jos to reduce the cost of yam and ensure that yam supplies were able to meet up with the demands for the product in the state. However, most of the traders (43.19%) that use silos as adaptation strategies did not feel the impact of climate change in the study area because they perceived the extreme events as normal cycle of the season (Figure 6):



**Figure 6. Perception of respondents on the annual loss and waste of yam tubers**

*We thank God as the business has been booming over the past three decades. But for the police and other law enforcement agents that used to exploit money from us, and the poor road networks that used to delay transportation to the markets, we hardly record losses.*

*Our farmers are complaining of inadequate supply of yam tubers due to famine and grazing of their farmlands by Fulani herdsmen... because of that I have to travel to Kafanchan to get more yams for my increasing customers.*

Similar results of the interview were obtained for the Oko Olowo, Ganmo, Sango, Bode Ssadu and Jebba markets. However, some respondents to the FGD have attributed intense dryness to causes of yam tuber losses and wastes. This group of respondents explained that the intense hot weather was usually accompanied by pest and disease attacks on the yam stocks. This group constituted the respondents who opined that between 20% and 30% of yam tubers have contributed to economic damage over the past few decades. However, what can be deduced from this study is that climate change directly or indirectly contributed to yam tuber losses and waste. The findings showed that 38% of the respondents believed that rainfall and temperature did not affect yam tuber even though about 28% of respondents asserted that rainfall and temperature slightly affected yam tuber, however, about 22 % believed that rainfall and temperature strongly constituted yam tuber losses and wastes. The f-test showed that there was no difference between variance of categories of respondents who agreed that less than 20% of yam tubers incurred loss and wastes annually and the categories of respondents who agreed that between 20% and 30% of yam tubers incurred loss and wastes annually  $p$  (df:4,  $f:1.62 \leq f_c:15.98$ ) one tail, (0.32), at  $p < 0.01$  level of significance. Thus, the t-test result showed that there is no significant difference between the number of respondents who agreed that less than 20% yam tubers incurred loss and wastes and the number of respondents who agreed that there was no yam loss and wastes over the last three decades ( $p$  (df:8,  $t:2.67 \leq t_c: 2.90$ ) one tail, (0.01), at  $p < 0.01$  and; ( $p$  (df:8,  $t:2.67 \leq t_c:3.35$ ) two tail, (0.03), at  $p < 0.01$ . at  $p < 0.01$ .

However, the t-test result showed that there is a significant difference between the number of respondents who agreed that between 20% and 30% of yam tubers incurred loss and waste and the number of respondents who agreed that there was no yam loss and waste over the last three decades. The result implies that between 20% and 30% of yam tubers incurred significant loss and waste during the last 30 years. Moderate rainfall and temperature values were received at most months annually. The perception of yam tuber losses and waste among the respondents also varies from market to market. Figure 6 highlights the perception of yam tuber losses and wastes among the respondents in the six selected markets in Ilorin. What is clear from the above finding is that the variation of rainfall and temperature values differently contributed to yam tuber losses and wastes because of the heterogeneity of the yam species and different ecological locations of farming. Yam tuber species exhibit different sensitivity to rainfall and temperature at different ecological locations in the country. Different sensitivity to climatic variables may significantly contribute to yam tuber losses and wastes during the long distance transportation from other parts of the country. However, good road networks and the development of improved storage facilities may reduce the probability of the impacts of climatic variables on the yam losses and wastes. One of the market leaders in Oja Oba shared her opinion as follows:

*Except for the mechanical damage in the course of transportation and counting, cases of yam losses and wastes from my yam stocks are few. My late parents were full-time farmers, and in my childhood, we were used to eating cooked yam and pounded yam throughout the year despite that we used to experience the hot and cold weather we are experiencing today.*

Generally, responses on the quantities of yam impacted by climate change differ. Kumar *et al.* (2022b) investigate change and the future of agri-food production. They noted that the current scenario showed increased yam yields but warned of imminent threats to losses caused by climate change in the near future, examined the impacts of climate change on yam yields and noted that between 27% and 33% of yam yields were affected by climate change. However, this results was based on yam yields and yam productivity whereas future studies need to focus on regional scales climate-induced yam losses to establish the exact climate impacts in absolute numerical terms (Srivastava *et al.*, 2012; Baffour-Ata *et al.*, 2023). Differentials in climate change perception have

been widely linked to low yam yields globally and lack of data have been responsible for the inability to account for the quantity of yam losses over the decades (Baffour-Ata *et al.*, 2023). Many scholars opined that extreme poverty and lack of monitoring technology are responsible for the limited data on yam losses in Africa (Abolade, 2018). The present study is expected to bridge the data gap as finding from the study shows that 43.19% of the respondents admitted that climate change did not impact yam tuber losses and wastes, 31.81% of the respondents showed that less than 20% of the yam tuber losses and wastes was insignificantly affected and, and 25% of the respondents showed that between 20% and 30% of the yam tuber losses and wastes significantly affected.

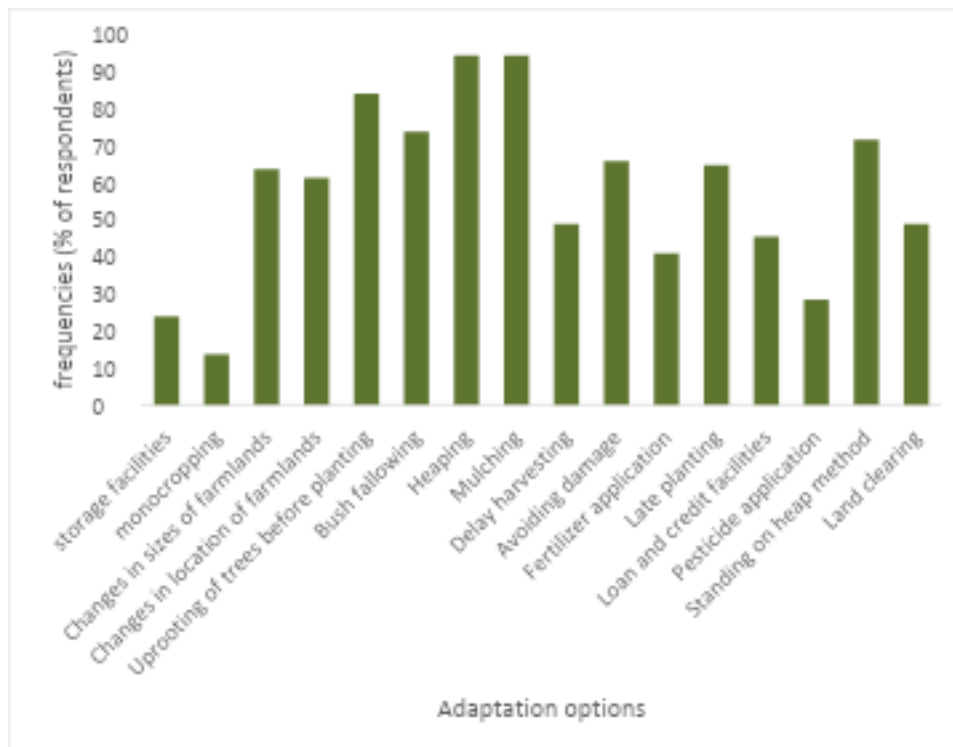
### *3.4 Adaptive Capacities of Farmers and Traders*

The result shows that the majority of the traders are farmers, hence, all also the traders sampled were farmers. The result showed that 23.86% of the yam traders utilize storage facilities as adaptation strategies, while about 76.14% do not. 13.64% of the yam traders engage in monocropping of yam tubers while 86.36% practice mixed farming. 63.64% of the total respondents adopted changing the sizes of farmlands while 36.36% maintained the same size of farmlands. 61.36% of the traders engage in changing the location of farmlands to a more weather favourable location while about 38.64% of the total traders maintain the same location they use for yam tuber crops. 84.09% of farmers engage in the removal of big trees, including uprooting to pave the way for the smooth growth of yam tuber while 15.91% are not doing uprooting. 73.86% of the farmers engage in bush fallowing, while 26.11% of the respondents do not. Mulching makes up 94.31% of adaptation practices by the yam farmers, while 5.69% of the total respondents do not. 48.86% of farmers practise delayed harvesting, while 51.11% of the total farmers do not. 65.91% of farmers engage in the avoiding damage method popularly called the traditional indigenous method (TIM), while 34.09% of the total farmers do not.

The traditional method involves the use of locally manufactured traditional knives to cut the yam tubers into seeds. Farmers in this category normally invoke unseen creatures in the preservation of the yam tuber seeds throughout the germination period to prevent loss and waste. 40.91% of farmers utilize fertilizer on their yam farmlands while 59.09% of the total farmers do not. 64.77% of the farmers engage in late planting while 35.23% of the total farmers do not. 45.45% of the farmers could access loan and credit facilities while 54.55% of the total respondents could not. 28.41% of the farmers utilize pesticides on their farmlands while 71.59% of the total farmers do not. 71.59% of the farmers engage in standing on the heap popularly referred to as natural positioning method (NPM), while 28.41% of the total farmers do not. The natural positioning method involves aligning yam tubers in the same position it was while in the heap during trading. 48.86% of the farmers engage in land-clearing activities before planting while 51.14% of the total farmers do not (Figure 6).

The inability to make adequate land clearing and other adaptation practices can be attributed to several reasons in the literature. 28.48% of losses and wastes of respondents agreed that poor road networks account for low adaptation while 29.55% of losses and wastes of the farmers decried low capacity to adapt. Farmers/herders crises accounted for 15.91% of losses and wastes, banditry accounted for 14.77% of losses and wastes, over-exploitation by the law enforcement agencies accounted for 26.14%, losses and wastes lack of adequate time for trading processes accounted for 36.36% losses and wastes, financial constraints accounted for 48.86% losses and wastes, lack of training and empowerment of farmers accounted for 15.91% losses and wastes, lack of external supports accounted for 21.59% losses and wastes, cultural/religious or social norms accounted for 20.45% losses and wastes, long distances to the markets accounted for 48.86% losses and

wastes, land fragmentation accounted for 14.77% losses and wastes, land disputes contributed 15.91% losses and wastes, lack of social capital accounted for 18.18% losses and wastes, while lack of physical capital contributed 47.73% losses and wastes (Figure 7). The result above pointed out that the present and future adaptation practices need to incorporate sociocultural, financial and physical capital to prevent the loss and waste of yam tubers.



**Figure 7. Percentages of respondents on adaptation practices to prevent loss and waste of yam tubers**

Because of the ability to thrive in the weather throughout the year in the tropics, yam tubers remain the staple food of average people in many African households (Obidiegwu and Akpabio, 2017). Burial in the ground has been the most common means of preserving yam over the decades. However, the security threats caused by the farmers-herders crisis has affected this preservation technique by the yam farmers. Many farmers in Africa have increased the use of chemicals for the preservation of yam tubers (Wumbei, 2019; Afolabi *et al.*, 2023). The use of fertilizers and pesticides have reduced the tastes and quality of yam tubers (Abolade, 2018). Interestingly, it is becoming increasingly clear that a traditional approach may be a more effective method of accounting for yam losses over the decades. The traditional techniques involve the use of indigenous knowledge as a potential climate change adaptation measure towards reducing yam tuber losses. However, the adoption of indigenous knowledge is not suggesting that other adaptation options are no more important, but indigenous knowledge and practices reduces barriers to yam tubers adaptation to climate risks (See *et al.*, 2024; Dorji *et al.*, 2024). Traditional approach will not only boost yam production, but also promote food security.



#### **4.0 Conclusion**

The study examined the impacts of variations in temperature and rainfall on Yam tuber loss and wastes in Nigeria, investigated the perception of climate change among the farmers and traders that constituted the Boluyo Yam Flour Association, and evaluated the climate adaptation practices among the farmers and identified the adaptation barriers in the study area. The study showed that there was insignificant variation in the temperature and rainfall. Although respondents perceived climate change as a real phenomenon, some farmers did not attribute yam tuber losses and wastes to climate change. The result revealed that a significant level of between 20% and 30% of Yam tubers have been lost and wasted over the last three decades as a result of the direct and indirect effects of climate change. Scholars have warned that the magnitude of losses and wastes may increase provided the current adaptation barriers in Nigeria are adequately addressed to achieve sustainable staple yam production in Nigeria.

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