CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES

Edited by

Eteyen Nyong

Edith C. Chuku

Ibisima Etela

B. M. Auwalu

Okorinama A. F. Wokoma

Opara E. Umunna

PUPLISHED BY:

Society for Agriculture, Environmental Resources & Management (SAEREM)

SAEREM BOOK CHAPTERS First published July 2026-- ISBN 978-978-60709-1-7 @ SAEREM World

First published August 2026

SAEREM World , Nigeria

CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT --- ISBN 978-978-60709-1-7

Typeset in Times New Roman

CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT --- ISBN 978-978-60709-1-7

Global Issues & Local Perspectives

Printed at: SAEREM World

TABLE OF CONTENTS

CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT --- ISBN 978-978-60709-1-7

Part one: CLIMATE SMART AGRIBUSINESS FINANCING (CSAF)

Chapter 1:

Sources and Constraints to Agroforestry Financing in Nigeria

[1]Edoka, M. H. and [2]Edoka, Edebo L.

Chapter 2:

Climate- Smart Agricultural Waste Management: The Circular Economy Perspective

*Okwor, Uchechi Mercy [1] and Okwor, Kelechi C.[2]

Chapter 3:

Farmers Perception on the Effect of Climate Change on Soybean Production and the Adoption of Coping Strategies

Paul, A. H. (B. Sc. M. Sc, Ph. D.,) and Oyigbenu A. O. (B. Sc. MSc)

Chapter 4: **Resource-Efficient Waste Management and Financing in Climate-Smart Agribusiness**

Dr. Ijeoma Rose Ezebuike

Chapter 5:

Social Capital as an Evolving Framework for Shaping Livelihood and Farming System Resilience amidst Climate Adaptation

Sesugh Uker [1], Muhammad B. Bello [2] and Aminu Suleiman [2]

CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT --- ISBN 978-978-60709-1-7

Part two: FORESTRY AND WASTE MANAGEMENT

Chapter 6:

Influence of Climate Change Adaptation Strategies and Information Communication Technology (ICTS) Utilization by Soybean Farmers in North East Nigeria

Paul, A. H. (BSc., MSc., PhD) and Gadu, H. O., (BSc, MSc)

Chapter 7:

The Impact of Climate Change on Animal Health and Productivity

Oyeleye, O. O.

Chapter 8:

Advances in Remote Sensing for Biodiversity: Theory, Methods, Applications, and Validation

[1]Salami, K. D. and [2]Falade, L. O.

1

Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** necessary in policy making process that will stimulate increase in food production and environmental sustainability. **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management : *Global Issues & Local Perspectives*** is organized in two parts. Part One deals with The Concept of **Climate Smart Agribusiness Financing (CSAF)**, Part Two is concerned with The Concept of **Forestry and Waste Management**

Eteyen Nyong; August 2026

Chapter Three

Farmers Perception on the Effect of Climate Change on Soybean Production and the Adoption of Coping Strategies

Paul, A. H. (B. Sc. M. Sc, Ph. D.,) and Oyigbenu A. O. (B. Sc. MSc)

Department of Agricultural Economic and Extension, Faculty of Agriculture, Federal University Wukari Taraba State Nigeria. Email Address: amadepaul.ap@gmail.com.

Oyigbenu A. O. (B. Sc. MSc)

Department of Agricultural Education, College of Education, Akwanga Nasarawa State. Email Address: oyigbenu2019@gmail.com.

Table of Contents

1.0 Introduction

Climate change would have a more detrimental effect on the majority of Nigeria's coastal states. Local weather differences have caused significant setbacks to all agricultural activity in the drought-prone northern part of Nigeria. Hot, dry, dusty, and high temperatures are what set apart Nigeria's northern region; these conditions would affect a number of agricultural outputs (Akande *et al.*, 2017 and Ebele and Emodi, 2016). Climate change is causing major lakes like Chad and others across the nation to dry up and maybe perish. As a result of the lengthier dry season in this part of the nation, animals and people must fight for access to water (Elisha *et al.*, 2017; Dioha and Emodi, 2018). Because of the many instances of high temperatures and flooding that have occurred since the 1980s, the government constructed internally displaced camps (IDC) for the victims and provided palliative care; however, as time has proven, succeeding governments have never been able to find a long-term solution to these problems. According to the most recent climate change warning, all ecological zones will see significant temperature increases over the next decades, which will have an impact on agricultural production in those areas. Therefore, methods to mitigate this impact must be developed by all concerned parties (Nzeh, *et al.*, 2016, and Federal Ministry of Environment, 2015). Climate change is a serious problem that has been defined as an uncontrollable statistical variation that lasts for a longer length of time—usually ten years or more—and has an impact on every country in the world. It can manifest itself in a variety of ways, such as alterations in the frequency and intensity of recurrent weather phenomena such as droughts and rainstorms, among many others, and a gradual but continuous increase in the average surface temperature of the world, which can have detrimental effects on the ecosystem for both humans and animals (Akande *et al.*, 2017).

Soybean is a leguminous vegetable belonging to the pea family, that can be grown in temperate, tropical, and subtropical regions. The crop was domesticated in northeast of China, about the eleventh century BC. It is thought that Chinese traders along Africa's east coast may have brought it to the continent in the 1800s. Soybean may now be successfully farmed in many areas of Nigeria with less agricultural input and labor because of better technologies. Soybean farming has increased because of its economic importance, range of domestic uses, and nutritional advantages for both human and industrial use and also it is also a sizable provider of vegetable oil on the international market. By dry mass, soybean seeds contain 20% oil that is 85% unsaturated and cholesterol-free. Soybeans are more protein-rich than any other vegetable or animal food source found in Nigeria, with an average protein level of 40% (Dugje, Omoigui, Ekeleme, Bandyopadhyay, Kumar and Kamara, 2019). As more farmers and other

stakeholders become aware of the potential of this crop, not only for money/food, but also for improving soil fertility, soybean planting and output has risen and farmers are utilizing the expanding soybean market to increase output, processing, and distribution.

2.0 Statement of Problems

Adaptation is coping strategies for lower-carbon, cleaner energy sources which is generally necessary to deal with climate change. African continent is most severely affected by climate change; Africa also has the weakest ability to adapt to climate change. Most African nations, including Nigeria, have limited and divided resources available to assist in managing the risk of disaster and adapting to climate change. One of the biggest challenges in Nigeria is the lack of progress in reducing deforestation. Additional difficulties include decreased agricultural output, deteriorating food security, a rise in the frequency of droughts and floods, the spread of illness, and a higher chance of conflict over limited water and land resources.

It is thought that farmers' knowledge, attitudes, behaviors, and belief systems play a significant role in both improving and guaranteeing a sustainable living for their family while also developing mitigation and adaptation techniques to overcome the consequences of climate change. Documenting farmers' perspectives, beliefs, and management approaches about climate change is necessary since, in comparison to other aspects, it is believed that these affect the effectiveness of coping strategies or measures of farmers in the rural area. There are most likely gaps in the indigenous knowledge of farmers on the impact and coping mechanisms of climate change. Therefore, research on the farmers perception on the effect of climate change on soybean production and the adoption of coping strategies become important.

3.0 Concept of Soybean Production

Soybean (*Glycine max*) is an important leguminous crop widely cultivated in Nigeria for food, oil, and feed purposes. It is cultivated because it naturally increases soil fertility, which raises agricultural yields. In Nigeria, soybean is an important source of protein that is consumed to address nutritional issues (Idrisa *et al.*, 2019). We need to change this tendency by include soybeans in our meals because Nigerians tend to eat more starchy staples food, which leads to malnutrition and a high prevalence of chronic illnesses like diabetes (Akah *et al*., 2021). Nigerians who consume vegetable oils high in omega-6 fat have health problems like cardiac difficulties (Falade *et al*., 2017). However, because soybean oil lowers cholesterol levels in the gastrointestinal tract by reducing cholesterol absorption, it is believed to reduce the risk of cardiac issues (Messina *et al*., 2021). To make soy-lafun, soy-gari, dadawa, soymilk, tom brown, and soy-ogi, soybeans are processed nowadays in Nigeria. Soybean meal is an important

component of formulated feed used in livestock production. In order to boost output, soybeans are typically interplanted with other crops like maize, wheat, and sorghum and control weeds that are parasitic, like striga (Smith, 2017). Climate change directly affects soil and water supplies, it has a severe impact on agriculture. Nigerian agriculture is experiencing a reduction in the productive potential of its soil resources as a result of declining soil fertility and increased fertilizer costs as a result of the elimination of subsidies. Crop productivity fell as a result of this continuous soil deterioration and loss of fertility (Al-Tayar, *et al.,* 2020).

4.0 The trend in Nigeria's Soybean Production

Considering the numerous unsuccessful attempts to plant imported soybean seed in the southern Nigerian rainforest region, the crop was only flourishing in the Guinea savanna region of Nigeria at the beginning of the 20th century (Shurtleff and Aoyagi, 2021). Nigeria was first introduced to soybeans in 1908 (Oyegbami, 2020), but large-scale cultivation didn't start until 1937, when the "Malayan variety" was discovered to be suited in Benue State. In 1946, farmers were able to obtain the "Malayan" cultivar in large quantities due to its high potential and excellent yield potential. In 1947, Nigeria exported approximately 9 tons of soybeans that were grown in Benue, Zaria, and Katsina (Shurtleff and Aoyagi, 2021).

The primary producing region was the Tiv Division of Benue Province, which produced roughly 10.5 tonnes and 700 tonnes of soybeans in 1946 and 1948, respectively. Nigeria exported 9,050 tonnes of soybeans in 1947; this increased to 15,860 tonnes in 1963. The Benue province is still Nigeria's most significant soybean production region till date (Shurtleff and Aoyagi, 2021).

It was discovered that the "Malayan" variety of soybeans was late-maturing, low-yielding, prone to bacterial infections, and prone to pod shattering when it was introduced for commercial production in Nigeria. Consequently, research was done to create high-yielding, early-maturing cultivars with favorable agronomic characteristics that can modulate in conjunction with nearby rhizobia. Nigeria's soybean production has increased since roughly 1974 to approximately 758,033 tonnes (1.0 ton/hectare) from 780,679 hectares in 2018. This is due to the International Institute of Tropical Agriculture (IITA) improving African soybean lines through the crossing of Tropical Glycine Cross (TGx) lines with other Asian origins. The goal of the study was to find a way to address the problems associated with producing soybeans using the cultivars that are currently grown in Nigeria (Nzossié and Bring, 2020).

The nutritional value and economic significance of soybeans have been cited as reasons for their production growth in other states (Nater *et al.,* 2021). After South Africa, Nigeria is currently the

continent's second-largest producer of soybeans. Because of the unique soils in the northern part of Nigeria, which have low levels of nitrogen and phosphate, it grows well in the subhumid and semiarid savanna agroecology (Khojely *et al.*, 2018). Among the seventeen (17) producing states in Nigeria, the Guinea savanna belt is regarded as the primary production region. The use of early maturing soybean varieties is suggested by the low quantity and duration of rainfall seen in the Sahel savanna and Sudan (Haruna *et al.*, 2015). When compared to early maturing varieties, late-maturing soybean varieties are reported to yield more grain and biomass.

Nigeria's production appears to be much behind America's in 2018 with a yield of approximately 3.4 tons per hectare, which can be attributed to various contributing variables. Consequently, research endeavors to comprehend the characteristics that constrain ideal soybean production are in progress in order to achieve yield potential beyond 2.5 tons per hectare. In Nigeria, smallholder farmers produce the majority of soybeans, as evidenced by their small farms' usage of minimal or nonexistent farm inputs including fertilizer and enhanced varieties. Because most farmers rely on using local soybean varieties and rainfed conditions to reduce production costs, this restricts the number of soybeans that can be produced at its best.

5.0 Agronomic Practice for Soybean Production

Moderately productive, well-drained sandy or medium-loam soil with a pH of 4.5 to 8.5 is ideal for growing soybeans. Considering to the variations in the amount of rainfall in Nigeria's savanna region, early June and the second week of July are suggested times to sow. Research on how row spacing affects soybean production shows that, for some carefully chosen soybean varieties, the shorter the row spacing, the higher the yield (Nater *et al*., 2021). It had been recommended to space soybean 50 cm by 10 cm instead of the standard 75 cm by 10 cm. It is advised that fertilizer containing single and triple superphosphate be applied to soybean fields at moderate rates, around 75 and 150 kg/ha, respectively, in order to increase soybean production. Weed control is essential for the best possible soybean yield.

6.0 Cultivar selection for Soybean Production

Climate change is causing a shift in Nigeria's agroecological zones, which poses a challenge to formerly surviving soybean varieties. This makes it necessary to choose soybean cultivars that can flourish in challenging environments and that can withstand or repel diseases and pests. The National Cereal Research Institute (NCRI) and IITA collaborated to enhance the soybean variety in order to increase yield and provide resistance to rust, blight, and leaf spot. They concentrated on three agroecological zones that are thought to be appropriate for the production of soybeans: the Sudan savanna, Derived, and Guinea. Based on the maturity group, the improved varieties resulting from the breeding

programmes were divided into three groups: early (91-100 days), medium (100-110 days), and late (>110 days) maturing soybean varieties (Tefera *et al.*, 2019).

This soybean development programme increased production from 0.5 tons/ha to over 1 tons/ha and made soybean varieties suitable for every agroecology in Nigeria's savanna zone available (Bebeley *et al.*, 2022). However, there is a noticeable difference in the amounts of soybeans produced in research stations with better variety field trials than in fields belonging to farmers. In Nigeria's southwest, soybean cultivar TGX 1485-1D has a significant potential yield but is rust-prone, whereas TGX1951-3F fared better across the country's entire savanna agroecology. In Guinea savanna agroecology, soybean cultivars TGX 1448-2E, TGX 1987-10F, and TGX 1835-10E grow well and yield more (Pajo *et al.*, 2018).

7.0 Impact of Soybean Production

Because so much soybean is grown in the north east, the Northern region of Nigeria has seen a growth in the number of industries, particularly in the areas of oil mills, livestock feed mills, and cereal processing companies. Nigerian farmers who grow soybeans, particularly those in the country's middle belt, are expanding their output in order to increase revenue from both local and international markets now that they are aware of the crop's potential as a cash or food crop. The present soybean selling price, which takes into account the low need for fertilizer, encourages farmers. The poultry business in Nigeria has grown rapidly due in part to the relative availability of soybean meal in the country. In Nigeria, almost 25% of the soybean crop is used immediately in the rural areas where it is grown. Food security, farmer poverty, and Nigerians' nutritional status are all being improved by the production of soybeans.

8.0 Factors affecting Soybean Production in Nigeria

Abiotic Stress: Nigeria's output of soybeans and other food crops is seriously threatened by climate change. Because rainfed agriculture is the only source of food for Nigerian farmers, the country is severely affected by the effects of climate change, including rising temperatures, flooding, water shortages, the introduction of new pests and illnesses, and more (Tologbonse *et al.*, 2015). Flooding along Nigeria's coastline, a shorter harmattan season in some areas (from November to March to two months in December and January), and low crop yields are all signs of the country's changing climate. In summary, Nigeria's shifting agroecological zones are caused by climate change (Bosello, *et al.*, 2018). In the producing region, the length and amount of rainfall decrease with increasing northward movement. Nigeria's guinea savannah agroecology is distinguished by strong sunlight during crop

maturity and harmattan winds, which facilitate pod-shattering and account for almost 80% of losses that impact soybean yield (Bebeley *et al*., 2022).

Biotic Stress: The most common insect pests in the Guinea savanna of Nigeria's soybean crops are Aphis glycines (Hemiptera), beetles (Coleoptera), and other insects in the orders Hymenoptera and Orthoptera. Aphids, bugs, and beetles are among the insect pests that feed on foliage and cause significant harm to soybean plants. By sucking sap and spreading plant viruses, they physiologically stress soybeans. The pod-sucking bug Nezara viridula (Hemiptera), defoliating beetles Coleoptera like Siderodactylus sagitarius Meigen, and Egadroma discriminatum Bassi are common insect pests of the Sudanese savanna (Asala *et al.*, 2016). The blooming stage of soybeans attracts pod-sucking insects, which lowers the quality of the seed. The highest number of bug pests occurs in July. The type of soybeans grown, the number of natural enemies, and the current weather all affect the activities and population of insect pests on soybean fields. There is currently little information available about how this pest affects Nigeria's soybean crop. To support an adequate management plan, this data on predicted crop losses from insect pest damage is essential (Asala *et al.*, 2016).

Bacterial pustules are the cause of the observed early defoliation in most Nigerian soybean fields. Another significant disease affecting soybean foliage in Nigeria is frogeye leaf spot, which can also affect the seeds, pods, and stems. The fungus Phakopsora pachyrhizi is the source of soybean rust, a foliar disease that poses a danger to soybean production and causes 40–80% yield loss in Nigeria and other African countries that produce soybeans. Soybean rust was initially discovered in 1999 during the core soybean growing season in Oniyo, Oyo state, Nigeria. Because of the high levels of humidity and rainfall in Nigeria's derived savanna and southern Guinea savanna, soybean rust is a common problem. It turns immature soybean leaves brown and then causes them to fall off (Hossain *et al.*, 2024).

Plant viruses that impact soybean yield are stored in weeds surrounding soybean fields. Blackeye cowpea mosaic virus and soybean mosaic virus are significant viruses that impact productivity in Nigerian soybean-growing regions (Ahmed *et al.*, 2019).

9.0 Concept of Climate Change and Global Warming

Climate can be described as a long-term (average 35 years) averaged weather conditions of a location, which include typical weather patterns, storm frequency and intensity, cold snaps, and hot temperatures. The five interacting components of a highly complex system that collectively make up the climate are the atmosphere (air), hydrosphere (water), cryosphere (the area of the planet that is frozen), land surface, and biosphere (the area of the earth where life resides) (Fariya and Farida, 2015). Global warming and

climate change are intimately linked, particularly as co-travelers in the delicate balance between naturally occurring and artificially produced greenhouse gases (GHGs), which are commonly held to be the cause of the planet's atmosphere's and the oceans' rising temperatures. A change in the climate that can be directly or indirectly attributable to human activities is known as climate change. This change affects the temperature of the planet, leading to global warming. Climate change has the potential to affect all ecosystems, endangering human lives as well as social, political, and economic advancement (Wheeler, 2017).

The term "global warming" refers to both the present increase in surface air and ocean temperatures as well as the predicted continuation of this trend. The term "climate change" refers to certain observable alterations in the natural world that are associated with human activity, especially actions that alter the earth's atmosphere and ultimately result in global warming. The average temperature of the planet's atmosphere, oceans, and coasts can be measured when the quantity of heat-trapping gases, or greenhouse gases (GHGs), such as water vapour, CO2, methane, nitrous oxide, and manmade chemicals, increases (Ayoade, 2019). Conversely, climate change encompasses both global warming and other reversal movements that would point to a cooling rather than a warming. Global warming is one of the main causes of climate change. A change in climate usually lasts at least 150 years and has visible, long-lasting consequences on the ecosystem; secular variations in climate that last between 100 and 150 years might not be called climate changes if they will quickly reverse (Fariya and Farida, 2015). The terms "climatic variability" and "climatic fluctuations" are more often used than "climate change." These sentences suggest that, over a variety of time scales, climate is intrinsically dynamic. These shifts in the temporal scale could be periodic, quasi-periodic, annual, decadal, seasonal, monthly, or non-periodic (Ayoade, 2019).

For a very long time, Nigeria's climate has changed in many ways, and the government has paid little or no attention to these changes. Its inhabitants' lives are becoming more challenging, as seen by the rising temperatures, shifting rainfall patterns, rising ocean levels, catastrophic flooding, land degradation, an increase in the frequency of extreme weather events, compromised clean water supplies, and a decline in biodiversity. All economic sectors are feeling the effects of environmental degradation, but the agricultural sector is severely affected because crops and cattle—farmers' only sources of income—are in poor shape (Elisha *et al.,* 2017; Ebele and Emodi, 2016; Olaniyi *et al.,* 2019). Climate change has caused unexpected increases in the length and intensity of rainfall in some parts of the nation, while having the opposite effect in other areas. Certain areas also experience flooding and waste water from heavy rains, which is harmful to human health and agricultural productivity. If the government and all stakeholders do not take any action to reduce its impacts, rainfall in the southern part of Nigeria is

expected to grow and rising waters are expected to worsen floods and submerge the coastline (Nzeh, Uke, Attamah, Nzeh, and Agu, 2016).

As we all know, change is inevitable, but it can be challenging to adjust to a new environment after becoming acclimated to one. This transformation is the biggest threat to human existence in the twenty-first century. Climate change is a result of a process known as global warming, which is typically attributed to "greenhouse gases" produced by human activities as well as other inevitable natural processes. Global warming is having an impact on both developed and developing nations; however, developing nations are more acutely affected because they are the main sources of climate variation and lack the political, social, and economic infrastructures needed to effectively mitigate these effects. According to the German Advisor Council on Global Change (GACGC), global warming is a serious problem that has already had a significant detrimental effect on people, animals, the environment, and ecological systems in every nation on Earth, albeit to varying degrees. Industrialized nations have been perceived to be less vulnerable to the effects of global warming because of factors such as wealth, natural advantages, better adaption strategies, advanced technology, mechanized agricultural systems, and government regulations. The industrialized economies have been able to mitigate the negative consequences of climate change because of these characteristics (Olaniyi *et al.*, 2019; Sunday, 2020).

Because of Nigeria high temperatures, limited ability to adapt, absence of an early warning system, and ineffective policies, has made Nigeria as one of the developing countries most affected by environmental change. Nigeria is currently suffering unfavorable climate conditions as a result of severe climate change, which is negatively affecting the lives and properties of millions of people. Frequent droughts, flooding, off-season rains, and dry spells have made it difficult for farmers in a country that primarily depends on rain-fed agriculture to determine the exact growing seasons. Because lakes are drying up and river flows in the arid and semi-arid areas are significantly decreasing, it is getting harder to find water for agriculture, which will negatively affect agricultural output. Global warming would have a severe effect on Africa, and Nigeria in particular, as we do not have the necessary characteristics and technologies to adapt to change (Olaniyi *et al.*, 2019).

10.0 Farmers Perception of the Effect of Climate Change on Soybean Production

Farmers overwhelmingly perceive climate change as a significant threat, noting increased temperatures, erratic rainfall, and higher rates of pests, leading to reduced crop yields and increased poverty. They adapt by using early-maturing, drought-resistant seeds, adopting mixed cropping, and diversifying crops The perception of farmers on the effect of climate change on soybean farming or production shown that many of the farmers notice the following effects on the farm

10.0.1 Stunted Growth of Soybean: Stunted growth of soybean refers to a condition where the plant is significantly smaller, shorter, and less developed than expected for its age, often accompanied by a reduced root system, fewer nodes, and lower biomass. This phenomenon indicates that the soybean plant is under stress, which inhibits cell division and metabolic functions, generally leading to lower pod counts, poor seed fill, and reduced overall yield. Stunted soybeans often have lower yield potential due to a reduced number of pods and smaller seeds. However, if the stress occurs early in the vegetative stages, soybeans may sometimes compensate by producing new growth, provided favorable conditions for growth (Ruiz Diaz, 2023).

10.0.2 Delay Flowering of Soybean: Delaying soybean flowering—often desired to increase biomass, nodes, and yield in early-maturing types—can be achieved by selecting varieties with higher relative maturity (later maturing) or by moving planting northward. Long-day conditions (closer to the summer solstice) also naturally delay flowering by slowing photoperiod-sensitive cultivars. Soybeans are short-day plants; longer days (summer) or shorter nights prevent flowering. While delaying flowering can increase biomass in some situations, it may also lead to a risk of premature frost before maturity, especially if the delay is too significant (Billore *et al.*, 2018).

10.0.3 Early Flowering of Soybean (4.05): Early flowering in soybeans, often triggered by short days, high temperatures, or drought stress, causes plants to enter the R1 (beginning bloom) stage earlier than normal, sometimes at the V4 stage instead of V7–V10. While this can allow for faster maturity, it often leads to reduced height, fewer nodes, and lower yield potential due to shorter reproductive periods. Soybeans are short-day plants; days becoming shorter (typically after June 21st) trigger flowering. High temperatures and drought conditions accelerate this process, forcing early blooming (Ogiso-Tanaka, Shimizu, Hajika, Kaga and Ishimoto, 2019)

10.0.4 Change in Sowing Time and Maturity Duration (4.09),: Climate change is forcing earlier soybean sowing to avoid late-season drought, although this increases risks from low temperatures, pests, and diseases. Rising temperatures shorten the vegetative growth period, accelerating maturation. Optimizing sowing (e.g., late June in some regions) is crucial to manage maturity duration and maximize yields against climate variability. Higher temperatures can reduce the grain-filling period and accelerate plant senescence, leading to lower yields (Lee, Kim, Lee, Kim, Jeon, Shin, Jang, Sung, 2025)

10.0.5 Reduction in Germination Podding and Quality of Soybean: Reductions in soybean (Glycine max) germination, podding, and overall quality are primarily caused by environmental stresses—most notably excessive rainfall, drought, and high temperatures during the reproductive stages (R1-R8). These factors lead to physiological, pathological, and physical damage, resulting in lower seed viability, reduced pods per plant, and poor grain quality. Drought stress during early reproductive stages (R1-R4)

significantly reduces the number of nodes, pods, and total seeds. Wet/dry cycles make pods brittle and prone to splitting, leading to early seed loss (shattering) before harvest (Lee, *et al*, 2025)

10.0.6 Soil Erosion: Soil erosion significantly reduces soybean production by depleting essential nutrients, organic matter, and moisture-holding capacity, leading to yield losses of 15–30% compared to non-eroded soils. Severe erosion can reduce soybean yields by up to 59%, while a 10 cm loss in topsoil can cause a 4.0%–27.0% reduction in yield. As erosion increases, soybean yields show a marked decrease, with severe erosion significantly reducing grain yield, leaf area, and root weight. Erosion reduces the soil's ability to retain water, which is the most critical limiting factor for soybean growth. Topsoil removal lowers essential soil organic carbon (SOC), nitrogen, and phosphorus contents (Panagos, *et al.* 2024)

10.0.7 Increase in the Cost of Cultivation of Soybean: Climate change significantly increases the cost of cultivating soybeans by elevating input costs for pest control, irrigation, and remedial farming practices, while simultaneously reducing net revenue due to lower yields. Rising temperatures and erratic rainfall (droughts and flooding) have escalated production expenses, particularly in regions like India and Nigeria, where rainfed agriculture is prevalent. Higher temperatures and humidity levels foster the proliferation of pests (e.g., stem fly, pod borers) and diseases, increasing the cost of pesticide application. Erratic rainfall and prolonged dry spells require increased expenditure on irrigation to prevent crop failure. In some cases, water shortages during the flowering and pod-filling stages lead to 31% direct production losses, requiring higher costs for mitigation (Ibrahim, *et al* 2016)

10.0.8 High Incident of Soybean Pest and Diseases: Climate change is driving a high incidence of soybean pests and diseases by altering environmental conditions, which expands the geographical range of pathogens and insects, enhances their survival rates, and increases the frequency of outbreaks. Rising temperatures, elevated levels, and volatile precipitation patterns are creating environments that favor pathogen virulence and pest reproduction, often leading to reduced soybean yield and quality. Higher temperatures accelerate the life cycles of insects, allowing for more generations per season. Each degree-Celsius rise in temperature could increase global yield losses from insect pests by 10–25%. While some pathogens thrive in wet conditions, dry conditions caused by climate change can promote diseases like charcoal rot (caused by *Macrophomina phaseolina*) and Fusarium wilt (Adak *et. al.*, 2023)

10.0.9 Post-Harvest Losses Due to Climate Variability: Post-harvest losses (PHL) in soybean due to climate variability are a critical issue, with studies indicating that up to 8% of soybean production can be lost between harvest, transport, and storage. Climate-driven variability, including erratic rainfall, high temperatures, and extreme weather events, directly impacts the quantity and quality of soybean by intensifying spoilage and disrupting post-harvest operations. Increased humidity and higher, erratic

temperatures during storage, especially for farmers using traditional methods, lead to elevated moisture content in seeds. This accelerates metabolic activity, causes grain breathing, and increases the likelihood of mold and microbial contamination (Adak *et. al.*, 2023)

10.0.10 Reduced Yield of Soybean: Climate change, driven by drought, heatwaves, and excessive rain, is significantly reducing global soybean yields, with losses estimated up to 50% in certain regions during extreme years. Key factors include water deficits during reproductive stages, shortened growing periods, and increased pest pressures, often canceling out benefits from elevated water. Soybean yields are highly sensitive to water availability. Droughts, such as those in 2009, 2012, and 2018, caused massive production deficits, including a 31% reduction during severe events in some regions. Rising temperatures, especially increasing night temperatures, negatively impact yield, with studies suggesting a 17% decline for every degree of warming (Chander, *et. al.*, 2023)

11.0 Impacts of Climate Change on Various Sectors of Nigeria

The vast majority of the earth is experiencing decreasing precipitation and rising temperatures due to climate change. These can have positive or negative ecological consequences depending on the location in the world. The cumulative and eventual impacts of unchecked greenhouse gas emissions and the continuous depletion of the ozone layer, which serves as a protective barrier, result in rising global temperatures (Okareh and Dada, 2020). An increase in global temperature is anticipated to affect natural ecosystems, cause changes in the amount and pattern of precipitation, raise sea levels generally, and cause coastal areas to flood. Reduced stream flows, changed agricultural yield, species growth as a result of the loss of ecological niches, and an expansion of disease vector ranges are some further consequences of climate change on agriculture. The same would hold true for our water bodies, which are rich in biodiversity, our wetlands, which are ideal breeding grounds for many kinds of biodiversity, and our trees, which help filter the air. There could be an increase in the frequency and intensity of bush and woodland fires (Sunday, 2020). Some of the sectors that are affected by climate change include:

11.1 Agricultural Sector: The scientific community is coming to a greater consensus that global temperatures will rise and precipitation patterns will shift during the coming years. Climate change will lead to inadequate or subpar agricultural output, such as low crop yields, etc. This is particularly true in low-income countries where the primary factors influencing agricultural productivity are climate and insufficient capacity for response (Temesgen, Rashid, and Claudia, 2020). Many African countries, such as Nigeria, are particularly vulnerable to climate change since their economies mostly depend on weather-sensitive farming methods. This susceptibility has been demonstrated by the devastating effects

of recent flooding in some parts of the country and the various lengthy droughts that are currently occurring in some sections of the Northern region (Roco, Bravo, Engler, and Jara, 2017).

There is a significant risk that changes in precipitation timing and amount, frequent outbreaks of crop pests and diseases, and heat stress would have on Nigeria's food production system, given that 80% of the country's population depends on rain-fed agriculture and fishing as their primary source of income. Because greenhouse gas emissions will increase the risk of hunger by an additional 80 million people in Africa by 2080, food shortages will worsen and many farmers may lose their livelihoods as a result of global warming. Climate change has already started to negatively affect agriculture and food security and is likely to do so in the future. Unquestionable evidence already exists showing the distribution and behaviors of plants, animals, and birds are all impacted by climate change (Okon, Falana, Solaja, Yakubu, Alabi, Okikiola, Awe, Adesina, Tokula, Kipchumba, Edeme, 2021).

If greenhouse gas emissions are not significantly reduced, 25% of animal, bird, and plant species may become extinct due to climate change. The country's agricultural practices have altered in some areas due to global warming (William, 2017). In addition, the growing season's reduction brought on by recurrent droughts and insufficient rainfall has exacerbated crop failure and the food shortage brought on by climate change. Due to insect and disease incidences that grow more varied and uncontrollable in severe weather, crop yields are declining. The country's northeast is especially vulnerable to severe droughts and floods, which can affect livestock output, agricultural operations, and harvests (Bahta and Myeki, 2022).

Agriculture is the primary occupation and source of income for over 70% of the country's people. The main source of agriculture in Nigeria is rain. The fluctuations in rainfall provide a difficulty for farmers in planning their operations (Onwutuebe, 2019, Shiru *et al.*, 2018; Nkechi *et al.*, 2016). Crop output is impacted by reduced acreage as a result of droughts, deserts, higher temperatures, and less rain, as well as by lower agricultural productivity. Increased rainfall along the coast, rising sea levels, flooding, and farmland degradation will all contribute to lower agricultural productivity (Ogbuabor and Egwuchukwu, 2017).

11.2 Demographic impacts: Climate change will affect people in different ways depending on their age, gender, social class, and economic level. Since a larger percentage of women are impoverished farmers who depend on small-scale, rain-fed agriculture, women will also continue to be disproportionately affected by the agricultural sector's high susceptibility to climate change (Amobi and Onyishi, 2015). Women are dependent on natural resources because they are usually in charge of getting the family's food, water, and wood for heating and cooking. Since many of them miss school when it

rains, particularly in isolated villages with little transportation, children are also impacted by the effects of climate change in that their education is significantly disrupted Hunger caused by a lack of food is another hinderance to children's capacity to learn (Amanchukwu *et al.*, 2015).

11.3 Economic Sector: Economic development is the process of using a nation's natural and human resources to further that nation's interests. It entails improving people's lives by providing them with social amenities. An additional 3 billion people are expected to need to be fed by 2030, during a period when many countries are struggling with more extreme weather conditions like sea storms, droughts, and floods. Climate change and the cost of addressing global warming—estimates vary by country but are typically in the trillions—have an impact on almost every element of the economy. Climate change may impede UN attempts to halve global poverty and establish a world free from hunger because of its effects on agriculture and food costs. As per the Report, governments in Africa may suffer continual losses of up to four to five percent of their GDP if global temperatures rise by two degrees Celsius. In contrast, wealthier nations would only experience minimal losses. Again, the Report projects that the annual cost of mitigation measures to lower carbon emissions in developing countries might reach $400 billion by 2030. It becomes more difficult to transform infrastructure, businesses, and way of life the longer important climate change issues are disregarded (Robert, Ariel, and Larry, 2018).

While some individuals witness the favorable financial consequences of global warming, others encounter its adverse implications. Among the organizations that make money are those that are able to quickly adapt to the shifting needs of the planet and its people, those that are situated in warmer climates and won't flood, and those whose job it is to do scientific research on the natural world (Gregg, and Graham, 2019). The financial benefits of global warming are already being seen by "green" firms. Many businesses and careers quickly become outdated and fail. Global warming also affects the production of forest goods like wood and cane in Nigeria due to erosion and strong winds (Jonathan, and Emmanuel, 2017). Because of this, there will be less money and forestry produce, which will drive up the cost of building and furnishing supplies. Deforestation and losses in nontimber forest products were expected to have cost Nigeria's economy N120 billion a year, or 1.7% of GDP, over the preceding five years. The effects of global climate change are expected to be rather severe by 2030, when they will likely worsen and could cause an approximate 30% reduction in average income. This is because of the potential outcomes of climate change. Policies that reduce the use of fossil fuels like oil, gas, and carbon have a huge economic impact on the companies who produce or, more accurately, provide these fuels. A sustained decrease in the utilization of fossil fuels will have a significant impact on the economic condition of Nigeria.

Given the significance of agriculture to Nigeria's economy and way of life, issues with crop yields and productivity may have a negative impact on GDP because of climate change. Extreme weather conditions, like floods, can also hinder economic growth by causing damage to infrastructure and production, necessitating exorbitant spending.

14.4 Environmental Sector: The word "environment" encompasses any harsh circumstances that affect the way organisms live and change, whether they are found on land, in the air, or in water. It encompasses all that surrounds and is contained within one individual, including the environment's resources, other people, the air, water, and land, as well as their interactions. An environment is a system in which organisms interact with their external surroundings. Nigeria is among the African countries most vulnerable to the adverse impacts of climate change. Nigeria will face drought, desertification, and rising sea levels as a result of climate change. Climate change affects the characteristics and nature of freshwater supplies, which are vital to many Nigerians. Sea level rise and extreme weather will have an effect on fishing. Inland fisheries are also threatened by decreasing rivers and lakes and rising salinity (Ebele and Emodi, 2016). Some of the areas of environmental sectors mostly affected area:

Desert Encroachment and Drought: Nigeria is suffering as a result of the aridity and drought that are getting worse due to climate change. These environmental occurrences have been especially severe in the nation's northeast. The bulk of the northern states are being decertified, and this process is intensifying due to drought brought on by climate change in the region. As they advance further south, fast-moving desert conditions have reached the states of Adamawa, Gombe, Kwara, Kogi, Nasarawa, Niger, and the Plateau. This has severely impacted the grasslands and vegetation in the north. Consequently, the entire savanna environment of the nation has been fundamentally altered by desertification (Jonathan, and Emmanuel, 2017).

Food shortages may result from heat stress, drought, and fluctuations in precipitation. These factors can also negatively affect agricultural productivity. The northern states pose a substantial danger to the nation's food security due to their high vulnerability to climate change. The drought that has plagued parts of Northern Nigeria has resulted in a decrease in the amount of drinking water available (Abdulkadir *et al.,* 2017; Elum *et al.,* 2017; Ebele and Emodi, 2016).

Soil Erosion/Flooding: There is a serious environmental concern associated with erosion and the flooding that results in many parts of Nigeria, especially in the southeast. The zone is commonly identified by various forms of erosion, such as gully, rill, and sheet erosions. Gully erosion is the biggest danger to the survival of local populations and villages, though (Aliyu, Nura, and Abiodun, 2017). Human activities, such as bush burning, deforestation, improper farming methods, and most crucially,

construction activity (building of buildings, industries), are mostly to blame for the erosion problem facing the area. However, because of the loosely cemented subsurface geological layers in these areas, rainfall intensity and duration are the most important natural sources of soil erosion (Wen, and Elliot, 2018). These areas were more severely affected by extended rainfall and increased flooding, which resulted in significant erosion and sedimentation. Devastation of priceless property, loss of livelihoods, loss of ecosystems and soil minerals, loss of productivity, and extinction of plants and animals (like fish in rivers and streams) due to the spread of poisons or mineral deposits to other natural ecosystems are just a few of its effects. Lost production and valuable property pose a danger to food security, personal safety, and social order and may result in internal relocation (Wen, and Elliot, 2018).

Depletion of Biodiversity: There are many different kinds of plants and animals, as well as subspecies of primates, wetland, rainforest, savanna grasslands, and other unique ecosystems and species that exist in a certain area (Davide, 2022). The biodiversity of a country is one of its natural resources, vital to human survival and the advancement of society. This is mostly due to the fact that biodiversity acts as a storehouse for genetic resources that can be used for pharmaceutical research, food security, and the manufacture of wood for furniture and fuel. Recent estimates indicate that between 15 and 37 percent of a sample of 1,103 terrestrial plants and animals would eventually become extinct due to the expected temperature increases by 2050 (Tais and Susanne, 2020).

Climate change is expected to have a significant impact on Nigeria's already limited supply of electrical power due to its effects on hydroelectric and thermal output. Less rain in the north, for example, results in fewer trees and less biomass available for burning, which affects the generation of hydroelectric power. Increased precipitation intensity along the coast and in rainforest regions is also expected to negatively affect energy generation by bringing down transmission networks and substation equipment (Davide, 2022).

Coastal Erosion/Flooding: Floods and coastline erosion are the main environmental problems in Nigeria's south-south region, which is commonly referred to as the Niger Delta. Of Nigeria's 853 km of coastline, the Niger Delta accounts for around 450 km. Of the 30 million people that live in the Niger Delta region, more than 75% live along the coast and rely mostly on fishing and agriculture for their subsistence. There is a major risk to the lives, property, way of life, and infrastructure of the local population due to the problem of coastal erosion and floods caused by storm surges and sea level rise.

11.5. Health Impacts: The effects of climate change on human health are multifaceted, both directly and indirectly. For example, increased temperatures, increasing sea levels, and an increase in storm frequency all have a major effect on human health in terms of disease and harm. The sea and ocean

levels rise during the rainy season due to global warming. As a result, flooding could happen, making the impoverished more vulnerable to illnesses like pneumonia, cholera, typhoid, and malaria Haines (Ayoade, 2019). The dynamics of temperature and rainfall may contribute to the spread of disease vectors such as dengue and malaria, as well as an increase in the occurrence of diarrheal illnesses. Urban flooding survivors run the risk of spreading diseases and developing mental disorders (Kovats, Campbell, Corvalan, 2016). The dynamics of temperature and rainfall may contribute to the spread of disease vectors such as dengue and malaria, as well as an increase in the occurrence of diarrheal illnesses. Urban flooding survivors run the risk of spreading diseases and developing mental disorders. Extreme weather, especially in the north of Nigeria, is often the cause of multiple illnesses. Static water from heavy rains can attract mosquitoes, which can then transmit malaria to those nearby (Shiru, Shahid, Dewan, 2020).

The indirect impacts, albeit hard to define, might include disease-carrying vectors, increased psychological stress and depression, and a feeling of isolation among persons who have had to evacuate their homes because of natural catastrophes (Nura, and Alison, 2022). Meningitis, measles, and chicken pox are just a few of the ailments that are more likely to arise during hot weather. Insects and viruses can spread more quickly during bad weather. The weather and surroundings have a big impact on asthma episodes, with temperature having a bigger effect than any other meteorological factor (Shiru, Shahid, Dewan, 2020). The weather and surroundings have a big impact on asthma episodes, with temperature having a bigger effect than any other meteorological factor. The attack may take the form of an indirect infection (an increase in other infectious disorders due to more widespread infections from insects) or a direct infection (deaths and illnesses caused by heat extremes, injury from floods and storms). Effects of air pollution on the lung's malnutrition brought on by illnesses brought on by migration and social unrest, as well as disturbances to agriculture.

11.6. **Human and National Security:** Security is a basic concern for all people, whether they be individuals, communities, or governments. There are several different kinds of security that are often mentioned, including state, local, social, and national security. The body of research on the relationship between climate change and security has expanded dramatically as a result of growing scholarly and popular interest. States, international organizations, and regional groups are all concerned about the relationship between climate change and security (Oya, 2021). Considering the corpus of extant research, it can be inferred that a common understanding of how climate change will impact national security views it mainly as a stressful event within a state's security threat matrix. Climate change is considered a "threat multiplier of instability" in Nigeria (Military Advisory Board, 2019). According to

this perspective, climate change is a threat to national security because it has the potential to exacerbate already unstable security situations or bring about new disruptions that profoundly alter social order, lower national income, and upend political order. National security is at risk due to the cumulative impact of the different effects of global climate change on businesses, communities, and governments (Christopher, Julian, Eileen, and Jennifer, 2021).

Drought intensification brought on by climate change in one area of a country may result in failures for livestock and agriculture, the loss of livelihoods, and a rise in food poverty. People can thus be compelled to migrate in order to survive or to create new sources of income. Such adaptive conduct, which can occasionally be criminal, poses a threat to national security, just as resource disputes resulting from migrant arrivals in new settlement areas jeopardize the stability of the host society (Christopher, *et. al* 2021).

12.0 Coping Strategies Adopted by Soybean Farmers

The farmers ability to employ coping system that will enable him or her overcome new climate change challenges in a given farming season is what farmers are adopting in their agricultural activities. The collection of quick actions or reactions to possible effects that can be successfully used seasonally or annually to preserve farmer's agricultural livelihood, way of life, and income etc. is known as coping strategies. Certain coping mechanisms are specifically anticipatory and include things like off-farm activities and emergency implementation of programs that can reduced the effect of climate change.

Some of the coping strategies adopted by soybean farmers include:

1 Participated in government intervention program that provides fertilizer and improved soybean seed to farmers

2 Participated in crop insurance against natural disaster,

3 Increase the use of organic manure

4 Use of credit facility to increase soybean production

5 Plant pests and disease resistant/tolerant soybean varieties

6 Plant other crops on the same farm land with soybean (multi-crop agriculture)

7 Decrease the use of chemical fertilizer on their soybean crop

8 Plant drought resistant/tolerant soybean varieties

9 Use of irrigation facilities

10 Migration of soybean farmers to another community due to climate change effect

11 Regular contact with extension agents for information

12 Change planting dates of soybean

13 Drainage construction around the farm for free flow of rain water

14 Engaged in off-farm activities

15 Practiced shifting cultivation method of agriculture as soybean farmer

16 Change plant spacing of soybean

17 Adapted different methods of coping strategies.

13.0 Conclusion

Climate can be described as a long-term (average 35 years) averaged weather conditions of a location, which include typical weather patterns, storm frequency and intensity, cold snaps, and hot temperatures. The five interacting components of a highly complex system that collectively make up the climate are the atmosphere (air), hydrosphere (water), cryosphere (the area of the planet that is frozen), land surface, and biosphere (the area of the earth where life resides). Farmers overwhelmingly perceive climate change as a significant threat, noting increased temperatures, erratic rainfall, and higher rates of pests, leading to reduced crop yields and increased poverty. They adapt by using early-maturing, drought-resistant seeds, adopting mixed cropping, and diversifying crops. Soybean (*Glycine max*) is an important leguminous crop widely cultivated in Nigeria for food, oil, and feed purposes. It is cultivated because it naturally increases soil fertility, which raises agricultural yields and in Nigeria, soybean is an important source of protein that is consumed to address nutritional issues. Moderately productive, well-drained sandy or medium-loam soil with a pH of 4.5 to 8.5 is ideal for growing soybeans. Considering the variations in the amount of rainfall in Nigeria's savanna region, early June and the second week of July are suggested times to sow. Nigerian farmers who grow soybeans, particularly those in the country's middle belt, are expanding their output in order to increase revenue from both local and international markets now that they are aware of the crop's potential as a cash or food crop.

14.0 References

Abdulkadir, A. Maryam, Muhammed (2017). Climate change and its implications on human existence in Nigeria: a review. *Bayero Journal of Pure and Applied Sciences,* 10,152-158.

Adak S, Mandal NA, Mukhopadhyay A, Maity PP and Sen S. (2023). “Current state and prediction of future global climate change and variability in terms of CO2 levels and temperature, pp. 15–43. In: Enhancing Resilience of Dryland Agriculture Under Changing Climate: Interdisciplinary and Convergence Approaches, Singapore: Springer Nature Singapore.

Ahmed, A.A., Kolo, M.G.M., Salahudeen, M.T., Wada, A.C. (2019). Weed hosts of major legume viruses in Niger state, Southern Guinea Savanna of Nigeria. *International Journal of Current Research in Biosciences and Plant Biology*. 6. 30-36.

Akande, A., Costa, A.C., Mateu, J., and Henriques, R. (2017). Geospatial Analysis of Extreme Weather Events in Nigeria (1985–2015) Using Self-Organizing Maps. *Advances in Meteorology, 2017*, 8576150

Akintonde J, O. and Shuaib L (2016) Assessment of Level of Use of Climate Change Adaptation Strategies Among Arable Crop Farmers Oyo and Ekiti States, Nigeria. *J Earth Sci Clim Change* 7:369. doi: 10.4172/2157-7617.1000369

Aliyu, H. I., Nura, A. Y. and Abiodun O. A. (2017). Assessing the Socio-Economic Impact of Gully Erosion in Chikun Local Government Area, Kaduna State, Nigeria. *International Journal of Advanced Studies in Economics and Public Sector Management. 5(2).30-50*

Al-Tayar, A.R., Ali, M.A., and Shaker, A.T. (2020). The Response of Growth, Yield and Quality of Two Soybean Varieties Glycine Max (L.) To Sowing Depth. *Plant Archives, 21*.

Amanchukwu, R.N., Stanley, G.J., & Ololube, N. (2015). A Review of Leadership Theories, Principles and Styles and Their Relevance to Educational Management. *Management Science, 5*, 6-14.

Aminu, R. O., Kilani, F. A., Ibrahim, S. B., Afolayan, S. O., and Ayinde, I. A. (2023). Assessing Climate Change Vulnerability and Risk Coping Strategies among Arable Crop Farming Households in Oyo State, Nigeria. *Nigerian Agricultural Journal* 54, (1) 141

Amobi, D. and Onyishi, T. (2015). Governance and climate change in Nigeria: A public policy perspective. *Journal of Policy and Development Studies*, 9(2), 199-210.

Asala, S.W., Olubusuyi, P.T., Abdulrazaq, S. (2016). Evaluation of insect pests associated with growth of soybean [Glycine max (L.) Merr] in Nigerian Guinea Savanna. *International Journal of Advance Agricultural Research.* 4:51-56.

Ayoade, J. O. (2019). Introduction to climatology for the tropics. *Implications of tropical atmospheric behavior and climate change for those living in* the tropics. *Journal of Climatology 4 (2) 628*

Bahta, Y. T. Myeki, V. A. (2022). The Impact of Agricultural Drought on Smallholder Livestock Farmers: Empirical Evidence Insights from Northern Cape, South Africa. *Agriculture, 12*,

Bebeley, J. F. Kamara, A. Y. Jibrin, J. M. Akinseye, F. M. Tofa, A. I. Adam, A. M. Kamai, N. and Solomon, R., (2022). *Evaluation and application of the CROPGRO-soybean model for determining optimum sowing windows of soybean in the Nigeria savannas. Scientific Reports (TSI), 12. 1-15. 2045-2322*

Billore, S. D., Dupare, B. U. and Purshottam S., (2018). Addressing Climate Change Impact on Soybean through Resilient Technology. *Soybean Research* 16(1&2): 01-24

Bosello, F., Campagnolo, L., Cervigni, R. (2018). Climate Change and Adaptation: The Case of Nigerian Agriculture. *Environ Resource Econ* **69**, 787–810 (2018). https://doi.org/10.1007/s10640-016-0105-4

Chander S, Ghosh D, Pawar D, Sreekanth D, Chethan CR and Singh PK. 2023a. Elevated CO2 and temperature influence on crop–weed interaction in soybean. Indian Journal of Weed Science 55(3): 287–293.

Christopher, F. Julian, E. B., Eileen, S. and Jennifer S. (2021). Climate Change Poses a Widening Threat to National Security. The New York Times

Davide V. O. (2022). Achieving sustainable environmental governance in Nigeria: A review for policy consideration. *Urban Governance*.

Dioha, M. O. and Emodi, N. V. (2018). Energy-climate dilemma in Nigeria: Options for the future. International Association for Energy Economic Forum

Dugje, I.Y., L.O. Omoigui, F. Ekeleme, R. Bandyopadhyay, L. Kumar, and A.Y. Kamara. (2019). Farmers' Guide to Soybean Production in Northern Nigeria. International institute of Tropical Agriculture, Nigeria. 21(4) 324-332

Ebele, N. E. and Emodi, N. V. (2016). Climate change and its impact in Nigerian economy. *Journal of Scientific Research & Reports*, 10(6), 1-13.

Elisha, I. Sawa, Ejeh and Lawrence (2017). Evidence of climate change and adaptation strategies among grain farmers in Sokoto State, Nigeria. IOSR *Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 11(3), 1-7.

Elum, Z. A, Modise, D. M, Marr, A. (2017). Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. Climate Risk Management 16:246-257.

Enete, A. A., Otitoju, M. A. and Ihemezie, E. J., (2015). The Choice of Climate Change Adaptation Strategies Among Food Crop Farmers in Southwest Nigeria. *Nigerian Journal of Agricultural Economics* (NJAE). 5(1). 72- 80

Falade, A.O., Oboh, G., Okoh, A.I. (2017). Potential Health Implications of the Consumption of Thermally-Oxidized Cooking Oils – a Review. Pol. J. Food Nutr. Sci. 67:95–105.

Fariya A. and Farida A. (2015). Effects of climate changing on food crop production system in Ghana. *Academic Journal of Agricultural Science and Research* 3(4). 76-79

Federal Ministry of Environment (2015). Climate Change in Nigeria and National Communication (NC). NC 2.

Gregg, G. and Graham S. (2019). Climate Change Threatens the Stability of the Financial System

Hossain M. M, Sultana F, Yesmin L, Rubayet MT, Abdullah HM, Siddique SS, Bhuiyan MAB and Yamanaka N (2024) Understanding Phakopsora pachyrhizi in soybean: comprehensive insights, threats, and interventions from the Asian perspective. Front. Microbiol. 14:1304205. doi: 10.3389/fmicb.2023.1304205

Ibrahim F. D., Ibrahim, P. A., Odine, A. I., Jirgi, A. J., Usman R. K., Ogaji, A. and Gbanguba A. U. (2016). Impact of Climate Change on Soybean Production in Lapai Local Government Area of Niger State. Asian Journal of Agricultural Extension, Economics & Sociology 10(1): 1-6,

Jonathan E. O. and Emmanuel I. E. (2017). The Impact of Climate Change on the Nigerian Economy. *International Journal of Energy Economics and Policy. 5(2). 217*

Kovatsa, R.S., Hainesa, A. Campbell-Lendrumb, D., and Corvalanb, C. (2016). Climate change and human health: Impacts, vulnerability and public health. Public Health 120, 585–596

Lee, J., Kim, M., Lee, B., Kim, M., Jeon, S., Shin, P., Jang, H., & Sung, J. (2025). Optimizing Sowing Time Using Cumulative Temperature-Tailored Yield of Vegetable Soybean. *Agronomy*, *15*(12), 2767.

Messina, M., Shearer, G., Petersen, K. (2021). Soybean oil lowers circulating cholesterol levels and coronary heart disease risk and has no effect on markers of inflammation and oxidation. Nutrition. 89:111343.

Military Advisory Board (2019). Report 'National Security and the Accelerating Risks of Climate Change. "Catalyst for instability and conflict."

Nater, I., Osabuohein, O.L., Sesugh, U.M., Chibuike, E.G., Peter, O. (2021). Effects of inter-row

Nkechi, O. Alphonsus E. (2016). Mitigating climate change in Nigeria: African traditional religious values in focus. *Mediterranean Journal of Social Sciences*, 7(6), 299-308.

Nura, U. and Alison Gray (2022). Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data. *International Journal of Environmental Studies* 80(3)540-561

Nzeh, E. C., Uke, P. C., Attamah, N., Nzeh, D. C., and Agu, O. (2016). Climate Change and Agricultural Production in Nigeria: A Review of Status, Causes and Consequences.

Ogbuabor, J. E. and Egwuchukwu, E. I. (2017). The impact of climate change on the Nigerian Economy. *International Journal of Energy Economics and Policy,* 7(2), 217-223.

Ogiso-Tanaka, E., Shimizu, T., Hajika, M., Kaga, A., and Ishimoto, M. (2019). Highly multiplexed AmpliSeq technology identifies novel variation of flowering time-related genes in soybean (Glycine max). DNA Res. 26: 243–260.

Okareh, O. T., and Dada A. (2020). A Systematic Review of the Causes and Challenges of Climate Change on Nigerians' Economy and Ecosystem. *Africa Journal of Medicine and Medical Science*. 48(1). 310

Okon, E. M. Falana, B. M. Solaja, S.O Yakubu, S.O. Alabi, O.O. Okikiola, B. T. Awe, T. E. Adesina, B.T. Tokula, B. E. Kipchumba, A. K. Edeme A. B. (2021). Systematic review of climate change impact in research in Nigeria: implication for sustainable development. P 7941

Olaniyi, O. A. (2019). Review of climate change and its effect on Nigeria ecosystem. *International Journal of African and Asian Studies*, 1(1)57.

Olapido, E. (2017). Towards enhancing the adaptive capacity of Nigeria: a review of the country's state of preparedness for climate change adaptation. Heinrich Böll Foundation Nigeria.

Onwutuebe, C. J. (2019). Patriarchy and Women Vulnerability to Adverse Climate Change in Nigeria. *Sage Open*, *9*(1). https://doi.org/10.1177/2158244019825914

Oya D. O. (2021). The Nexus Between Security Sector Governance/Reform and Sustainable Development Goal-16: An Examination of Conceptual Linkages and Policy Recommendations

Pajo, N. D., Vange, T., Kortse, P. A. (2018). Evaluation of soybean lines for resistance to rust (Phakopsora pachyrhizi). *International Journal of Environment, Agriculture and Biotechnology*. 3:469-476.

Panagos, P., Matthews, F., Patault, E., De Michele, C., Quaranta, E., Bezak, N., Kaffas, K., Patro, E. R., Auel, C., Schleiss, A. J., et al. (2024). Understanding the cost of soil erosion: An assessment of the sediment removal costs from the reservoirs of the european union. Journal of Cleaner Production, 434:140183.

Robert, M. Ariel, D. and Larry, W. (2018). The distributional impact of climate change on rich and poor countries. Environment and Development Economics

Roco, L. Bravo-Ureta, B. Engler, A. Jara-Rojas, R. (2017). The Impact of Climatic Change Adaptation on Agricultural Productivity in Central Chile: A Stochastic Production Frontier Approach. *Sustainability*, *9*, 1648.

Ruiz Diaz, D. 2023. Identifying nutrient deficiency symptoms in soybean. Kansas State University, Agronomy eUpdates. https://eupdate.agronomy.ksu.edu/article_new/identifying-nutrient-deficiency-symptoms-in-soybeans-551-5

Shiru, M.S., Shahid, S., Dewan, A. (2020). Projection of meteorological droughts in Nigeria during growing seasons under climate change scenarios. *Sci Rep* 10

Shiru, M.S., Shamsuddin Shahid, Noraliani and Eun-Sung (2018). Trend Analysis of Droughts During Crop Growing Seasons of Nigeria. *Sustainability*, 10(3), 871

Smith, B. (2017). The farming Handbook. University of KwazuluNatal Press, Hand covers. New 432

Sunday D. N. (2020). A Review of Greenhouse Gas Emissions from Fossil Fuels and Climate Change. *International Journal of Creative Research Thought* 8(5)2833

Tais W. D. and Susanne K. M. A. (2020). The impacts of land plant evolution on Earth's climate and oxygenation state – An interdisciplinary review

Tefera, H., Kamara, A.Y., Asafo-Adjei, B., Dashiell, K.E. (2019). Improvement in grain and fodder yields of early maturing promiscuous soybean varieties in the Guinea savanna of Nigeria. *Crop Science* 4(9)2037–2042

Temesgen T. D., Rashid M. H., and Claudia R. (2020). Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States. International Food Policy Research Institute

Tologbonse, E.B., Auta, S.J., Bidoli, T.D., Jaliya M.M., Onu, R.O., Issa, F.O. (2015). Farmers' Perception of the Effects of Climate Change and Coping Strategies in Three Agro-Ecological Zones of Nigeria. *Journal of Agricultural Extension* 14:125-136

Wen, P. and Elliot, M. B. (2018). The Concept of Food Security. Book: Module in Food Science

Wheeler, D. (2017) Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance. Center for Global Development, Working Paper 240.

William R. C., (2017). Global Warming and Agriculture: Impact Estimates by Country Washington: Center for Global Development and Peterson Institute for International Economics.