

Harnessing the link between climate change and traditional food preservation methods: implications for global food security and public health

Original Research Article

Abstract

Climate change is a global issue, which impacts the different geographical zones in different levels. It is also linked to numerous human health issues, which are a concern to human health. The impact of climate change on traditional methods of food preservation in Nigeria and the consequences for food security and health are examined in this research. Information from the Nigerian Meteorological Agency (NIMET) and the National Emergency Management Agency (NEMA) show that average temperatures are increasing and rainfall is decreasing, which are effects of climate change that affect agriculture, water resources, and traditional food preservation methods that are detrimental to public health. Traditional food preservation methods are critical for understanding the link between climate change and food security. This paper uses a case study of Nigeria to examine the effects of climate change on traditional food preservation practices and public health. The research focuses on the shifts in the conventional preservation techniques, the impact of these shifts on nutrition, and policy interventions for enhancing sustainable preservation of food. Climate change indicators such as temperature and rainfall were used as surrogates for climate change, food insecurity such as undernourishment rates were used for food security and nutritional health outcomes such as child stunting and micronutrient malnutrition.

The study shows that climate change has a negative effect on food security since it reduces crop yields and enhances post-harvest losses. Sun-drying and smoking are the common preservation techniques that are now less efficient because of high humidity and unpredictable weather. As such, people are experiencing increased incidences of food wastage, nutritional imbalance, and food borne diseases especially with those people in rural regions. Furthermore, the study confirms the relationship between climate change and food insecurity, which has a negative impact on the health of pregnant women and children, especially under five years, and high under-five mortality despite a decrease in child mortality in the last decade. The results provide important regional information relevant to the entire Sub-Saharan Africa and useful to the international community in matters of climate change, food security and health. This study calls for the use of innovation that combines the conventional and contemporary methods of food preservation in order to mitigate the impacts of climate change on food security systems. Furthermore, it underlines the need for the policy interventions that may prevent food borne illness and other diseases. These insights are in line with the United Nations Sustainable Development Goals (UN-SDGs) 2, 3, and 13, namely; Zero Hunger, Good Health and Well-being, and Climate Action, respectively. This research addresses a significant gap in the literature by linking climate change effects with food preservation practices and offering recommendations for improving food system vulnerability to climate change. It provides a clear picture of the prospects and constraints of mitigating climate change impacts on food insecurity and enhancing food security and health in the world.

Keywords: Climate Change, Food Security, traditional Preservation, human health

1. Introduction

Climate change is now affecting ecosystems around the world in a way that has major implications for agriculture, food security, and health. Its impacts are being felt differently across different regions and it presents a major threat to the attainment of the UN Sustainable Development Goals (SDGs) especially those that are environmental and health related (Halim et al., 2019). It has different effects depending on the location and it is worse in the resource scarce and developing nations. With increasing global temperatures and increased incidences of natural disasters, the world is faced with increasing challenges in realizing sustainable development and food security, and maintaining public health. One of the emerging issues is how climate change hampers the attainment of the United Nations Sustainable Development Goals (SDGs) with focus on environmental, food and health SDGs (Halim, S.A.; Dasgupta, P.; Hayward, B.; Kanninen, M., 2019). Although much has been written about the general consequences of climate change on agriculture, the specific consequences on traditional methods of food preservation have not been given much attention particularly in the rural and resource poor areas. These methods, which have for a long time been essential for food preservation, are now more exposed to the effects of climate change.

Climate change and its impact on the disruption of traditional food preservation techniques is an emergent and understudied problem. These traditions in drying, fermenting, smoking and salting, are more important in regions where modern methods of preservation are unavailable. These preservation methods also benefit areas in which most foods are produced and consumed locally, especially in preserving food for use in the odd seasons or during shortages. Due to climate change the methods aforementioned are becoming less efficient compared to the past with rising cases of temperatures, humidity, cases of extreme weather events resulting to increased food wastage and post-harvest losses. Therefore, the situation becomes aggravated and the nutritional situation and, in turn, the health of the populace becomes affected. Climate change, indigenous food preservation, food security, and public health are the main areas of concern that are central to this research.

The preservation of food has been very important in the provision of food in societies before the modern technology was invented. Some of the traditional practices include: The sun drying, smoking, and salting these methods are quite simple ways of preservation. Such practices are traditional to many areas of Sub-Saharan Africa inclusive of Nigeria, especially among the subsistence farming communities. However, due to climate change, the traditional methods of preservation are under pressure as has never been before. Apart from extending a negative hand to farming practices, the increase in average temperatures worldwide, instability in rainfall patterns, and increased frequency of extreme weather events including droughts and floods buildings are no longer very effective with the changing climatic conditions (Abegunde & Hoffman, 2022). It is imperative to analyse how climate change influences these preservation techniques for developing effective to reduce the loss of food and improve food security.

Food systems affected by climate change are also not limited to the farm level, and preservation of the products assumes significant importance. High temperatures, high humidity, and unpredictable rainfall patterns affect the preservation conditions needed. For example, sun-drying which is one of the traditional methods of preserving food in the rural areas depends on dry weather. But in the tropical and sub-tropical areas, the increasing humidity increases the rate of spoilage of the dried products like grains, fruits and fish . However, unpredictable rainfall reduces the time available for drying and this leads to mold formation and food borne diseases. (FAO, 2021).With the effectiveness of conventional preservation methods reducing the rise in food wastage with post-harvest loss poses food insecurity threat. This is especially the case in low income countries where households rely on processed foods to feed on during food deficit periods. Small holder farmers who constitute a large percentage of the agricultural labour force in Nigeria and other SSA countries are the most affected. These farmers do not have adequate access to modern storage and preservation facilities and therefore use traditional methods that are becoming ineffective because of climate change. When these methods fail, households experience food deficits, and the probability of experiencing seasonal hunger and malnutrition increases (Khan & Johnson, 2022).

Food insecurity is not only a concern of the commodities remaining available but also a concern of the quality of food that remains available. Since climate change leads to losses in the production of foods that are rich in nutrients, the households in the affected areas have limited choices of nutritional foods. People who have restricted access to properly stored foods end up consuming very boring diets that are deficient in micronutrients. Climate change is therefore expected to worsen the situation in Sub-Saharan Africa where malnutrition is already a major public health concern. For example, deficiencies in micronutrients including vitamin A, iron and zinc typical with food insecurity will have a devastating impact on the at risk especially children, pregnant women and the elderly (Fraval et al., 2019). Deficiency in Micronutrients causes diseases like anemia, bad immune system, high risk of infections including respiratory tract infections and diarrhoea, which all put more pressure on the health facilities (UNICEF, 2020). Food contamination by pathogens also occurs when food is stored in hot and humid conditions, which raises the rate of food borne diseases. It is notable that foods which do not undergo a good drying or are poorly stored are vendors of bacteria, fungi, and other microorganisms. (Bai et al., 2023). The effects which arise from such contamination affects health in a way, especially in the rural areas where access to other healthy facilities may be rare.

Interference in the traditional food preservation methods is therefore central to questions of food sovereignty, population health and attainment of the SDGs. If proper preservation techniques are not employed, then food losses persist and the difference between food supply and food access increases. This not only go against SDG 2 but also SDG 3 as food insecurity equals to malnutrition and poverty which leads of poor health. Moreover, climate change effect on food preservation is also interrelated with the seventh sustainable development goal; this is on climate change and more especially expresses the importance of taking actions on climate change.

Since traditional preservation method for foods contributes to food security and nutritional health of the people, it is therefore important that prediction adaptation measures should be applied in order to minimize impacts of climate change on the preservation methods. One possible approach is the combination of the conventional and innovative approaches to preservation. Although previous practices have been useful in the past, innovative technologies like solar dryer, better storage structures,

and better access to cold chain can improve the food system's ability to adapt to climate change. These innovations can assist in cushioning post harvest losses, food insecurity and public health risks. For instance, the application of solar dryer can effectively overcome the problems caused by the unstable climate, and farmers can dry their products even in the case of high humidity or unpredictable rainfall (Fang & Wakisaka, 2021). Besides the technological approaches, there is need for policy measures to help smallholder farmers and rural people as they cope with the new climate. In Nigeria for instance, the government can in consultation with international organizations and participants at the grass-roots come up with programs that help farmers learn or improve on the methods they apply for preserving their produce that warmer climates require. In this way, policymakers are in a position to guarantee that food insecurity threatening particularly susceptible groups will not be accompanied by severe adverse health consequences (Khan & Johnson, 2022).

In addition to the national level, the results of this study are relevant for the entire Sub-Saharan African region and other countries. Multilateral schemes like the CAADP of the African Union provide ways through which countries can work collectively in achieving such collective goals as climate change, food security and health. Combined the countries and the regional area of Southern Africa can therefore come up with harmonized policies that address the effects of climate change on conventional food preservation techniques and improve the food systems' work. That is why this approach is aligned with the Sustainable Development Goals, the 17th of which focuses on the partnerships for goals at the international and regional levels.

Although, much has been written about climate change and its general effects on agriculture and food security, little is known about its effects on traditional methods of food preservation and the resultant nutritional and health implications in rural, resource poor environments. This study seeks to address this by offering a systematic review of how climate change is transforming conventional food systems and the consequences for health. This study is useful in understanding the difficulties and possibilities of constructing sustainable food systems that can endure climate change impacts by linking preservation practices to food security and health results.

Finally, this study will be of great importance to the need to address the challenge of climate change, produce ample and healthy food in a sustainable manner as well as

safeguard health . The findings of this study will contribute to the realization of the following SDGs; SDG 2, SDG 3, and SDG 13 as well as the policy formulation at the regional and international levels.

2.0 Conceptual Framework

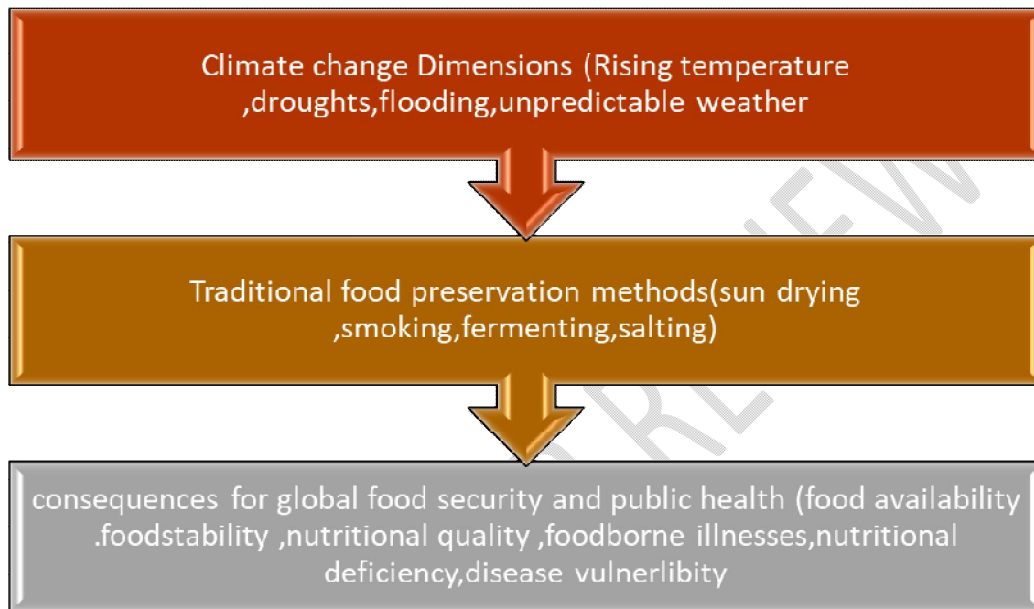


Fig 1: Study Protocol

Table 1: Climate Change Impact on Traditional Methods

Climate Change Impact	Effect on Traditional Methods
Rising Temperatures	Sun drying becomes inconsistent due to excessive heat causing food spoilage; fermenting processes are altered, potentially leading to food contamination.
Droughts	Reduces water availability for fermenting and smoking .
Flooding	Moisture-sensitive preservation methods like sun drying and smoking are severely disrupted by increased humidity, leading to spoilage.
Unpredictable Weather	Makes it difficult to time preservation processes accurately, affecting sun drying, salting, and fermenting efficiency.

This conceptual framework links climate change to traditional food preservation as the core process that affects food security and health . In this way, the framework shows how the improvement of traditional approaches through adaptation and innovation can lead to sustainability and resilience of food systems under climate conditions.

Climate change and malnutrition are two of the most pressing issues in the world today. Salas, R. N., Shultz, J. M., & Solomon, C. G. (2020). Addressing climate change and malnutrition shows a number of sectors and how they are related and how combating one has benefits to the other and public health. Phalkey, R. K., Aranda-Jan, C., Marx, S., Höfle, B., & Sauerborn, R. (2015). By enhancing traditional methods through adaptation and innovation, the framework illustrates a pathway to achieving sustainability and resilience in food systems amidst climate pressures.

Climate change and malnutrition are two of the biggest challenges facing humanity today. Responding to climate change and malnutrition reveals a range of areas where the two interact and how addressing one can have positive impacts on the other. (FAO, 2024)

Traditionally, food preservation techniques have been used to minimize post harvest losses especially in the rural areas where access to modern preservation methods such as refrigeration and cold chain are limited. These techniques are not only important for sustaining food stocks but also for retaining the quality of the foods. For example, fermentation, which is a common preservation technique, enhances nutrient absorption and decreases the number of pathogenic micro-organisms. However, as climate change affects food systems across the world, these preservation methods are becoming less effective. These techniques are influenced by changes in humidity, temperature, and rainfall, which lead to higher spoilage and food borne illnesses, according to Zenda (2024).

The application of traditional preservation methods in the light of climate change may therefore lead to more severe adverse effects on the public health. Some of these methods are sensitive to environmental changes and since climate changes are now more frequent, these techniques are less accurate. For example, drying, which is one of the most widespread methods of preservation, requires sunny weather, but it can rain at any time, and then foodstuffs will be covered with mold and other unwanted additions. This in turn threatens food safety and quality, and a decrease in the availability of safe and healthy foods especially in the developing countries where access to modern preservation techniques is a challenge (Liu et al., 2023).

Global warming, which is defined by the rise in temperature, fluctuating weather conditions, and natural disasters, has an impact on food production and perishability.

Culturally acceptable practices of storing and maintaining food through traditional food preservation techniques are normally influenced by the climate of the region. Since climate change affects these environmental factors, sun-drying, fermentation, and smoking may not be as effective in the future, and therefore, may need to be modified or replaced. This relationship implies that the preservation of food in the light of climate variability is becoming more difficult, particularly for rural and agrarian societies that use these techniques.

Several researches have shown that long dry seasons and unstable temperatures can affect traditional drying and fermentation practices resulting in higher spoilage and contamination levels (FAO, 2021). Other studies have established that post-harvest losses which are already high in SSA are further compounded by climate shocks (Zenda, 2024).

Although there are numerous papers that have examined the effects of climate change on traditional food systems, there are few papers that have made cross-regional comparisons. This gap raises questions as to whether or not risks to climate change differ from one region to another because of climatic conditions, cultural practices, and resource endowment. Prior studies indicate that adaptive approaches – including altering conventional practices or integrating contemporary technologies – may require adjustments for distinct regions because of these variations.

Surprisingly, few studies have comprehensively examined the gender differentiated effects of climate change on these preservation functions. Since women are more vulnerable to food insecurity and have limited access to resources, the analysis of gender aspects can reveal how the enhancement of women's knowledge and access to better tools might affect the stability of whole communities. The use of modern technologies such as solar drying and cold chain systems has been proved to decrease post-harvest losses and enhance food safety. However, these technologies are too expensive or not practical to be implemented in many traditional communities.

Sahoo (2022) studied Climate Change and Its Impacts Assessment Through Geospatial Technology—A Theoretical Study from Extreme Weather Perspective for Disasters Resilient India". The study focuses on the use of Geographical Information Systems (GIS), Remote Sensing (RS) and other spatial analysis tools in mapping, monitoring and forecasting the impacts of climate change in India. The paper is devoted to the increase in the number and severity of natural disasters, including

floods, droughts, and cyclones, due to climate change. All these events have a great influence on disaster risk reduction in India. The use of geospatial tools is presented as essential for the assessment of risk, the study of the distribution of the intensity of extreme weather conditions, and the provision of timely information that can enhance disaster management. The paper also looks at how geospatial data can help the policymakers in the formulation of policies that will help in the development of a disaster-ready India especially in the areas of climate risk mapping for the purposes of planning and development, infrastructure development and environmental conservation. Sahoo opines that geospatial technology is useful in providing information on climate change risks and disaster risk reduction for climate change in India.

Similarly, a study on disasters and Climate Change Adaptability at Odisha Coast written by Sahoo and Satpathy in 2020, focused on the Odisha coast of India to understand how climate change affects the region and to what extent it has adapted to climate change disasters. The study is a contribution to the ongoing debate on development in coastal areas and disaster risk reduction. The paper focuses on the susceptibility of Odisha's coastline to the effects of climate change such as rising sea levels, more frequent cyclones, erosion of the coast and flooding. Odisha has been affected by many calamities, especially of the meteorological nature, and therefore is a focus of disaster management. The authors describe several adaptation strategies that are being used to increase the ability of coastal communities to cope with the impacts of climate change. These are disaster preparedness, early warning systems, construction of cyclone shelters, and encouraging sustainable livelihoods to avoid over reliance on climate sensitive sectors. The paper also underlines the significance of the local communities' participation in the disaster risk reduction and adaptation. It carries the message of the importance of sound public policies for addressing climate change and disaster risk reduction.

3.0 **Methodology.**

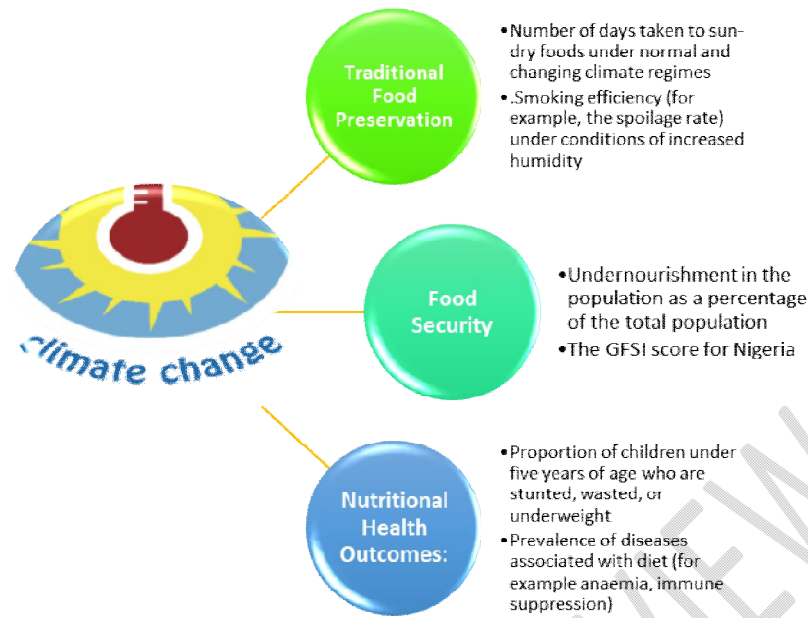


Fig 2: Proxies used for climate change

Carrying out case studies in selected areas can help in understanding the correlation between traditional food preservation techniques, health status, and climate change. Nigeria was chosen as the case study. The following set of questions were used to assess the research interest properly.

>>>The changes that have occurred to traditional food preservation in Nigeria due to climate change?

>>>>>The nutritional consequences of changes with climate?

>>>>>> Policy measures can be taken to encourage sustainable food preservation in Nigeria?

For this study, we used the following proxies for climate change, Traditional Food Preservation, food security and Nutritional Health Outcomes:

Climate Change:

1. Rising average annual temperature
2. Fluctuations in the annual rainfall (mm)
3. Droughts, floods, or extreme weather events occurring with a certain frequency

Traditional Food Preservation:

1. Number of days taken to sun-dry foods under normal and changing climate regimes

2.Smoking efficiency (for example, the spoilage rate) under conditions of increased humidity

Food Security:

- 1.Undernourishment in the population as a percentage of the total population
- 2.The GFSI score for Nigeria

Nutritional Health Outcomes:

- 1.Proportion of children under five years of age who are stunted, wasted, or underweight
- 2.Micronutrient malnutrition (for example vitamin A, iron, zinc)
- 3.Prevalence of diseases associated with diet (for example anaemia, immune suppression)

4 Results and Discussions

In Nigeria,available data on some of the key proxies for climate change are presented below.

Category	Proxy	Data Source	Value (2013)	Value (2014)	Value (2015)	Value (2016)	Value (2017)	Value (2018)	Value (2019)	Value (2020)	Value (2021)	Value (2022)	Value (2023)
Climate Change	Average annual temperature increases (°C)	Nigerian Meteorological Agency (NIMET)	0.3°C	0.4°C	0.5°C	0.6°C	0.7°C	0.8°C	0.9°C	1.0°C	1.1°C	1.2°C	1.3°C

Table 2. Available data on some of the key proxies for climate change

Source: Nigerian Meteorological Agency (NIMET)

This table has details on climate change in Nigeria.The measure of climate change is the change in average annual temperature (°C). Temperature rise is one of the most employed indicators to measure the climate change effects over time, especially the mean annual temperature change between 2013 and 2023. The information used in

this research was obtained from the Nigerian Meteorological Agency (NIMET) which is responsible for the observation of weather and climate in Nigeria. The table above shows that Nigeria's average annual temperatures are gradually rising each year. The temperature increase starts from 0.3°C in 2013 and increases by 0.1°C per year and becomes 1.3°C in 2023. This gradual rise is an indication of the constant rise in temperature due to climate change in Nigeria. Average temperature rise has various impacts including heat waves, change in rainfall patterns and impact on agriculture and food production. These temperature increases are significant because a degree change in temperature can cause a drastic change in climate, ecosystems, and health of the people. The increase in temperature is also cumulative, which means that there is gradual warming in Nigeria over the decade as a result of climate change.

The data obtained from the year 2013 to 2023 shows that the average annual temperature has been gradually rising by 0.1°C per year and a total rise of 1°C in the decade. This trend shows that climate warming is still on with serious implications on different sectors of the economy. This is because the rise in temperature presents serious threats to food production, health, economy and the physical environment in Nigeria. It is imperative to proceed to implement adequate climate change adaptation and mitigation on vulnerable areas of activity and production.

Temperature Rise Impacts (2013-2023)

Agriculture & Food Security: Warming increases the irregularity of agricultural seasons; decreases crop production; and leads to higher crop deterioration rates, which poses food security concerns, more so in the rural regions where the influence of global heating is more profound.

Water Resources: Distribution of water becomes poor and abundant food is now scarce and the prolonged dry seasons now experienced in northern Nigeria affects the freshwater and increase the supplies of water in urban areas.

Biodiversity & Ecosystems: Rising temperatures pose a risk to Nigeria's flora and fauna, and their habitats, and climate, and economies.

Public Health: This means that cases of heat sickness, and the prevalence of vector borne diseases such as malaria increase leading to increased strain on the healthcare sector.

Economic Impact: Climate change impacts areas such as agriculture, fisheries, and tourism sector, results in low economic yields and high poverty levels in affected regions.

Displacement & Migration: Seasonal displacements across the country, especially from dry, and flooded areas, lead to a rise in the number of people flocking rural areas creating pressures on urban facilities in services delivery.

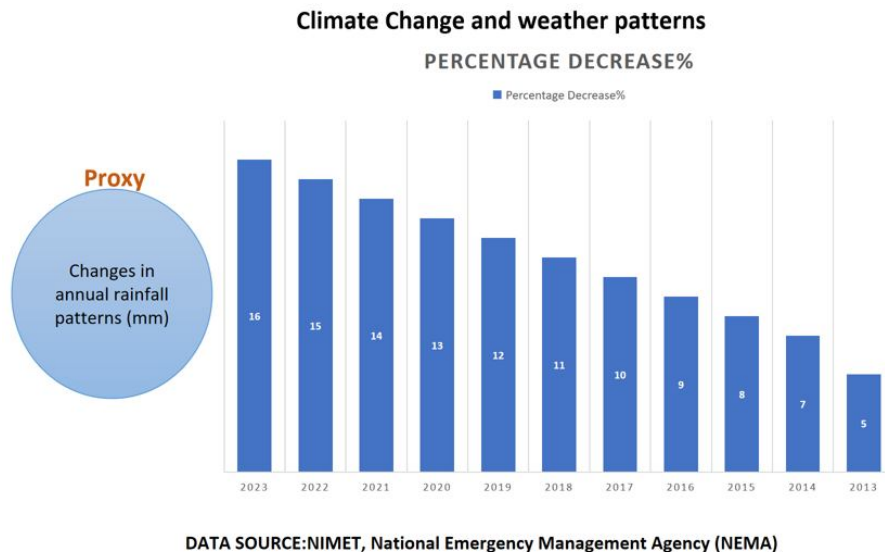


Figure 3 .Climate Change and Weather Patterns

The figure above shows how the annual rainfall in Nigeria has been reducing over the years from 2013 to 2023. The graph illustrates that the annual rainfall has been gradually decreasing year by year. Starting with 5% in 2013, the reduction is achieved by about 1-2% annually and is 16% by 2023. This is a cumulative reduction in rainfall that has serious consequences for agriculture, water resources and the balance of ecosystems in Nigeria. This has resulted in decreased water supply for crops hence decreased agricultural yields particularly in the rain fed agriculture. Reduced rainfall also implies a reduction in the rate at which water sources like the rivers and lakes are

replenished, which may cause water scarcity for human consumption, agricultural and industrial uses. The progressive reduction in rainfall may result in conditions of drought, soil degradation and desertification especially in the northern part of Nigeria. These changes may lead to rural people moving to other areas and there may be more competition for the limited resources.

This is in line with climate change predictions whereby an increase in temperature affects the hydrological cycle and results in changes in the weather patterns and rainfall in particular, which in this case has been on the decline. Climate Change and its impact on Food Security .Nigeria's annual rainfall patterns over a period from 2013 to 2023, highlighting a consistent decrease in rainfall across the years. The data shows a steady decline in annual rainfall over time. Beginning with a 5% decrease in 2013, the reduction continues by approximately 1-2% each year, reaching a 16% decrease by 2023. This is a significant cumulative reduction in rainfall, which can have severe implications for agriculture, water resources, and overall ecosystem balance in Nigeria. This reduction in rainfall means less water available for crops, leading to lower agricultural productivity, especially in rain-fed farming areas. Decreased rainfall also affects the replenishment of water bodies such as rivers and lakes, potentially leading to water shortages for drinking, irrigation, and industrial use. The ongoing decrease in rainfall can lead to drought conditions, land degradation, and desertification, particularly in northern Nigeria. These changes may force rural populations to migrate and could increase conflicts over diminishing natural resources. The continuous decline in rainfall aligns with climate change predictions, where rising temperatures alter the hydrological cycle, leading to more erratic and extreme weather patterns, including decreased precipitation in certain regions.

2.2: Climate Change affecting Food Security.

Climate change impacts food security through decreased yields, changes in seasons and increased post harvest losses due to natural disasters. However, when these traditional food preservation methods do not help in reducing these losses, the chances of food insecurity increases. This is especially the case in areas where there are few technological developments in food preservation. Further, areas that are vulnerable to more severe climate change effects are likely to face lower food supply, higher food prices, and lower nutritional quality.

The figure below shows the records of major floods and severe droughts in Nigeria from 2013 to 2023 obtained from NIMET and NEMA.).

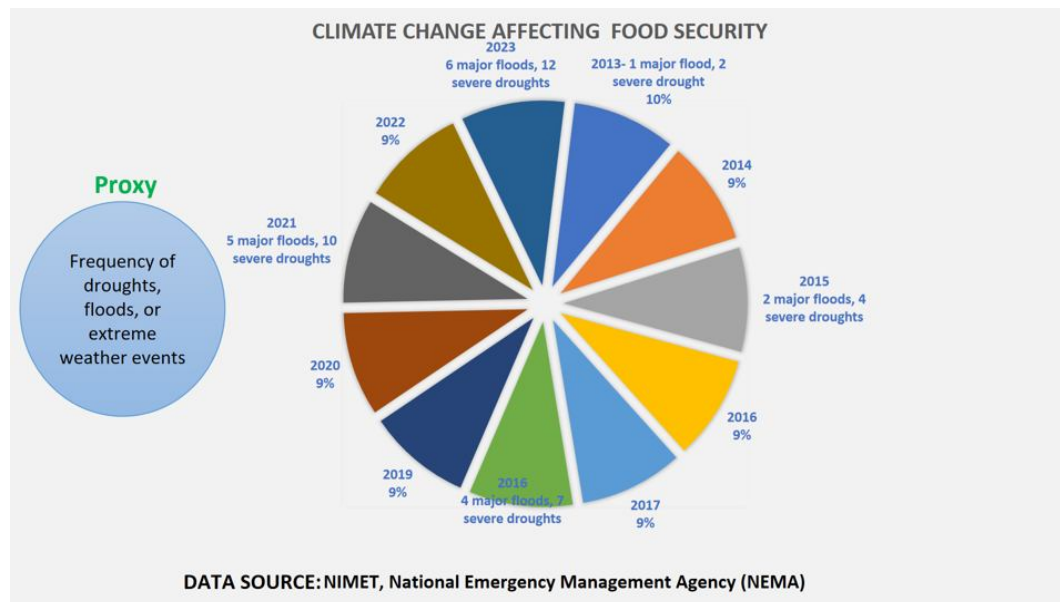


Figure 4: Climate Change Affecting Food Security

The analysis of the data shows that there is an upward trend in the frequency of both major floods and severe droughts in the region. This increasing frequency may be due to either a deterioration of climate conditions or an increase in the susceptibility of the region to extreme weather events. The effects of extreme weather events are social-economic and include agriculture, livelihoods and health. The trends in the data are useful for policy makers and stakeholders to understand in order to plan for interventions to address the effects of major floods and severe droughts in Nigeria from 2013 to 2023, using data sourced from the). The frequency of both major floods and severe droughts has been increasing in the recent past. This rising trend may be attributed to either worsening climate conditions or increased susceptibility of the region to climate change related disasters. The effects of climate change are felt in various sectors such as agriculture, livelihoods, and health. The analysis of these trends is important for policy makers and other stakeholders to develop and implement appropriate measures to address the impacts of climate change.

2.3 On Traditional food preservation

Food preservation is an important aspect of food security because it helps in reducing post-harvest losses and also serves as a buffer against food shortage especially in regions where access to modern preservation methods like refrigeration is not easily available. The specific method being tracked is sun-drying, which is one of the traditional techniques of preserving food especially in the rural areas of Nigeria. The table below reveals the time taken in this process under normal climate conditions and under changing climate conditions over the years.

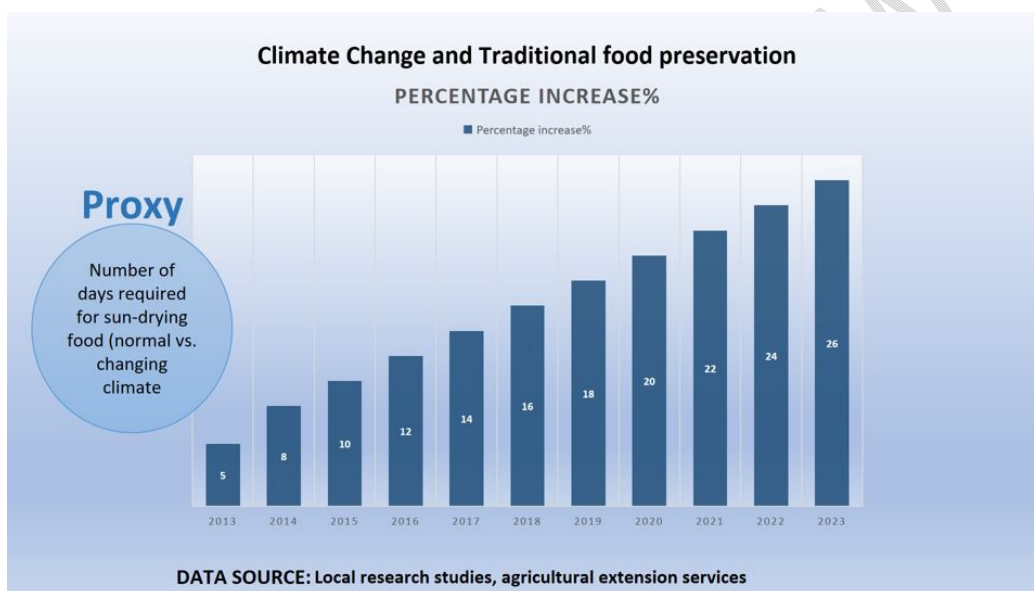


Figure 5: Climate Change and Traditional Food Preservation

The following figure (Figure 5) illustrates the following:

The figure reveals that climate change is gradually encroaching on traditional food preservation in Nigeria, therefore, the need for climate change adaptation to improve food security and public health in vulnerable rural areas. The values are the percentage changes in the time taken for sun-drying food due to climate change over the years as shown below. The findings show a progressive increase in the number of days taken to sun-dry foods because of climate change. This implies that new weather conditions like less sun, high humidity and changes in weather are impacting on sun-drying food preservation in Nigeria.

The longer it takes to dry, the less effective traditional preservation methods are, which may result in even more food loss, especially for perishable crops such as fruits, vegetables, and fish, which are sun-dried in rural Nigeria. These areas are more

vulnerable to food losses since sun-drying is still prevalent in the rural areas because of the unavailability of modern preservation structures. This could lead to increased hunger, malnutrition and other health complications that affect the normal functioning of the body and economic problems particularly in developing countries that depend on agriculture. As food preservation becomes more difficult, the chances of getting food borne diseases could rise because the food is likely to be contaminated. such as reduced sunlight, higher humidity, and increased unpredictability of weather conditions, are affecting traditional food preservation methods in Nigeria.

As drying time increases, conventional preservation techniques are less effective; this could result in higher food losses especially for perishable crops such as fruits, vegetables and fish, which are sun-dried in rural Nigeria. This is because rural areas where sun-drying is still common due to inadequate modern preservation structures lose more food. This could worsen hunger, malnutrition and economic shocks particularly in the developing world where many depend on agriculture for food.

As food preservation becomes more difficult, the risk of food-borne illnesses could increase, as improperly preserved food is more susceptible to contamination. This is a clear threat to human health particularly in the developing world where access to refrigerator and other modern means of food preservation is rare.

2.4 Conventional Techniques of Food Preservation and Health Issues

Appropriate traditional preservation techniques can help minimize the incidence of food borne diseases and malnutrition through preservation of the nutritional value of foods and minimizing spoilage. However, the old or less effective techniques may bring in contaminants that are unhealthy for the public. With the increase in the effects of climate change, the importance of preserving food safely to avoid food borne diseases and promote health increases.

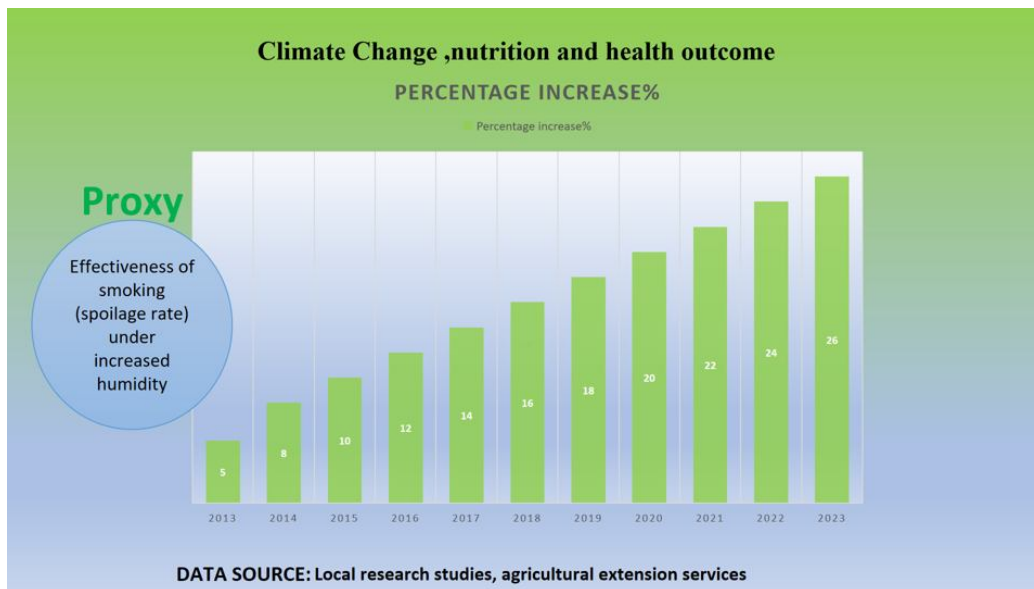


Figure 6: climate change, nutrition and health outcome

Source: Author's compilation.

The figure is centered on the efficiency of smoking as a traditional way of preserving foods in Nigeria with special reference to spoilage rates under conditions of raised humidity from 2013 to 2023 and increased unpredictability of weather conditions, are affecting traditional food preservation methods in Nigeria.

With longer drying times, traditional methods of food preservation become less efficient, which could lead to greater food spoilage, particularly for perishable crops like fruits, vegetables, and fish, commonly preserved using sun-drying in rural Nigeria. Rural areas, where sun-drying is still widely practiced due to a lack of modern preservation infrastructure, are more vulnerable to food losses. This could exacerbate hunger, malnutrition, and economic instability, especially in regions that rely heavily on subsistence farming.

If food preservation is a problem, then the incidence of food poisoning could rise because spoiled food is more likely to be contaminated. This is a direct threat to public health, especially in areas where people cannot afford to store their food in refrigerators and other modern methods of food preservation.

2.4 Traditional Food Preservation Methods and Public Health

Appropriate traditional preservation techniques can minimize the likelihood of contracting **food borne** illnesses and malnutrition since it preserves the nutrient content of food and minimizes spoilage. However, the traditional or less efficient techniques can bring in contaminants that are not good for the health of the people. With the increase in the effects of climate change, the preservation of food safely is even more important to avoid the outbreak of food borne diseases. The table is concerned with the role of smoking as a traditional technique of food preservation in Nigeria and relative to the spoilage level under the condition of raised humidity in the period 2013-2023. As climate change worsens, the need for preserving food safely becomes more critical to prevent **food borne** diseases and maintain public health.

The table focuses on the effectiveness of smoking as a traditional food preservation method in Nigeria, particularly in relation to spoilage rates under conditions of increased humidity from 2013 to 2023. Smoking is one of the most common methods used in Nigeria particularly in the rural areas to preserve perishable foods including fish, meat and other protein foods. The data used in this research is derived from local research and agricultural extension services on the effects of changing environmental conditions on food preservation in Nigeria.

The data shows that spoilage rates for smoked foods are gradually increasing due to high humidity, which may be attributed to climate change. This is especially so when the environment is humid such as during the rainy season or when the climate is tropical as in the case of Nigeria where smoking cannot effectively prevent the growth of mold, bacteria and other spoilage organisms.

The increasing spoilage rate is a potential danger to food security, especially among the rural population that uses smoking as one of the most available and effective ways to preserve food. Lack of proper food preservation methods results in high wastage of food, high expenses, and food scarcity especially during the periods when there is no harvest. Smoking is a very important process in preservation of fish and meat and areas that rely on this method are the most affected. If spoilage increases, it means that the income of the small scale farmers and fishers will be affected and this will lead to more economic difficulties. This is due to the fact that the spoilage rates are directly proportional to the humidity levels that are resulting from the effects of

climate change. Since weather conditions are changing, traditional preservation techniques that require dry and stable weather conditions are not as effective as they used to be, hence the need for climate smart preservation techniques. The consumption of spoiled food leads to food borne diseases, which puts a lot of pressure on the health facilities, especially in rural Nigeria where health care is scarce

The rising spoilage rate threatens food security, particularly in rural communities where smoking is one of the most accessible and affordable food preservation methods. The inability to effectively preserve food can lead to increased food waste, higher costs, and food shortages, especially during off-harvest seasons. This is especially so for rural and coastal populations who rely on smoking fish and meat respectively for preservation. If spoilage rises, it can decrease the income of small scale farmers and fishers, thereby worsening poverty. High spoilage rates are directly associated with higher levels of humidity resulting from climate change. Traditional preservation techniques that work well in dry conditions are no longer as useful as the climate changes, and this makes climate adaptation important. The consumption of spoiled food is dangerous because it leads to food borne diseases that put a lot of pressure on the health facilities, especially in rural Nigeria where access to health care is already a challenge. As the climate shifts, traditional preservation methods that rely on stable, dry conditions are becoming less effective, underscoring the need for climate-adaptive strategies. The consumption of spoiled food poses a risk of food borne illnesses, which can strain healthcare systems, especially in rural Nigeria where access to healthcare is already limited.

The table above shows the issues that relate to high humidity on the conventional ways of preserving food in Nigeria. With spoilage rates rising because of climate change, food security, health, and economic risks for rural and vulnerable populations are also on the rise. It is now high time that measures like climate change friendly preservation methods are employed to counter the situation. The data shows that spoilage rates for smoked foods are on the rise due to high humidity, which is believed to be caused by climate change. Another disadvantage of smoking is that it is not effective in the tropical climate of Nigeria especially during the rainy season because high humidity is a good breeding ground for mold, bacteria and other spoilage organisms.

The increased spoilage rate is a major concern for food security, especially in rural areas where smoking is one of the most readily available and inexpensive techniques of food preservation. Lack of proper food preservation methods results in increased food wastage, high costs, and food scarcity during seasons other than the harvest seasons. Smoking is a common method of preserving fish and meat in many countries and rural areas and coastal regions are the most affected. If spoilage rises, it will lower the income of small-scale farmers and fishers, compounding poverty.

Due to climate change, traditional preservation methods that rely on stable, dry conditions are becoming less effective, underscoring the need for climate-adaptive strategies. The consumption of spoiled food poses a risk of food borne illnesses, which can strain healthcare systems, especially in rural Nigeria where access to healthcare is already limited.

The figure presented underscores the challenges posed by increased humidity on traditional food preservation methods in Nigeria. As spoilage rates continue to rise due to climate change, rural and vulnerable communities face heightened risks to food security, public health, and economic stability. There is an urgent need for interventions, such as climate-resilient preservation techniques, to adapt to the changing environment.

2.5 Climate change, poor nutrition and their impact on health outcome.

We present below the trends of infant mortality rate and under-five mortality rate in Nigeria from 2014 to 2022 in deaths per 1,000 live births. Both of these rates have been declining over the years, but at a slower pace, which shows some improvement in child mortality rate over the years. However, the high mortality rates in Nigeria have remained high due to various factors such as climate change and poor diet especially among pregnant women and children. There is a gradual decline in both rates, indicating some progress in reducing child mortality over the years. However, the persistent high mortality rates in Nigeria can be linked to a variety of factors, including climate change and poor nutrition, particularly for pregnant women and children.

Table 3. Mortality rate, under-5 (per 1,000 live births)

Source : World development Indicator

Nigeria	Year	Mortality rate, under-5 (per 1,000 live births)
	2004	160
	2005	154.6
	2006	149.7
	2007	145.2
	2008	141.3
	2009	138
	2010	135.3
	2011	132.9
	2012	130.9
	2013	129.1
	2014	127.7
	2015	126.2
	2016	124.5
	2017	122.4
	2018	119.9
	2019	116.9
	2020	113.9
	2021	110.6
	2022	107.2

The under five mortality rate also reduced from 87 deaths per 1,000 live births in 2014 to 72 in 2022. The under five mortality rate has reduced from 127.7 per 1000 live births in 2014 to 107.2 in 2022. The under-5 mortality rate dropped from 127.7 per 1,000 live births in 2014 to 107.2 in 2022.

Droughts, floods and high temperatures are some of the adverse effects of climate change that reduce food production, hence food availability and quality. This directly affects the food intake of pregnant women and children, the most affected by malnutrition, because crop failure due to climate change affects food production, especially in rural areas where most people depend on agriculture. Rising temperatures negatively affect food production, leading to reduced food availability and quality. This directly impacts the nutrition of pregnant women and children, who are most vulnerable to malnutrition. Again, crop failures increase malnutrition rates, especially in rural areas where agriculture is the main source of livelihood. Malnutrition compromises immune systems and therefore children are more prone to diseases such as diarrhoea, pneumonia and malaria which are some of the major

causes of child mortality in Nigeria. Pregnancy related anaemia is associated with preterm births, low birth weight and developmental complications . Babies born under these conditions are more likely to die because they are more susceptible to infections and other related complications. Global warming leads to food scarcity and poor quality food which in turn increases the prevalence of malnutrition among pregnant women. This can cause infant and under 5 mortality because it impacts on the general wellbeing of children from the time they are in the womb.

Malnutrition in pregnancy increases the risk of preterm births, low birth weight, and developmental issues in infants. Babies born under these conditions have higher mortality risks, as they are more vulnerable to infections and other health complications. Climate change exacerbates food shortages and makes nutritious food less accessible, leading to higher rates of malnutrition in expectant mothers. This can contribute to both infant and under-5 mortality by affecting the overall health and development of children from the womb.

Child malnutrition is a major contributor to high mortality rates. Stunting, wasting, and underweight conditions compromise the children's immune system, which makes them more vulnerable to fatal diseases. As climate change affects food production and poverty deepens, it becomes difficult to feed adequately leading to a cycle of malnutrition and high child mortality among the under fives. The decline in the infant and under 5 mortality rates suggest some progress in healthcare and perhaps better strategies that seek to prevent child deaths. live births in 2014 to 107.2 in 2022

The gradual reduction in infant and under-5 mortality rates indicates some improvements in healthcare and possibly better interventions aimed at reducing child deaths. Nevertheless, the high rates still portray the system's problems in the various organizations. The two leading causes of child mortality are climate change and poor nutrition because they cause malnutrition, which makes children susceptible to diseases.

Although there has been an improvement in the proportion of under five mortality in Nigeria, the high figures call for more efforts. Climate smart agriculture, better access to healthy foods, and appropriate and timely health care for pregnant women and

children are critical in reducing the effects of climate change and malnutrition on child mortality.

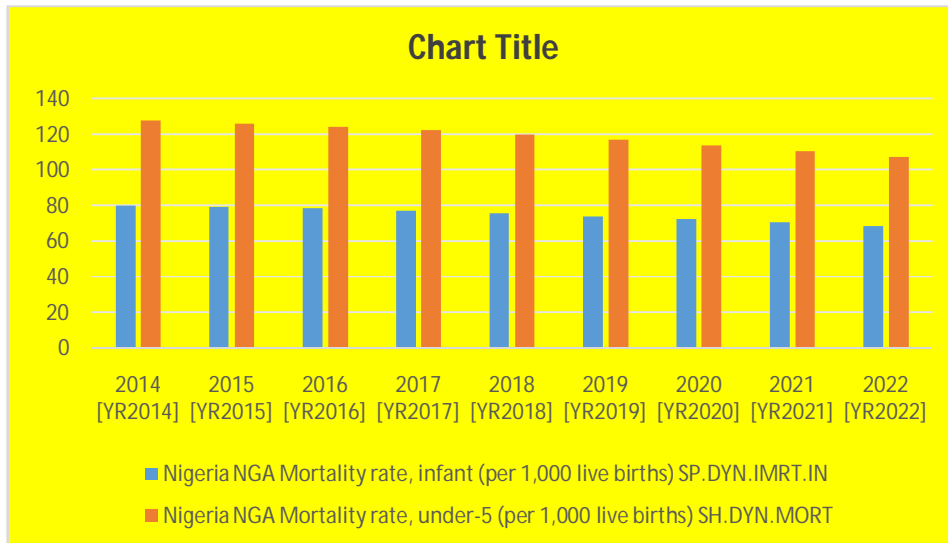


Fig 7 : Decline in the infant and under 5 mortality rates in Nigeria

4.0 Conclusion

Harnessing the link between Climate change and Traditional Food Preservation Methods is an important study towards appreciating the key gaps in post-harvest losses, and their impacts on food security and public health.

This paper examined the relationship between climate change and traditional food preservation techniques in Nigeria. Our findings reveal that climate change has a major effect on post-harvest losses and the consequent risks to food security and health. The results highlight the exposure of traditional food systems to climate-related risks, especially in areas where innovative preservation methods are still unavailable or too expensive. Moreover, the study establishes a need for the use of integrated approaches, which engage the traditional and innovative methods of food preservation as a means of overcoming these challenges. Some of the key findings are that climate variability negatively affects traditional food preservation techniques hence increasing post-harvest losses and food borne diseases. Again, the exposure of

food systems to risks enhances food insecurity and the incidence of food borne diseases affecting the health of the people especially in rural and hard to reach areas. We equally, explored adaptive strategies needed to mitigate climate change. This contributes towards global and regional policies aimed at achieving sustainable food security and improved health outcomes. This therefore become essential to the international discourse on climate change, food security, and public health.

Although the study was conducted in Nigeria, the results can be useful for policy and practice in other SSA countries where climate change poses a threat to food security. This paper fills the gap in the global literature on climate change, food security, and health by exploring how traditional methods of food preservation can be modified to address climate change challenges. It challenges policy makers to focus on food security and public health preparedness in the context of continuing climate volatility.

Policy Implication and recommendation.

Interventions must be targeted within the policy domain to manage climate change and food insecurity as well as malnutrition impacts to the public. In order to address these challenges, efforts should be made to enhance healthcare systems in order to address malnutrition, promote nutrition sensitive agriculture and ensure food security programmes have a consideration for climate change (Fraval et al., 2019).

Besides, it can be argued that utilizing some strategies to reduce loss after produce has been harvested can greatly assist in improving the offers of healthy foods which is critical in fighting malnutrition among the intended vulnerable groups.

As the climate changes and gets warmer and climate variability rises, so too does the need for food systems to adapt. The challenge of ensuring that there is safe, nutritious and preserved food in the future in view of climate change is one that has to be solved at the local, national and international level.

The integration of traditional methods with the modern tools provides an opportunity to solve these problems. There is therefore need to embrace technology such as modified atmosphere storage and smart cold chain which is a blend of traditional and

modern technology in food preservation in the fight against climate change (Zenda, 2024). These systems play a role in minimizing some of what climate variability does to the safety of food and health of people in the societies.

Essentially, climate change, traditional food preservation, and public health are the three issues that need an adaptive strategy. Due to dynamic climate conditions, the sustainability of local food leading to food security and health could be challenged due to change in climate conditions. In the interest of the vulnerable, there is a need to progress—combining traditional and modern methods will maintain both quantity and quality of food (Fang & Wakisaka, 2021).

There is need for new adaptation measures such as the use of solar dryers which capture and focus solar radiation and protect from adverse weather conditions to shorten the drying time. For example, the traditional methods of smoking are not as effective as before because of the climatic conditions. This requires the use of better preservation methods than the traditional ones such as the modern methods of smoking, solar drying or refrigeration in order to reduce on food waste levels and therefore make a contribution to enhanced food security.

Climate change, improved food security and child and maternal health are crucial in decreasing under-five mortality in Nigeria. This study, therefore, fills this gap by providing a step in understanding the challenges and opportunities in addressing climate-induced food insecurity and health risks, building food system resilience and advancing sustainable global food security and public health.

Recommendation for future research

Future research could try to establish a comparison of the effects of climate change on traditional food preservation techniques in different parts of SSA. This way it will be possible to determine if there is any difference in the kind of vulnerabilities and adaptation that exist or if there are regional variation that may need different actions taken. Since women takes an important role in traditional food processing particular in Africans' societies, research can look at gender implications of climate-smart food preservation. Research could examine whether and how enhancing women's

knowledge and resources might impact the ability of a community to cope with climate risks to food security.

Future research could focus on how indigenous knowledge can be incorporated into the construction of more climate change resilient food systems. Thus, by writing and publishing traditional knowledge on food preservation, the researchers help to improve the work on the enhancement of sustainable solutions that can be used according to the culture and climate of the country. Another research area could be the creation of cost-effective technologies for the further usage of traditional preservation techniques. Future research could be directed towards the development and application of technologies that are low energy intensive and culturally appropriate.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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