CLIMATE CHANGE, FOOD SECURITY, NATIONAL SECURITY and ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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PUPLISHED BY:

Society for Agriculture, Environmental Resources & Management (SAEREM)

SAEREM BOOK CHAPTERS2023: First published 2024: ISBN 978-978-60709-9-5

First published 2024

SAEREM World

Nigeria

Typeset in Times New Roman

Climate Change, Food Security, National Security and Environmental Resources

Global Issues & Local Perspectives

ISBN 978-978-60709-9-5

Printed at: SAEREM Worl

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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 change, food security, national security and environmental resources 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 change, food security, national security and environmental resources 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 change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

Climate Change, Food Security, National Security and Environmental resources: Global issues and Local Perspectives is organized in four parts. Part One deals with Climate Change with Six Chapters, Part Two is concerned with Food Security with Nine chapters, Part Three deals with National Security with Five Chapters, while Part Four pertains Environmental Resources, has Five Chapters.

Ahmed Makarfi / Eteyen Nyong

April 2024

SAEREM BOOK CHAPTERS2023: First published 2024: ISBN 978-978-60709-9-5

CHAPTER 10

Climate Change, Pollution and National Insecurity

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Abstract

The paper reviewed the climate change within the context of climate-smart agriculture practices among smallholder holder farmers in developing countries. It focused on the synthesis of the policy contribution to the menace of climate, examined the impact of climate on agriculture and delineated those practices that are peculiar to crop production. The empirical impacts of climate across the continent were also reviewed. Coupled with the articulation of the challenges that face climate-smart agriculture practices, the paper concluded that climate-smart agriculture practices constitute the most cost-effective and farmer-friendly approaches to combating climate change. It was recommended that both the government and farmer-based organisations should collaborate in combating climate change.

Keywords: Climate change, climate-smart agriculture, crop, environment, policy, farmers.

Introduction

Climate refers to the weather conditions that prevail in an area over a long period of time. Weather itself is the state of the atmosphere at a particular place and time. The state of the atmosphere includes heat, cloudiness, dryness, sunshine, wind and rain. A change in any of the state of the atmosphere culminates in the concept of climate change. These changes alter the course of nature and are, more often than not, unfavourable to the ecosystem. Hence, climate change is crisis-ridden. According to Ayinde et al. (2013), climate change is a global crisis. The entire universe shares the same atmosphere. Besides, the implications of climate change on agriculture constitutes an array of systematic risks for the globe. This dimension underscores the rapid, massive and consistent response of the United Nations to the menace of climate change. This is due to the fact that climate change will, no doubt, slow down the progress towards the attainment of the Sustainable Development Goals (Dhahri & Omri, 2020; Ogundele, 2022; United Nations, 2016;

Williams et al., 2015). Literature is awash with increasing evidence that climate change will be one of the most challenging issues for sustainable develsopment in agriculture and food systems, including food security and nutrition (Djido et al., 2021). Apart from the global experience of climate change, there is also a trend of climate variation across the country. The Federal Ministry of Environment (2003) noted that the climate of the country varies from a very wet coastal area with annual rainfall greater than 3,500 mm to the Sahel region in the north western and north eastern parts, with annual rainfall less than 600 mm.

Climate change is real, with clear evidence such as high temperatures and changes in rainfall, which have distressing effects on humanity, especially on its livelihood (IPCC 2014). The regions of the world which are most vulnerable to climate change are the developing countries, particularly the African countries. In these countries, droughts, strong windstorms, floods, unpredictable rainfall volume, rising temperatures, late and early rain start, affect the entire environment. These elements of climate change constitute serious threats to Africa's agricultural sector and food security because agriculture in the region is highly sensitive and vulnerable to changes in temperature and rainfall (Onyeneke et al., 2021).

In these countries, there are glaring evidence of a high level of poverty, food production at subsistent level and challenges of land degradation. The major reason for the vulnerability of African countries revolve around the substantial dependence of their economies on agriculture. These countries also have inadequate capital and technologies for resisting or mitigating production constraints and ensuring sustainable food production. Nigeria is one of those countries where climate change poses threat to sustainable food production due to her heavy reliance on rain-fed agriculture, a sector that suffers utter neglect by successive administrations at the center of government. The consequences of climate change range from hunger, food insecurity, malnutrition, poverty to environmental degradation (Adebisi et al., 2022).

The goal of this piece of work is to review climate change and adaption strategies. The specific objectives of this study are to:

i. review government policy responses to the menace of climate change;
ii. describe the effect of climate change on agriculture;

iii. expound climate-smart agriculture;
iv. delineate CSA practices that are related to crop production;
v. describe the determinants of CSA adoption practices; and
vi. project relevant policy recommendations.

Synthesis of government policy responses: Mitigation of climate change via CSA, is expected to be compatible with national development priorities (Ameyaw et al., 2018). Consequently, the UNFCCC encouraged countries to evolve national communications as well as home-grown policies. In response to this directive, the Federal Ministry of Environment coordinated two national communications (Federal Ministry of Environment, 2003, 2014). Under the inter-ministerial platform, the Federal Ministry of Environment has also articulated policies to respond to climate change. The synthesis of the policies of the FGN, including those that Nigeria endorsed, to combat climate change is presented in Table 1.

Table 1: Government Policies on Climate Change

S/NO	Policy	Major Policy Thrust	Source
1	KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE	Promotion of sustainable forms of agriculture in light of climate change considerations	(United Nations, 1998)
2	Building Nigeria ' s Response to Climate Change (BNRCC) Project	Gender and Climate Change Adaptation: Tools for Community-level Action in Nigeria	(Nigerian Environmental Study/Action Team (NEST), 2011)
3	THE AGRICULTURE PROMOTION POLICY (2016 – 2020) For Smallholder Women Farmers	The policy captured most of the challenges experienced by the smallholder segment of food growers especially smallholder women farmers and offered solutions to those challenges in form of commitment to resolve the	(ActionAid Nigeria, 2016)

		setback within specified time frame	
4	National Policy on Climate Change (NPCC), 2013	The major thrust is to foster low-carbon, high growth economic development path and build a climate-resilient society through the attainment of set targets	(Federal Ministry of Evironment, 2013, 2014)
5	NATIONAL POLICY ON THE ENVIRONMENT (REVISED 2016)	To coordinate environmental protection and natural resources conservation for sustainable development	(Federal Ministry of Environment, 2016)
6	National Water Resources Policy	The main policy objective is to foster the integrated management of water resources for optimum, sustainable, efficient, and equitable water resources development and management in order to meet the current and future user water demand, conserve the water quality and protect the environment.	(Federal Ministry of Water Resources, 2016)
7	NATIONAL ADAPTATION STRATEGY AND PLAN OF ACTION ON CLIMATE CHANGE FOR NIGERIA (NASPA-CCN)	To reduce the impacts of climate change through adaptation measures that can be undertaken by the Federal, State and Local Governments, civil society, private sector, communities and individuals, including measures that will: 1. Improve awareness and preparedness for climate change impacts 2. Mobilize communities for climate	(Building Nigeria's Response to Climate Change (BNRCC) Project, 2011)

		change adaptation actions 3. Reduce the impacts of climate change on key sectors and vulnerable communities 4. Integrate climate change adaptation into national, sectoral, State and Local Government planning and into the plans of universities, research and educational organizations, civil society organizations, the private sector and the media	
8	NATIONAL ENVIRONMENTAL, ECONOMIC AND DEVELOPMENT STUDY (NEEDS) FOR CLIMATE CHANGE IN NIGERIA (Final Draft)	Towards meeting the challenges of addressing the key environmental problems and challenges of land degradation (deforestation, desertification and coastal and marine environment erosion), and air and water pollution, urban decay and municipal waste, as well as hazards of drought, coastal surges, floods and erosion, the Nigerian government elaborated a National Environmental Policy in 1989.	(Federal Ministry of Environment Abuja-Nigeria (Special Climate Change Unit), 2010)
9	First Biennial Update Report (BUR1) of the Federal Republic of Nigeria under the United Nations Framework Convention on Climate Change (UNFCCC)	To improve Nigeria's response to climate change impacts, increasing resilience and managing the unavoidable impacts of climate in line with UNFCCC	(Federal Republic of Nigeria, 2018)

Source: Federal Ministry of Environment/Agriculture and Rural Development

10	NIGERIA'S FIRST NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE	Forest protection whereby the forest reserves are increased from the present 10% to 25% of the total area of the country by the year 2010.	(Federal Ministry of Environment, 2003)
11	Nigeria's Second National Communication Under the United Nations Framework Convention on Climate Change	This Second National Communication (SNC) captures the progress in climate change actions in the country since the First National Communication. It also includes a summary of future actions towards climate-proofing Nigeria's environment.	(Federal Ministry of Environment, 2014)
12	Sectoral Action Plans for Nigeria's Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC)	Dedicated climate funds typically allocate funding to projects via a transparent allocation process • Recipient countries submit project proposals to the fund which demonstrate how the project contributes to achieving the fund's strategic objectives • The fund reviews each proposal and those that score the highest in a given funding round are approved for finance	(Federal Ministry of Evironment, 2017)
13	CLIMATE CHANGE LEGISLATION IN Nigeria	Implement mitigation measures that will promote low carbon as well as sustainable and high economic growth • Strengthen national capacity to adapt to climate change; • Raise climate change-related	(Nachmany et al., 2015)

		science, technology and R&D to a new level that will enable the country to better participate in international scientific and technological co-operation on climate change; • Significantly increase public awareness and involve the private sector in addressing the challenges of climate change; • Strengthen national institutions and mechanisms (policy, legislative and economic) to establish a suitable and functional framework for climate change Governance.	
14	The Paris Agreement	strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty	(United Nations, 2015)

How does Climate Change affect Agriculture: In diverse manners, climate change affects agriculture practices. Agricultural practices involve the selection of crops that can thrive in specific region as well as the adoption of appropriate production methods. Thus, agriculture is an industry that depends significantly on the climatic conditions of specific regions (Kim, n.d.). Regional characteristics are made up of the components of ecosystems which are dictated by the climate of the region. Climate change affects the agro-ecology, and are manifested in such elements as temperature, precipitation, and sunlight. These elements have direct influence on the arable, livestock, and hydrology sub-sectors of agriculture. In other words, regional characteristics determine the magnitude of impact climate change on a given ecosystem. Nigeria, a tropical country, can be more vulnerable to climate change. Chauhan & Rani (2021) and Abegunde *et al.* (2019) affirmed that climate change impact can vary to ecological or region specificity. In addition, the level of technological advancement of agriculture in a given region can affect the level of impact of climate change. For Nigeria, where agriculture is rain-fed, and dominated by smallholders who are mostly resource-poor, climate change can be a significant impact. The Federal Ministry of Environment (2003) and Adebisi et al. (2022) attested to the dependence of Nigeria's agriculture on the volume and distribution pattern of rains. Also, various authors (Abiola et al., 2021; Akpan et al., 2019; Olanrewaju, 2019; Oyetunde-usman & Olagunju, 2019) have attested to the fact that smallholder farmers in Nigeria are resource-poor.

i. To start with, the impacts of climate change on the arable and livestock subsectors are made manifest through biological alterations that manifest in changes of flowering and harvesting periods, change in quality of produce, and relocation of cultivation sites. Climate change influences the agroecology as it gives rise to disease incidence and pests infestation and altering biodiversity. In the livestock sector, climate change affects fertilization, breeding and the pattern of growth of pastures (Kim, n.d.).

ii. Climate change affects the underground water system, water temperature, river flow, and water quality of lakes and marshes. These happen through precipitation, evaporation, and soil moisture content. Specifically, changes of precipitation lead to changes in the outflow while the temperature increase directly affects evaporation, resulting in the decrease of outflow (Kim, n.d.).

iii. Transhumanism or population migration: Climate change induced desertification and pest infestation cause cattle rearers to increase migration southwards in search of vegetation and relatively disease-free environment for grazing, thus, clashing with the activities of crop-farmers and resulting in crisis cum decline in agricultural productivity According to (Vanger & Nwosu, 2020), transhumance, which originated from the Economic Community of the West African States (ECOWAS) namely the transhumance protocol which provided for the free movement of persons and livestock across the sub-region to promote the development of livestock in West Africa, has heightened farmer-herder crisis. Various authors (Bukari, 2017; Hussein et al., 1999; Ilu et al., 2016; Kubkomawa, 2017; Okoli & Addo, 2018) emphasized that transhumance is an opportunistic approach by pastoralists to maximize grazing resource management.

iv. Invasion of weeds, pest and diseases: There is evidence that climate change is changing the distribution, incidence and intensity of animal and plant diseases, including the invasion of alien species. Examples include the recent emergence of multi-virulent, aggressive strains of wheat yellow rust which are adapted to high temperatures (FAO, 2010).

v. Violence: Nigeria's climate is also likely to witness shifts in temperature, rainfall, storms, and sea levels for much of the 21st century. These challenges have the capacity to heighten the current shortages in natural resources. In addition, ineffective responses to shortages in resources could constitute such effects as ill-health, hunger, jobs losses, and poor economy, with resultant effect on violence (Sayne, 2011).

Climate-smart agriculture (CSA)

Due to the adverse impacts of climate change which undermines the ability of countries to achieve sustainable development, the United Nations Framework Convention on Climate Change (UNFCCC), an international, intergovernmental platform for planning a global response to climate change, emerged to control the menace of climate change. One of the tenets of the UNFCCC is climate-smart agriculture (CSA), which is a mitigation approach to the menace of climate change. The CSA is essential for controlling climate shocks to small-scale farming in developing countries, especially in sub-Saharan Africa (Atta-aidoo et al., 2022). This is because, as stressed by Lipper et al. (2018), CSA is anchored on three pillars, which are productivity, resilience and mitigation. The World Bank (2021) added that the CSA methodically takes into account the trade-offs and

synergies between productivity, adaptation, and mitigation and intends to seize new funding opportunities to checkmate the decline in agricultural investment. From a broader perspective, CSA seeks to achieve three related goals namely, sustainable increase in agricultural productivity and incomes; enhancement in farmers' climate change adaptive capacity and resilience building; and reducing the emission of greenhouse gases (Kifle et al., 2022; Mujeyi et al., 2021; van Wijk et al., 2020). According to Williams *et al.* (2015), CSA integrates these three dimensions of sustainable development with the aim of increasing agricultural productivity and incomes on a sustainable level; adaptation and building of resilience to climate change upwards from the farm to national levels; and developing opportunities to reduce greenhouse gas emissions from agriculture.

Different CSA practices or technologies are available. Some of them may be crop-smart, carbon-smart, water-smart, soil-smart, nutrient-smart, livestock, weather-smart or energy-smart (Mallappa & Pathak, 2023). The current study selected practices across these categories. As emphasized by Abegunde *et al.* (2019), policymakers need to focus on the factors that can affect the adoption of CSA practices and enact informed strategies that would fast-track the successful adoption of these practices among farmers. Given the location and content-specific attributes of CSA application as regards to the economic, environmental and social situations, location-specific policies on CSA are imperative. Chauhan & Rani (2021) stressed that CSA is a methodology that requires site-based evaluations to select the appropriate techniques and methods for agricultural production. Kifle *et al.* (2022) are of the view that CSA simultaneously addresses the issues of climate change adaptation and mitigation, including food security.

As a technology, its adoption depends on several factors, including socioeconomic factors. Underscoring such relevance as increased productivity, improved resilience, and climate change mitigation, Kurgat *et al.* (2020) emphasized that smallholder adoption of farming technology is necessary to speed the transition to CSA. Feyisa (2020) emphasized that technology adoption fosters smallholder farmers' productivity. In this regard, there is little information concerning CSA adoption in Benue State, particularly as it relates to the yam farming. In addition, the influence of socioeconomic characteristics of the choice or preference for a given CSA practice is yet to be done. Besides, studies on the distribution of yam farm income by CSA practices are not available.

Akter *et al.* (2022) added that little is known whether adoption of CSA augments crop yield and income. Ibrahim & Johansson (2021) lamented that despite the realization that climatic changes and extreme weather events are ravaging the agriculture sector, climate change adaptation by farmers is low. Negera *et al.* (2022) concurred that the adoption of CSA practices among farmers in developing countries is low.de Pinto *et al.* (2020) held that CSA has attracted interest given its promise to increase agricultural productivity under a changing climate while reducing emissions. The practices are mostly inexpensive farm-based sustainable agricultural land and fertility management techniques. These practices can be disaggregated into crop and livestock related practices.

CSA practices in crop production: Various CSA practices are available for crop farmers. While the practices are crop-dependent, others could be region-specific. Various authors have investigated different practices. The practices are synthesized as follows:

i. Crop-smart practices include short-duration varieties, high-yielding varieties, disease resistant varieties, pest resistant varieties, mixed cropping, drought resistant varieties, direct seeding, change in cropping pattern, integrated farming, reducing plant population during stress period, contingency crop planning, seed and fodder banks (Mallappa & Pathak, 2023).

ii. Nutrient-smart practices include use of compost, use of animal manure, green manuring, organic fertilizer, bio-fertilizer, soil testing, slow-releasing nitrogenous fertilizer as neem-coated urea, scheduled fertilizer application, intercropping with legumes, integrated nutrient management, site-specific integrated nutrient management, leaf colour chart for checking nitrogen deficiency, fertigation, precision fertilizer (Mallappa & Pathak, 2023).

iii. Livestock diversity, crop diversity, irrigation, chemical fertilizer application (Kurgat et al., 2020).

iv. Conservation agriculture, Use of organic manure, Crop diversification, Use of wet land (Fadama) and Planting of drought and heat tolerant crops in descending order, while Agro-forestry (Ojoko et al., 2017).

v. Use of organic manure, crop rotation and crop diversification, diet improvement for animals, agroforestry and the use of wetland, efficient manure management and diet improvement for animals(Abegunde et al., 2019).

vi. Mulching, bush fallowing, manure application, planting indigenous crops, crop rotation, agro-forestry, cover cropping, intercropping, multi-cropping and shifting cultivation (Elenwa et al., 2019).

Determinants of adoption of CSA practices: Like every technology, the adoption of CSA practices begins with awareness (Feyisa, 2020; Maseko, 2021; Olasunkanmi et al., 2022; Prodhan & Khan, 2018). In addition, certain socioeconomic, region and farm-specific characteristics can influence the adoption of various CSA practices. According to Negera et al. (2022), adoption of climate smart agricultural (CSA) practices are widely acknowledged as effective alternatives to minimizing the adverse impacts of climate change. Nevertheless, CSA adoption is low among smallholder farmers in developing nations. Here is a synthesis of empirical factors that influence the adoption of CSA among smallholder farmers:

In Ethiopia, the adoption of CSA practices significantly depends on the age of the household head, education, land size, household total asset value, frequency of extension contacts, farmer awareness of climate change, farmer experience with climatic shocks, parcel fertility, slope, and severity of soil erosion (Negera et al., 2022). The factors that influence the adoption of the various CSA practices among yam farmers in Ogun State, Nigeria were; radio information, farm size, volume of credit, farming experience, number of extension contacts, and cooperative society membership. Others were sex, age, years of education, use of credit, access to extension service and membership of farmers association were negatively significant (Faleye & Afolami, 2020).Factors including farming system, farm size, access to irrigated farm, access to extension service, distance to market places, and access to weather information were identified as determinants for the CSA practices in Siyadebrina Wayu District, Central highland of Ethiopia (Kifle et al., 2022).

Gender, age, number of family workers, climate-related factors, farm characteristics, distance to markets, access to climate information, confidence on the know-how of extension workers, membership in social/agricultural groups and attitude toward risk were the major factors affecting

the decision to adopt CSATs (Tran et al., 2019). Educational status, farm income, farming experience, size of farmland, contact with agricultural extension, exposure to media, agricultural production activity, membership of an agricultural association or group and the perception of the impact of climate change were found to be statistically significant and positively correlated with the level of CSA adoption. Furthermore, off-farm income and distance of farm to homestead were statistically significant but negatively correlated with the CSA level of adoption (Abegunde et al., 2019).

Sex, level of education, livestock holding, access to credit, farm distance, market distance and training were significant factors that affected the use of climate-smart agricultural practices in Wadla district, northeast Ethiopia (Belay et al., 2023).Age positively influenced the use of crop diversification at 5% significant. Household size had positive relationship with the choice of crop diversification as farm-level adaptation measures. Farm size had a negative effect on the choice of multiple crop varieties (Ikyoosu et al., 2017). Farmers' attitudes (notably their beneficial evaluation of CSA practices) had a significant impact (0.25) on their intention to adopt CSA practices. Social pressure exerted on farmers to use CSA practices (Subjective norm) also had a significant impact (0.52) on farmers' adoption behavior. Perceived behavior control which measures the controllability and use of CSA practices also had a significant impact on both the intention (0.43) and adoption behavior (0.20) of smallholder farmers (Atta-aidoo et al., 2022).

The use of weather and climate information services (WCIS) is endogenously treated to farmers in the adoption models of pest-resistant crops, water management, and multiple cropping practices. The use of WCIS significantly increases the adoption of water management and multiple cropping practices by 6.8% and 5.6% respectively. We found, however, no statistical significance on the effects of WCIS on the adoption rates of erosion control, pest-resistant crops, and integrated pest management (Djido et al., 2021).

Both the probability and intensity of adoption of CSAPs are affected by numerous factors, such as demographic characteristics, farm plot features, access to market, socio-economics, climate risks, access to extension services and training. Farmers who perceive high temperature as the major climate risk factor are more likely to adopt crop diversification and minimum tillage. Farmers are

less likely to adopt site-specific nutrient management if faced with short winters; however, they are more likely to adopt minimum tillage (Aryal et al., 2018).

Constraints to adoption of CSA practices: Much as CSA is effective, cost-effective and environmentally-friendly and sustainable, there are challenges militating against the adoption of the prctices. Drawing on empirical works, some of the constraints have been synthesized as follows:

i. In an order of severity, major constraints in their study to include: high input cost, inadequate knowledge of CSA technologies, migration of youth, absence of awareness about climate change, and lack of farmer-friendly CSA technologies. Other constraints include the lack of legal and policy frameworks from the government, uncertain returns, absence of extension activities about CSA technologies, lack of knowledge about adaptive practices of CSA, poor information dissemination about the technologies, non-availability of labour for the adoption of CSAT, small landholding, lack of access to credit, absence of subsidies on planting materials, delayed availability of inputs, limited marketing access, inadequate assistance from national and local authorities on climate-related issues, lack of improved communication facilities, lack of farmers' organisations, lack of necessary transportation facilities, poor supply of uniform electricity, and lack of irrigation facilities (Mallappa & Pathak, 2023).
ii. Unfavourable land tenure system, lack of incentives, cultural barrier, unavailability of information (40%), inadequate soil conservation skills, little road access to land, use of soil conservative practices, lack of technical knowhow and insufficient farm labour, population pressure on land (Elenwa et al., 2019).
iii. Decrease in yield, pest and disease infestation, short-season length (Faleye & Afolami, 2020).
iv. Incidences of pests and diseases was the highest ranked barrier affecting climate-smart agricultural practices, inadequate access to agricultural credit, high cost of improved crop varieties, destruction of crops by animals, lack of knowledge and education on climate-smart agricultural practices, shortages of timely labour for climate-smart agricultural practices, inadequate agricultural land for climate-smart agricultural practices, limited

user-friendliness of climate-smart agricultural practices, and limited access to weather and climate information (Atta-aidoo et al., 2022).

v. Lack of access to up to-date information, lack of access to micro-finance and insurance, lack of access to agricultural input and output markets (Igberi et al., 2022).

Conclusion: In as much as climate change has devastating effect on crop productivity and CSA practices are cost effective and environmentally friendly, the level of adoption is low in Africa. Juxtaposed against the vulnerability of Africa's agriculture to even slight changes in climatic factors, the low level of adoption calls for great concern, requiring urgent attention from the government, farmers and the industries. This study has successfully extracted commonly adopted CSA practices as well as the factors that influence the adoption of these practices. From empirical analyses, it is obvious that the CSA adoption has implications for sustainable crop productivity and food security. Although, there are factors militating against the adoption of CSA practices, it is believed that the intervention of relevant stakeholders can ameliorate the constraints and raise the level of CSA adoption among farmers.

Recommendations: Below are highlights of recommendations arising from various studies across countries, regions and crops: Stakeholders in agricultural policy makers and CSA should acknowledge the complementarity among CSA practices as the practices affect the intensification of adoption by farmers and dissemination across the country. Policymakers should also consider socio-economic, institutional, and parcel-specific factors that positively influence the adoption of CSA practices among households. CSA practices should be introduced to farmers not necessarily as new technologies but as improvements on indigenous practices. It is important to intensify climate change awareness among the farming communities alongside CSA technologies.Farmers should be intensely educated on the pros and cons of CSA as they relate to sustainable land-use practices. Stakeholders in agricultural development should encourage farmers to actively participate in technology development and decision-making processes of CSA adoption. This is because their insights and experiences could influence the success of CSA implementation. The Federal Ministries of Environment and Agriculture and Food Security should include the specific requirements and challenges of small, marginal, and resource-poor farmers in CSA programmes. The National Agricultural Extension, Research and Liaison Services should heighten the concept of site-specific CSA technologies among farmers. Further, policy and support programmes should harmonise and promote of CSA best practices from various places and disseminate same to smallholder farmers. Extension agents should give priority to the appropriateness of CSA packages to the specific conditions of the target areas before they are disseminated. The government should raise the technical capacity of local extension workers for effective delivery of CSA technologies

to farmers. Farm-based organisations should give adequate attention to CSA adoption as a means to climate change mitigation and resilience.

References

Abegunde, V. O., Sibanda, M. & Obi, A. (2019). Determinants of the Adoption of Climate-Smart Agricultural Practices by Small-Scale Farming Households in King Cetshwayo District Municipality , South Africa. *Sustainability*, *12*(195): 2–27.

Abiola, M. O., Omhonlehin, R. A. & Sani, T. P. (2021). Technical Efficiency Of Rice Production In North Central. *Natural Volatiles and Essential Oils*, *8*(6): 4546–4561.

ActionAid Nigeria. (2016). *THE AGRICULTURE PROMOTION POLICY (2016 – 2020) For Smallholder Women Farmers*.

Adebisi, L. O., Adebisi, O. A., Jonathan, A., Oludare, O. T. & Odum, E. E.-B. (2022). Effect of climate smart agricultural practices on food security among farming households in Kwara State , North-Central Nigeria. https://www.redalyc.org/journal/2530/253070366007/html/. *Pesquisa Agropecuária Tropical*, 1–12.

Akpan, S. B., Udo, U. J. & Akpan, P. J. (2019). Analysis of the gross margins and commercialization of manure and fertilizer based water leaf (Talintan triangulare) farmers in Nigeria. *Agricultural and Resource Economics-International Scientific E-Journal*, *5*(4): 5–31.

Akter, A., Geng, X., Endelani Mwalupaso, G., Lu, H., Hoque, F., Kiraru Ndungu, M. & Abbas, Q. (2022). Income and yield effects of climate-smart agriculture (CSA) adoption in flood prone areas of Bangladesh: Farm level evidence. *Climate Risk Management*, *37*, 100455. https://doi.org/10.1016/j.crm.2022.100455

Ameyaw, L. K., Ettl, G. J., Leissle, K. & Anim-Kwapong, G. J. (2018). Cocoa and climate change: Insights from smallholder cocoa producers in Ghana regarding challenges in implementing climate change mitigation strategies. *Forests*, *9*(12). https://doi.org/10.3390/f9120742

Aryal, J. P., Jat, M. L., Sapkota, T. B., Khatri-Chhetri, A., Kassie, M., Rahut, D. B. & Maharjan, S. (2018). Adoption of multiple climate-smart agricultural practices in the Gangetic plains of Bihar, India. *International Journal of Climate Change Strategies and Management*, *10*(3): 407–427. https://doi.org/10.1108/IJCCSM-02-2017-0025

Atta-aidoo, J., Antwi-agyei, P., Dougill, A. J., Ogbanje, E. C., Akoto-danso, E. K. & Eze, S. (2022). Adoption of climate-smart agricultural practices by smallholder farmers in rural Ghana: An application of the theory of planned behavior. *PLOS Climate*, *1*(10): 1–18.

Ayinde, O. E., Ojehomon, V. E. T., Daramola, F. S. & Falaki, A. A. (2013). Evaluation of the effects of climate change on rice production in Niger State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *6*, 763–773.

Belay, A. D., Kebede, W. M. & Golla, S. Y. (2023). Determinants of climate-smart agricultural practices in smallholder plots : evidence from Wadla district , northeast Ethiopia.

International Journal of Climate Change Strategies and Managemen, *15*(5): 619–637. https://doi.org/10.1108/IJCCSM-06-2022-0071

Building Nigeria's Response to Climate Change (BNRCC) Project. (2011). *NATIONAL ADAPTATION STRATEGY AND PLAN OF ACTION ON CLIMATE CHANGE FOR NIGERIA (NASPA-CCN). Prepared for the Federal Ministry of Environment Special Climate Change Unit* (Issue November).

Bukari, K. N. (2017). Farmer-herder relations in Ghana: interplay of environmental change, conflict, cooperation and social networks. *Dissertation for Conferral of a Doctoral Title by the Faculty of Social Sciences at Georg-August University of Göttingen*, 320. https://ediss.uni-goettingen.de/handle/11858/00-1735-0000-0023-3EE9-3?locale-attribute=en

Chauhan, A. S. & Rani, A. (2021). Climate-Smart Agriculture: An Integrated Approach for Attaining Agricultural Sustainability. *Climate Change and Resilient Food Systems*, 141–189. https://doi.org/10.1007/978-981-33-4538-6

de Pinto, A., Cenacchi, N., Kwon, H. Y., Koo, J. & Dunston, S. (2020). Climate smart agriculture and global food-crop production. *PLoS ONE*, *15*(4): 1–19. https://doi.org/10.1371/journal.pone.0231764

Dhahri, S. & Omri, A. (2020). Foreign capital towards SDGs 1 & 2—Ending Poverty and hunger: The role of agricultural production. *Structural Change and Economic Dynamics*, *53*, 208–221. https://doi.org/10.1016/J.STRUECO.2020.02.004

Djido, A., Zougmoré, R. B., Houessionon, P., Ouédraogo, M., Ouédraogo, I. & Seynabou Diouf, N. (2021). To what extent do weather and climate information services drive the adoption of climate-smart agriculture practices in Ghana? *Climate Risk Management*, *32*(April). https://doi.org/10.1016/j.crm.2021.100309

Elenwa, C. O., Emodi, A. I., Harcourt, P. & Harcourt, P. (2019). Soil conservation practices in arable crop production among rural farmers in Omuma Local Government Area of Rivers State, Nigeria. *Agro-Science Journal of Tropical Agriculture , Food , Environment and Extension*, *18*(3): 42–47.

Faleye, O. S. & Afolami, C. A. (2020). Determinants of choice of Climate Smart Agricultural practices adoption among yam-based farming households in Ogun State, Nigeria. *Journal of Agricultural Science and Practice*, *5*(June): 131–141.

FAO. (2010). Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. In *Food and Agriculture Organization of the United Nations (FAO)*. https://doi.org/10.1111/j.1467-825x.2009.02642.x

Federal Ministry of Environment. (2003). Nigeria's National First National Communication, under the United Nation's Framework Convention on Cimate Change. In *United Nations Framework Convention on Climate Change*. https://unfccc.int/documents/133354

Federal Ministry of Environment. (2014). *Nigeria's Second National Communication Under the*

United Nations Framework Convention on Climate Change (Issue February). https://unfccc.int/sites/default/files/resource/nganc2.pdf%0Ahttps://climatechange.gov.ng/wp-content/uploads/2015/06/NGN.SECOND.NATIONAL.COMMUNICATION5.pdf

Federal Ministry of Environment. (2016). *NATIONAL POLICY ON THE ENVIRONMENT (REVISED 2016)*.

Federal Ministry of Environment Abuja-Nigeria (Special Climate Change Unit). (2010). *NATIONAL ENVIRONMENTAL , ECONOMIC AND DEVELOPMENT STUDY (NEEDS) FOR CLIMATE CHANGE IN NIGERIA (Final Draft)* (Issue September).

Federal Ministry of Evironment. (2013). *National Policy on Climate Change (NPCC): 2013*.

Federal Ministry of Evironment. (2014). *National Policy on Climate*. https://climatechange.gov.ng/national-policy-on-climate-change/

Federal Ministry of Evironment. (2017). *Sectoral Action Plans for Nigeria's Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC)* (Issue August).

Federal Ministry of Water Resources. (2016). *National Water Resources Policy*.

Federal Republic of Nigeria. (2018). *Federal Republic of Nigeria First Biennial Update Report (BUR1) of the Federal Republic of Nigeria under the United Nations Framework Convention on First Biennial Update Report (BUR1) of the Federal Republic of Nigeria*.

Feyisa, B. W. (2020). Determinants of agricultural technology adoption in Ethiopia: A meta-analysis. *Cogent Food and Agriculture*, *6*(1): 1–12. https://doi.org/10.1080/23311932.2020.1855817

Hussein, K., Sumberg, J. & Seddon, D. (1999). *Increasing Violent Conflict between Herders and Farmers in Africa: Claims and Evidence* (Vol. 17).

Ibrahim, M. A. & Johansson, M. (2021). Attitudes to climate change adaptation in agriculture – A case study of Öland, Sweden. *Journal of Rural Studies*, *86*(March): 1–15. https://doi.org/10.1016/j.jrurstud.2021.05.024

Igberi, C. O., E., O. E., Odo, N. E., Ibekwe, C. C., Onyemauwa, C. S., Obi, H. O., Obike, K. C., Obasi, I. O., Ifejimalu, A. C., Ebe, F. E., Ibeagwa, O. B., Chinaka, I. C., Emeka, C. P. O., Orji, J. E. & Ibrahim-Olesin, S. (2022). Assessment of Prioritized Climate Smart Agricultural Practices and Technologies of Household Farmers in Southeast , Nigeria. *Universal Journal of Agricultural Research, 10*(1): 53–63. https://doi.org/10.13189/ujar.2022.100105

Ikyoosu, B. M., Ezihe, J. A. C. & Odoemenem, I. U. (2017). Climate Change farm-level Adaptation Measures among Soybean Farmers in Benue state , Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, *2*(5): 2361–2373.

Ilu, I. Y., Frank, A. & Annatte, I. (2016). *Review of the livestock/meat and milk value chains and policy influencing them in nigeria*.

Kifle, T., Ayal, D. Y. & Mulugeta, M. (2022). Factors influencing farmers adoption of climate smart agriculture to respond climate variability in Siyadebrina Wayu District, Central highland of Ethiopia. *Climate Services*, *26*(December 2021): 100290. https://doi.org/10.1016/j.cliser.2022.100290

Kim, C. (n.d.). *The Impact of Climate Change on the Agricultural Sector: Implications of the Agro - Industry for Low Carbon , Green Growth Strategy and Roadmap for the East Asian Region. Background Policy Paper for Korea Rural Economic Institute*.

Kubkomawa, H. I. (2017). Indigenous Breeds of Cattle , their Productivity , Economic and Cultural Values in Sub-Saharan Africa: A Review. *International Journal of Research Studies in Agricultural Sciences (IJRSAS): 3*(1): 27–43.

Kurgat, B. K., Lamanna, C., Kimaro, A., Namoi, N., Manda, L. & Rosenstock, T. S. (2020). Adoption of Climate-Smart Agriculture Technologies in Tanzania. *Frontiers in Sustainable Food Systems*, *4*(56): 1–9. https://doi.org/10.3389/fsufs.2020.00055

Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S. & Branca, G. (2018). *Climate Smart Agriculture: Building Resilience to Climate Change. Natural Resource Management and Policy Series*.

Mallappa, V. K. H. & Pathak, T. B. (2023). Climate smart agriculture technologies adoption among small-scale farmers: a case study from Gujarat, India. *Frontiers in Sustainable Food Systems*, *7*(July): 1–18. https://doi.org/10.3389/fsufs.2023.1202485

Maseko, S. (2021). *The impact of climate-smart technology adoption on f armers ' welfare in Northern Zambia*.

Mujeyi, A., Mudhara, M. & Mutenje, M. (2021). The impact of climate smart agriculture on household welfare in smallholder integrated crop–livestock farming systems: evidence from Zimbabwe. *Agriculture and Food Security*, *10*(1): 1–15. https://doi.org/10.1186/s40066-020-00277-3

Nachmany, M., Fankhauser, S., Davidová, J., Kingsmill, N., Roppongi, H., Schleifer, P., Setzer, J. & Sharman, A. (2015). *The 2015 Global Climate Legislation Study A Review of Climate Change Legislation in 99 Countries*.

Negera, M., Alemu, T., Hagos, F. & Haileslassie, A. (2022). Determinants of adoption of climate smart agricultural practices among farmers in Bale-Eco region, Ethiopia. *Heliyon*, *8*(7): e09824. https://doi.org/10.1016/j.heliyon.2022.e09824

Nigerian Environmental Study/Action Team (NEST). (2011). *Building Nigeria ' s Response to Climate Change (BNRCC) Project*.

Ogundele, F. (2022). Post Harvest Losses and Food Security in Nigeria: An Empirical Review. *African Journal of Agriculture and Food Science*, *5*(3): 77–89. https://doi.org/10.52589/ajafs-c0442z7j

Ojoko, E. A., Akinwunmi, J. A., Yusuf, S. A. & Oni, O. A. (2017). Factors influencing the level

of use of climate-smart agricultural practices (CSAPS) in Sokoto State, Nigeria. *Journal of Agricultural Sciences*, *62*(3): 1–23.

Okoli, F. C. & Addo, H. A. (2018). Implication of Fulani Herders / Benue Farmers Crises on Food Security of Benue State of Nigeria . *International Journal of Academic Multidisciplinary Research*, *2*(10): 16–23.

Olanrewaju, O. (2019). *Economic assessment of catfish farming in Nigeria: a case study of the federal capital territory. United Nations University Fisheries Training Programme, Iceland. Final project. http://www.grocentre.is/ftp/static/fellows/document/Olanrewaju19prf.pdf*.

Olasunkanmi, N. O., Ogunwande, I. O., Thompson, O. A., Afolabi, J. A. & Sofoluwe, N. A. (2022). Determinants of Adoption of Integrated Pest Management Practices Among Maize Farmers in Southwest Nigeria. *Serbian Journal of Agricultural Sciences*, *71*(1–2): 73–80. https://doi.org/10.2478/contagri-2022-0011

Onyeneke, R. U., Amadi, M. U., Njoku, C. L. & Osuji, E. E. (2021). Climate Change Perception and Uptake of Climate-Smart Agriculture in Rice Production in Ebonyi State, Nigeria. *Atmosphere*, *12*, 1–21.

Oyetunde-usman, Z. & Olagunju, K. O. (2019). Determinants of food security and technical efficiency among agricultural households in Nigeria. *Economics*, *7*(103): 1–13.

Prodhan, M. M. H. & Khan, M. A. (2018). Management practice adoption and productivity of commercial aquaculture farms in selected areas of Bangladesh. *Journal of the Bangladesh Agricultural University*, *16*(1): 111–116. https://doi.org/10.3329/jbau.v16i1.36491

Sayne, A. (2011). *Climate Change Adaptation and Conflict in Nigeria*.

Tran, N. L. D., Roberto F. Rañola, J., Sander, B. O., Reiner, W., Nguyen, D. T. & Nong, N. K. N. (2019). Determinants of adoption of climate-smart agriculture technologies in rice production in Vietnam. *International Journal of Climate Change Strategies and Management*, *12*(2): 238–256. https://doi.org/10.1108/IJCCSM-01-2019-0003

United Nations. (1998). *KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK*.

United Nations. (2015). *The Paris Agreement*.

United Nations. (2016). *Transforming our world: the 2030 agenda for sustainable development*.

van Wijk, M. T., Merbold, L., Hammond, J. & Butterbach-Bahl, K. (2020). Improving Assessments of the Three Pillars of Climate Smart Agriculture: Current Achievements and Ideas for the Future. *Frontiers in Sustainable Food Systems*, *4*, 1–14. https://doi.org/10.3389/fsufs.2020.558483

Vanger, E. T. & Nwosu, B. U. (2020). Institutional parameters that condition farmer – herder conflicts in Tivland of Benue State, Nigeria. *African Security Review*, *29*(1): 20–40. https://doi.org/10.1080/10246029.2020.1763413

Williams, T. O., Mul, M., Cofie, O., Kinyangi, J., Zougmore, R., Wamukoya, G., Nyasimi, M., Mapfumo, P., Speranza, C. I., Amwata, D., Frid-Nielsen, S., Partey, S., Girvetz, E., Rosenstock, T. & Campbell, B. (2015). *Climate Smart Agriculture in the African Context*. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Events/DakAgri2015/Climate_Smart_Agriculture_in_the_African_Context.pdf