

**CLIMATE SMART ACTIONS (CSA) AQUACULTURE, AGROFORESTRY
AND RESOURCES MANAGEMENT**

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Global Issues & Local Perspectives

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TABLE OF CONTENTS

Preface

Editorial Note

Table of Contents

Acknowledgement

Dedication

**CLIMATE SMART ACTIONS (CSA) AQUACULTURE, AGROFORESTRY AND
RESOURCES MANAGEMENT-- ISBN 978-978-60709-1-6**

Part one: CLIMATE SMART ACTIONS (CSA)

Chapter 1:

Restoration and Sustainability of Ecological Resource for Biodiversity Conservation in Nigeria

¹Salami, K.D., Muhammad S.I. Adeniyi, K. A. and ¹Nasir, T. Y.

Chapter 2:

Application of Electronic Monitoring and Control Systems in Climate-Smart Aquaculture (CSA) Management

Dr. Reagan N. Robinson

Chapter 3:

Determinants of Climate Change Adaptation among Arable Crop Farmers in Akwa Ibom State, Nigeria

Et-eye Nyong ; Udoh, Enobong Donald Udosen, Idem-Obong

Chapter 4:

Climate-Smart Weed Management Strategies for Sustainable Crop Production and Ecosystem Health

*Shittu, E.A¹., and Abubakar, A²

Chapter 5:

Gender-sensitive, Gender-responsive and Gender-transformative Climate Smart Actions

Okwor, Uchechi Mercy¹ , Amanze Alice Nnenna², and Ujoh, Stella Ukachi³

Chapter 6:

**Smart-Climate Change Adaptation Practices among Smallholder Farmers in
Nigeria**

Edoka, M. H., Adiel, K. B, and Fahad, I.

Chapter 7:

**Restoration and Sustainability of Ecological Resource for Biodiversity
Conservation in Nigeria**

Salami, K.D., Muhammad S.I. Adeniyi, K. A. and Nasir, T. Y.

Part two: AQUACULTURE: RESOURCES MANAGEMENT

Chapter 8:

Integrating Nature into Urban Planning for Climate-Resilient Fisheries Systems

**Victoria Folakemi Akinjogunla^{1*}, Emmanuel Ebuka Nwankwor² and Binta Isyaku
Usman¹**

CHAPTER 9:

Climate Smart Aquaculture

Muhammad Usman Mairiga and Aliyu Mohammed,

CHAPTER 10:

**Aquatic Food Systems at the Climate Frontier: Vulnerability, Adaptation, and
Resilience in Fisheries and Aquaculture**

Afia, O. Edet and Ekanem, I. Emmanuel

**CLIMATE SMART ACTIONS (CSA) AQUACULTURE, AGROFORESTRY AND
RESOURCES MANAGEMENT-- ISBN 978-978-60709-1-6**

CHAPTER 11:

Blue Carbon and Aquaculture: The Role of Coastal and Inland Culture Systems in Climate Mitigation

Akinjogunla, V. F.¹ and Olatunji, E. O.²

CHAPTER 12:

Rice-Fish Integration Systems: Climate-Smart Innovation for Sustainable Food Security and Livelihood Enhancement in Nigeria.

***MAHMOUD Ibrahim Opene¹ and ¹BASHIR, Abdullahi Kobe¹,**

CHAPTER 13:

Climate-Smart Hatchery Management as Climate Smart Action (CSA): Sustainable Breeding, Larval Rearing, and Fish Health in Aquaculture Systems

Victoria Folakemi AKINJOGUNLA^{1*}, Mahmoud Opene IBRAHIM¹ and Bashir Abdullahi SANI¹

Part three: AGROFORESTRY AND RESOURCES MANAGEMENT

CHAPTER 14:

Adoption and Scaling of Climate-Smart Aquaculture and Agroforestry Practices: The Role of Agricultural Extension Services

Dr. Taibatu Abdullahi Manga and Dr. Yohanna John Alhassan

CHAPTER 15:

**Ecological Engineering in Agroforestry: Resource Management Approaches to
Enhance Wildlife Services and Reduce Conflicts**

Ogunsusi Kayode

CHAPTER 16:

**Climate-Smart Pest and Resource Management Strategies in Agroforestry and
Aquaculture Systems: A Comprehensive Review**

Efurumibe, P.E and Opara, E.U

CHAPTER 17:

**Climate-Smart Strategies for Sustainable Insect Vector Control and Integrated Malaria
Prevention in Agroforestry and Agricultural Landscapes**

¹Adeniyi, K. A., ²Tolani, R. T., ³Mohammed, A. O., ⁴Salami, K. D. and ⁵Ihemanma, C. A

CHAPTER 18:

**Enhancement of Soil Fertility and Nutrients Sustainability on Arable Crops
Production in Agroforestry Ecosystem**

Nsien, I. B., Okonkwo, H. O., Akpan, U. F. and Eric, E. E.

CHAPTER 19:

**Rhizosphere Engineering and Soil-Microbe-Plant Interactions along Aridity Gradients:
Climate-Smart Strategies for Enhancing Agroforestry Resilience in Northern
Nigeria**

Abubakar, A., and Shittu, E.A

CHAPTER 20:

**Climate Smart Approaches to Forest Resources Management and their
Implications for Rural Farmers' Livelihoods in North Central Nigeria.**

Mohammed, U. and Maimuna, A. A.,

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 eschews pedantry and lays bare the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate smart actions (CSA) aquaculture, agroforestry and resources 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 actions (CSA) aquaculture, agroforestry and resources 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 actions (CSA) aquaculture, agroforestry and resources management** necessary in policy making process that will stimulate increase in food production and environmental sustainability. **Climate smart actions (CSA) aquaculture, agroforestry and resources management : *Global Issues & Local Perspectives*** is organized in three parts. Part One deals with The Concept of **Climate smart actions (CSA)**, Part Two is concerned with The Concept of **aquaculture**, and Part Three deals with the Concept of **agroforestry and resources management**

Eteyen Nyong; March 2026

Chapter 6:

**Smart-Climate Change Adaptation Practices among Smallholder
Farmers in Nigeria**

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Table of Content

- 1.0 Introduction
- 2.0 Causes of Climate Change
- 3.0 Effects of Climate Change
- 3.1 Climate Change and Agriculture
- 4.0 Mitigation and Adaptation Strategies to Climate Change
- 5.0 Factors Hindering Adoption of Climate Smart Agricultural (CSA) Practices in Nigeria
- 6.0 Conclusion
- 7.0 References

1.0 INTRODUCTION

Agriculture is the backbone of Nigerian economy, and smallholder farmers in rural areas constitute the major contributor to food production, the sector also serves as major source of employment and revenue generation. Agriculture plays a fundamental role in economic growth, enhancing food security, poverty reduction and rural development (Wandji, *et. al.*, (2021). Consequently, additional sustainable agricultural enterprise participation remains an important part of the efforts to boost food availability, crop production and improve wellbeing in a bid to reduce food and nutrition insecurity which is currently threatening human rights to food accessibility in developing countries (Sennuga and Fadiji, 2020).

Climate change has become one of the defining environmental and developmental challenges of the 21st century. It refers to long-term shifts in the Earth's climate system, often characterized by rising global temperatures, erratic precipitation, prolonged droughts, flooding, and increased frequency of extreme

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weather events. These shifts have wide-ranging implications for agricultural systems, food production, and rural livelihoods worldwide. The *Intergovernmental Panel on Climate Change (IPCC, 2022)* has consistently emphasized that agriculture remains one of the most climate-sensitive sectors, making it especially vulnerable in regions where smallholder farming dominates.

Africa is considered the most vulnerable continent to climate change due to its reliance on rain-fed agriculture, limited adaptive capacity, high levels of poverty, and weak institutional frameworks. Sub-Saharan Africa, where agriculture contributes significantly to household incomes and national economies, is projected to face increasing threats to food production as climatic variability intensifies (Ayanlade, et. al., 2018). Unlike developed economies that benefit from mechanized irrigation and technological buffers, African farmers largely depend on traditional methods and natural weather cycles, leaving them exposed to the adverse impacts of changing climatic conditions.

The contribution of agriculture over the years now have witnessed a down turn due to the effect of climate change. Farmers' efforts are thwarted and farm yields nosedived thereby leading to outright poverty and food insecurity. Smallholder farmers are the worst hit in this context, as most of them lack the necessary mitigative and adaptive skills to tackle the problem of climate change. Climate change is an upsurge in the concentration of atmospheric greenhouse gases, resulting in abundant climatic variations across the world (Environmental Energy Studies Institute EESI, 2019). It is called anthropogenic when it is caused by human actions such as burning of fossils, overgrazing, and refuse dump.

According to Ali (2018), climate change is one of the potential threats to human development and survival – socially, politically, and economically. Change in climate can have impact on many vulnerable individuals as it relates to awareness, knowledge, and information on where and how people, plants, and animals live as well as other components of agricultural activities. Africa is the least contributor to climate change, however, the continent is more vulnerable to the effects of climate change due to overdependence on rain-fed agriculture, compounded by factors such as widespread poverty, and weak capacity and poor sources of farming information led to great loss in yield of crops. Agriculture is one of the major causes of climate change. Clearing of land (deforestation) and burning of refuse during crop cultivation lead to the accumulation of greenhouse gases (GHGs) which bring about climate change as most studies attribute about 20 to 25% of all global GHG emission to the production of food, feed, and biofuels, including emission from agriculture-driven land use change (Barnabas, 2020).

The growing impacts of climate change demonstrated in irregular rainfall patterns, stretched dry seasons, rising temperature cause remarkable threats to agricultural productivity and food security in most rural areas in Nigeria. Smallholder farmers is Sub-Saharan African communities, are highly susceptible to climate

variability due to limited access to resources, technology and institutional support. These farmers depend on rain-fed agriculture, making them more prone to change in weather system. Therefore, the need to adopt climate-smart agriculture (CSA) has become increasingly imperative. Climate change adaptation strategies involves practices that viably increase productivity, enhance resilience (adaptation), lessen greenhouse gas emissions (mitigation) and amplify the procurement of national food security and development goals.

2.0. CAUSES OF CLIMATE CHANGE

Climate change refers to long-term alterations in temperature, precipitation, wind patterns, and other aspects of the Earth's climate system. While climate variability occurs naturally, the current trends are largely attributed to human activities, especially the burning of fossil fuels, deforestation, and industrial emissions that increase the concentration of greenhouse gases (GHGs) in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), the Earth's average surface temperature has risen by approximately 1.1°C since the pre-industrial era. This warming is linked to extreme weather events, melting ice caps, rising sea levels, and shifts in ecosystems and biodiversity.

Climate change has emerged as one of the most critical environmental and developmental challenges confronting humanity in the 21st century. The phenomenon, characterized by long-term changes in temperature, precipitation, wind patterns, and other elements of earth's climate system has had significant consequences for global agriculture and food security (IPCC,2022). Africa, and particularly sub-Saharan African, is recognized as one of the most vulnerable regions due to its heavy reliance on rain-fed agriculture, low adaptive capacity, and widespread poverty.

Climate change is primarily driven by anthropogenic (human-induced) activities: Greenhouse Gas Emissions: Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) trap heat in the atmosphere. These gases are released from burning coal, oil, and natural gas; agricultural practices; and deforestation. Chlorofluorocarbons (CFCs) which are man-made chemicals used in refrigeration and aerosols lead to the accumulation of greenhouse gas in the atmosphere.

Deforestation: Trees act as carbon sinks. Large-scale deforestation, especially in tropical regions like Nigeria, reduces the earth's capacity to absorb CO₂, thereby accelerating warming (FAO, 2020). Industrialization and urbanization cause severe climate change. Increased industrial activities and urban expansion have escalated energy consumption and environmental degradation (UNEP, 2019). Some of these causes are substantiated below;

Greenhouse Gas Emissions

The leading cause of anthropogenic climate change is the emission of greenhouse gases (GHGs), particularly carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These gases trap heat in the Earth's atmosphere, intensifying the natural greenhouse effect. Fossil fuel combustion for electricity, transportation, and industry remains the largest source of CO₂ emissions globally.

Deforestation and Land Use Changes

Forests act as carbon sinks by absorbing CO₂ from the atmosphere. Deforestation, especially in tropical areas like the Amazon and parts of Africa, releases large amounts of carbon and reduces the Earth's ability to absorb future emissions. Land use changes for agriculture and urbanization further contribute to GHG emissions.

Agricultural Practices

Agriculture contributes significantly to climate change through methane emissions from livestock and rice paddies, and nitrous oxide from fertilized soils. These gases have higher global warming potentials than CO₂. Unsustainable agricultural expansion also accelerates land degradation and biodiversity loss.

Industrialization and Urbanization

Rapid industrial growth and urban expansion have increased the energy demand, leading to higher emissions. Industrial processes such as cement production and chemical manufacturing release GHGs and other pollutants (UNEP, 2019). Urban centers also create "heat islands" that locally intensify temperature.

3.0 EFFECTS OF CLIMATE CHANGE

The effects of climate change are widespread and severe: Some of these are;

Temperature Rise: Increased temperatures can reduce agricultural productivity, affect human health, and increase evaporation rates. Temperature rise can lead to melting of glaciers, thereby increase water volume and coastal erosion. Excessive temperature can lead to wilting of crops and even death of grown crops if severe.

Rainfall Variability: Unpredictable rainfall patterns cause droughts and floods, leading to crop failure and food insecurity, especially for smallholder farmers in sub-Saharan Africa (NIMET, 2021).

Sea-Level Rise: Rising sea levels threaten coastal areas through flooding and salinization of freshwater resources. Rising sea levels have far-reaching effects on coastal cities and habitats. Increasing ocean temperatures and melting of ice sheets have steadily contributed to the rise of sea levels

Biodiversity Loss: Changing climates disrupt habitats and migration patterns of plants and animals, leading to biodiversity loss. Shifts in climate zones, habitat destruction, and changes in seasonal cycles threaten plant and animal species. Many species are unable to adapt or migrate quickly enough, leading to biodiversity loss (UNEP, 2020).

Health Effects: Climate change increases the spread of diseases such as malaria and dengue fever. Heat waves contribute to heat-related illnesses, while poor air quality worsens respiratory conditions. There are many ways in which climate change could impact people's health; depending on age, location, and economic status. Climate change is already affecting the health of many and has the potential to impact millions more. Some of these health-related risks include; heat-related illness, injuries and fatalities from severe weather, asthma and cardiovascular disease from air pollution, respiratory problems from increased allergens, diseases from poor water quality, and water and food supply insecurities (<https://www.cdc.gov/climatehealth/php/effects/index.html>).

3.1 Climate Change and Agriculture

In Nigeria, climate change is evident in: Increased frequency and intensity of extreme weather events like floods in the Middle Belt and droughts in the northern region, decline in crop yields, especially maize, sorghum, and yam, due to erratic rainfall and heat stress (Adejuwon, 2006). Livelihood threats to rural farmers who depend on predictable weather for rainfed agriculture, among others. Several rural Nigeria experienced irregular rainfall, delayed planting seasons, and flash floods. These patterns impact both subsistence farming and local food security.

Agriculture is both a victim and contributor to climate change. While it suffers from droughts, floods, and changing seasons, it also contributes through land clearing, methane from livestock, and fertilizer use. Smallholder farmers, who often lack access to climate-smart inputs or irrigation, are particularly vulnerable, temperature variations, rainfall distribution, and soil moisture levels directly affect crop growth, livestock productivity, and overall food security. In Nigeria, the agricultural sector accounts for about 25% of GDP and employs over 60% of labour force, making it both a contributor to and a victim of climate change (Ebenehi, et. al., 2024; National Bureau of Statistics NBS, 2022). Prolonged droughts, desertification, and flash floods are increasingly common, affecting both the timing and success of planting and harvesting cycles.

Agriculture, on the other hand, is major contributor to climate change. The sector is responsible for approximately 10-12% of total GHG emissions through activities such as enteric fermentation, rice cultivation, manure management, and deforestation for agricultural expansion (IPCC, 2022). This dual

relationship called for the need for a transformation towards climate-smart agriculture (CSA); which is an integrated approach that enhances productivity, builds resilience, and reduce emissions where possible.

4.0 MITIGATION AND ADAPTATION STRATEGIES

Efforts to combat climate change fall into two main categories:

Mitigation: Reducing emissions through renewable energy, afforestation, and sustainable land management.

Adaptation: Adjusting farming practices to reduce vulnerability, such as using drought-resistant crops, improved irrigation, and weather forecasting tools (UNFCCC, 2022).

Climate-smart agriculture (CSA) is one such approaches that enhances resilience while increasing productivity and reducing emissions. Adoption of CSA in Nigeria, however, is limited by poverty, low education, and lack of extension services. Climate change refers to significant changes in global temperatures and weather patterns over time. While climate change is a natural phenomenon, scientific evidence shows that human activities have been the primary driver of climate change since the mid-20th century (IPCC, 2021). This review examines the major causes of climate change and its wide-ranging effects on the environment, economies, and human populations. Some climate change mitigation strategies are;

Renewable Energy Transition: A central mitigation strategy involves transitioning from fossil fuels to renewable energy sources such as solar, wind, hydro, and biomass. According to the International Renewable Energy Agency (IRENA, 2020), renewables can significantly reduce CO₂ emissions while supporting energy security and economic development. Countries like Germany and China have led in scaling up clean energy infrastructure.

Energy Efficiency Improvements: Improving energy efficiency in buildings, transport, and industrial processes reduces overall energy demand and emissions. The IEA (2022) reports that energy efficiency improvements alone could account for more than 40% of the emission reductions needed to meet climate targets by 2040.

Carbon Sequestration and Afforestation: Forestry-based approaches such as afforestation, reforestation, and forest conservation help sequester atmospheric CO₂. The REDD+ framework (Reducing Emissions from Deforestation and Forest Degradation), promoted by the UN, supports developing countries in managing forests sustainably (UNFCCC, 2018).

Sustainable Transportation: Mitigation also involves promoting low-emission transport systems, including electric vehicles (EVs), non-motorized transport (cycling, walking), and efficient public transport networks (World Bank, 2019). Such changes reduce emissions and urban pollution.

Climate Policy and Carbon Pricing: Policy instruments such as carbon taxes, cap-and-trade systems, and emission trading schemes incentivize emission reductions. The European Union's Emission Trading Scheme (ETS) is a leading example, encouraging industries to reduce carbon outputs (OECD, 2021).

Climate Change Adaptation Strategies

Smart climate change adoption strategies, commonly referred to as climate-smart agriculture (CSA), encompass farming methods designed to increase agricultural productivity, enhance resilience to climate shocks, and, where possible, reduce greenhouse gas emissions (FAO, 2018). These strategies are particularly relevant in regions vulnerable to climate variability, such as the semi-arid zones of northern Nigeria, where farmers face challenges related to erratic rainfall, prolonged droughts, and soil degradation. CSA provides a framework for integrating both adaptive and mitigative approaches into daily farming practices, ensuring that production systems remain sustainable under changing climatic conditions.

Key CSA strategies include the use of drought-resistant maize varieties, which are specifically bred to tolerate water stress and maintain yield stability during periods of inadequate rainfall. Water harvesting techniques and small-scale irrigation systems also contribute to resilience by improving water availability during critical growth stages of crops. Additionally, agroforestry and intercropping practices enhance soil fertility, reduce erosion, and provide multiple sources of income, thereby strengthening farmers' adaptive capacity. The use of organic fertilizers, along with soil conservation techniques such as mulching and minimum tillage, further supports sustainable productivity by improving soil structure and nutrient retention.

Several adaptation strategies are adopted by farmers all over the world. Some of these strategies include;

Climate-Smart Agriculture (CSA): In developing regions, particularly sub-Saharan Africa, climate-smart agriculture is a key adaptation strategy. CSA integrates crop diversification, drought-resistant seeds, soil conservation, and water harvesting to improve productivity and resilience. Studies show that CSA enhances food security and reduces climate vulnerability in rural farming communities.

Infrastructure Resilience: Adaptation also involves climate-resilient infrastructure, such as flood defenses, elevated roads, and climate-proof housing. Investments in resilient infrastructure are particularly critical in coastal and flood-prone areas.

Early Warning Systems and Disaster Preparedness: Effective early warning systems for floods, droughts, and extreme weather events are crucial for risk reduction. Studies have shown that communities with functional early warning systems suffer fewer casualties and economic losses.

Water Resource Management: As rainfall patterns become more unpredictable, sustainable water management—including rainwater harvesting, efficient irrigation, and watershed protection—has become a central focus of adaptation.

Urban Planning and Ecosystem-Based Adaptation: In urban settings, adaptation includes green infrastructure such as urban forests, wetlands restoration, and permeable surfaces to reduce heat and flood risks. Ecosystem-based adaptation (EbA) promotes nature-based solutions to climate risks.

Integration of Mitigation and Adaptation: Recent literature stresses the need to integrate mitigation and adaptation for more sustainable outcomes. For example, agroforestry systems can sequester carbon (mitigation) while enhancing soil fertility and crop resilience (adaptation). Integrated approaches also enhance cost-effectiveness and build community ownership.

Application of organic fertilizers: Natural manures such as organic manure, farm yard manure, compost manure, animal dungs, poultry droppings, and green manure are some natural manure that enrich soil nutrients without any adverse effects on the environment. This is contrary to synthetic or chemical fertilizers such as NPK, UREA, Calcium Ammonium Nitrate (CAN), Single Super Phosphate (SSP), to mention but a few which have negative effects on soil and environment. These chemical fertilizers cause pollution of soil, atmosphere and water bodies, soil degradation, formation of soil complexes, irritation and bronchial issues.

Afforestation: Farmers in rural Nigeria practice afforestation especially those living along the Sudan-Sahelian regions of the country. In this process, trees are planted aggressively to reduce the rate of run-off and wind speed.

5.0 FACTORS HINDERING ADOPTION OF CLIMATE-SMART AGRICULTURAL (CSA) PRACTICES IN NIGERIA

Despite the benefits of climate-smart agriculture (CSA) practices among smallholder farmers, the adoption remains limited due to a range of socio-economic, institutional, and environmental factors. Some of these factors include;

- Inadequate access to credit and financial resources. Many CSA practices, such as the use of drought-tolerant seeds, small-scale irrigation systems, or organic fertilizers, require initial investments that smallholder farmers often cannot afford. Without financial support

or affordable loan facilities, farmers are unable to adopt these practices, even when they recognize their potential benefits.

- Limited access to climate change information and extension services constitutes another significant barrier. Farmers often lack awareness of CSA practices or do not receive adequate training on their implementation. Weak agricultural extension services, low farmer-to-extension agent ratios, and irregular training programs hinder knowledge transfer and reduce farmers' capacity to adopt innovations effectively. Studies in northern Nigeria have shown that households with limited extension contact are significantly less likely to implement CSA practices compared to those with frequent guidance.
- Socio-cultural factors also impede CSA adoption by several farmers. In many rural communities, traditional farming methods are deeply entrenched, and innovations may be perceived as risky or culturally inappropriate. Risk aversion, reluctance to change established practices, and reliance on indigenous knowledge can reduce farmers' willingness to adopt new climate-smart technologies. Additionally, gender dynamics can influence adoption, as women farmers may have less access to land, credit, and extension services, limiting their ability to implement CSA strategies.
- Environmental and infrastructural constraints further restrict CSA adoption. Poor road networks, limited access to markets, and inadequate storage facilities reduce the profitability of investing in improved practices. Water scarcity, soil degradation, and unpredictable climatic conditions can also limit the effectiveness of CSA interventions, discouraging farmers from adopting strategies that may fail under extreme conditions.
- Finally, policy and institutional gaps exacerbate adoption barriers. Weak implementation of agricultural policies, lack of supportive subsidies, and insufficient coordination between government agencies, NGOs, and local communities hinder the promotion of CSA practices. Without a conducive policy and institutional environment, smallholder farmers face high uncertainty and low incentives to adopt climate-smart strategies, despite the potential long-term benefits.

6.0 CONCLUSION

Climate change is an emerging major challenge to agricultural and rural development in Nigeria and other developing countries of the world. The unpredictable and erratic nature of weather systems in Nigeria have placed an extra burden on food security and rural livelihood, wide spread destruction of farmlands and homes. Several studies have shown that erratic rainfall, long dry spell farm flooding impact farmers' efforts hence leading to loss of income of farmers. Most worrisome is the fact that, rural farmers in Nigeria and other developing countries are constrained by several factors that limit their adaptation strategies. The Nigerian government can lessen these burden by coming out with policies and programmes that can ameliorate these constraints such as early access to climate information services (CIS) and early warning systems, provision of drought-resistant cultivars, and other irrigation facilities to supplement the erratic rainfall, among others. Farmers who can obtain timely and reliable information on rainfall patterns, temperature fluctuations, and potential hazards are more likely to adjust planting dates, select appropriate crop varieties, and implement water management strategies.

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