CLIMATE SMART AGRICULTURE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES volume One

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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 Smart Agriculture, Food Security and Sustainable Development** 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 agriculture (CSA) food security, Sustainable Development 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 agriculture, food security, and sustainable development necessary in policy making process that will stimulate increase in food production and environmental sustainability.

Climate Smart Agriculture, Food Security and Sustainable Development: *Global Issues & Local Perspectives* is organized in three parts. Part One deals with The Concept of **Climate Smart Agriculture**, Part Two is concerned with The Concept of **Food Security And** and Part Three deals with the Concept of **Sustainable Development**

Eteyen Nyong; October 2025

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Chapter One

Climate-Smart Agriculture (CSA) in Nigeria: An Examination of Successful Interventions, Challenges and Future Opportunities

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1.0 Introduction

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The concept of Climate Smart Agriculture (CSA) was developed in order to facilitate agricultural development and climate responsiveness without compromising environmental quality (Kuku and Okonkwo, 2023). As such, the adoption of CSA practices is crucial for ensuring food security, reducing poverty, and promoting sustainable development. Climate-smart agriculture (CSA) is a strategic approach that aims to transform agricultural systems to support food security in a changing climate. Its three main pillars are:

- Sustainably increasing agricultural productivity and incomes to meet the growing demand for food and improve livelihoods.
- Building resilience and adapting to climate change to help farmers cope with the impacts of extreme weather events and long-term climate shifts.
- Reducing and/or removing greenhouse gas (GHG) emissions to contribute to global efforts to mitigate climate change.

Nigeria, with a large population and an economy heavily reliant on agriculture, is particularly vulnerable to the effects of climate change. According to United Nations Population Fund (UNFPA) (2023), the population is expected to reach 400 million by 2050, making Nigeria the third most populous country globally and resulting in further pressure on agricultural production and natural resources. However, CSA initiatives are projected in order to increase agricultural production in order to meet up with the population demands. Although the concept of CSA is still evolving, many of the practices that make up CSA are already being implemented globally.

2.0 Climate-smart Agriculture Interventions in Nigeria

Various initiatives are underway in Nigeria to promote CSA, driven by both governmental and non-governmental organizations, actively supporting these initiatives through policy frameworks, capacity building and financing. These interventions focus on empowering smallholder farmers, who are mostly affected by climate change, with the knowledge and tools needed to adopt sustainable practices in order to build a more secure future for Nigerian agriculture.

2.1 HarvestPlus projects on climate-smart agriculture in Nigeria

Core Focus: Biofortification for Climate Resilience

HarvestPlus's strategy in Nigeria is centered on "biofortification," a process of breeding crops to increase their nutritional value. This is a form of climate-smart agriculture because these biofortified crops are also often selected for traits that make them more resilient to a changing climate, such as drought tolerance and pest resistance.

The main crops in the Nigerian program include:

- Vitamin A Maize: Drought-tolerant and high in Vitamin A, this maize variety helps combat micronutrient deficiencies while thriving in harsh conditions.
- Vitamin A Cassava: A vital staple food, the Vitamin A-rich varieties are also bred for improved performance and resilience.
- Iron Pearl Millet and Iron and Zinc Cowpea: These crops are a key focus in northern Nigeria, where they are promoted to enhance nutrition and improve the resilience of farming households to climate volatility and elevated CO2 levels.

HarvestPlus's work in Nigeria is implemented through several projects and partnerships, often with the goal of scaling up their biofortified crops and integrating them into the national food system.

Project A: Scaling Climate- and Nutrition-Smart Crops through Market Systems in Northern Nigeria

Objective: This two-year project (August 2022 – July 2024), funded by UK aid through the Propcom+ program, was designed to enhance the climate, nutrition, and economic resilience of smallholder farmers and consumers in Northern Nigeria.

Practices Promoted: The project strengthened markets for biofortified crops (Vitamin A maize, iron pearl millet, and iron and zinc cowpea) by promoting climate-smart production technologies and practices, including natural resource management and financing.

Impact: The goal was to reach a significant number of farming households and put a large area of farmland under climate and nutrition-smart agriculture.

Project B: The Commercialization of Biofortified Crops (CBC) Programme

Objective: A partnership with the Global Alliance for Improved Nutrition (GAIN), this program aims to increase access to biofortified seeds, grains, and foods through commercial channels.
Practices Promoted: The program works along the value chain, from seed multiplication and distribution to creating consumer demand for processed biofortified foods like garri and fufu.
Impact: The initiative is designed to create a sustainable market for biofortified crops, making them accessible to a wider population and helping to address hidden hunger, especially among vulnerable groups.

HarvestPlus employs a multi-faceted approach to ensure the widespread adoption of their climate-smart, biofortified crops:
Partnership and Collaboration: HarvestPlus collaborates with a wide range of public and private sector partners, including government ministries, research institutions (like the IITA and IAR-Zaria), seed companies, and NGOs. This collaborative model helps them to develop, test, and deliver new crop varieties.
Seed System Development: The organization works to strengthen Nigeria's seed sector by providing quality early-generation seeds to companies for multiplication. They also work with the National Agricultural Seed Council to develop and implement standards for biofortified crops, ensuring quality and trust for farmers.

Capacity Building: HarvestPlus provides training for extension agents, seed companies, and farmers on best agronomic practices for biofortified crops. This knowledge transfer is crucial for ensuring farmers get the maximum yield and benefit from the new varieties.

Market Development: The projects create market linkages for farmers, connecting them with aggregators and food processing companies. This ensures a stable market for their produce and incentivizes them to continue growing the biofortified crops. For example, some projects have facilitated contract farming arrangements to provide a dedicated market for farmers' produce.

Achievements and Outcomes
HarvestPlus's projects have had a significant impact on Nigeria's agricultural landscape
i. Widespread Adoption: Millions of Nigerian households are now growing and consuming biofortified crops. As of 2021, an estimated 1.8 million households were growing vitamin A cassava and almost 1.6 million households were growing vitamin A maize.

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ii. Increased Income and Yields: Farmers adopting these climate-smart varieties have reported increased productivity and better income, as the crops perform well even in challenging weather conditions.

iii. Improved Nutrition: By integrating biofortified crops into the national food system, the projects are helping to address micronutrient deficiencies, particularly Vitamin A deficiency, which is a significant public health issue in Nigeria.

iv. Policy Integration: The success of the biofortification program has led to its integration into national policies and programs, indicating a sustainable pathway for scaling these climate-smart practices.

2.2 LINKS Nigeria Climate-Smart Agriculture Initiatives

The LINKS (Links to Nigeria's Economic Restoration) project, funded by the UK's Foreign, Commonwealth and Development Office (FCDO), was a significant initiative in northern Nigeria that focused on "green growth" and climate-smart agriculture (CSA). While the project was closed earlier than its intended 2026 completion date due to FCDO budget cuts, its work in piloting and scaling green innovations in the agribusiness sector had a notable impact.

Objective: LINKS, a development program, has been at the forefront of implementing CSA pilots in northern Nigeria.

Practices Promoted: They focused on two key areas: System of Rice Intensification (SRI) and Regenerative Agriculture.

Impact: The projects have not only boosted farmers' incomes and crop yields but also contributed to improved resilience and adaptation to climate change for thousands of farmers.

LINKS's approach to CSA was practical and evidence-based, focusing on two key methodologies: the System of Rice Intensification (SRI) and Regenerative Agriculture.

The System of Rice Intensification (SRI)

SRI is a farming method that aims to lower greenhouse gas (GHG) emissions from rice production while simultaneously increasing yields. It is considered a CSA practice because it addresses both adaptation (increasing productivity and resilience) and mitigation (reducing GHG emissions).

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Practices Promoted:

- Early establishment of seedlings: Planting young seedlings (8–12 days old) to reduce transplant shock and allow for better root development.
- Reduced plant population: Wider spacing between plants to reduce competition for resources and allow each plant to flourish.
- Organic fertilizer use: The application of organic matter to improve soil health and fertility.
- Alternate wetting and drying: This practice involves periodically draining and re-flooding the rice field. This "aerobic" condition in the soil reduces the production of methane, a potent GHG, while still providing sufficient water for the rice plants.

Impact and Successes

The SRI pilot was hugely impactful.

Farmers trained: LINKS trained 66,043 farmers (of which 20% are women). Of the 66,043 trained 37,403 are applying SRI principles

Hectares cultivated: 31,379. Farmers started with a quarter of hectare each with some expanding on this in subsequent seasons.

Yield increased: 100% average increases in yield compared with fields applying traditional practices.

Incomes increased: LINKS increased incomes of 22,967 farmers (of which 4,553 are women) and expect this to nearly double by 2024.

Jobs created: 33,823 jobs (of which 6,631 are estimated to be women).

Reduced GHG emissions: net reduction in GHG emissions in production by 40%

Improved resilience and adaptation: LINKS has contributed to the improved resilience of over 10,000 famers and supported over 30,000 to adapt to the impacts of climate change

Regenerative Agriculture (RegenAg)

Regenerative agriculture is a system of farming principles and practices that aims to increase biodiversity, enrich soils, and improve the water cycle. It provides timely and location-specific solutions to help farmers adapt to climate change while restoring degraded lands.

Practices Promoted:

- ❖ Minimizing soil disturbance: Reducing or eliminating tilling to maintain soil structure and health.
- ❖ Maximizing crop diversity: Implementing crop rotation and intercropping to improve soil fertility and reduce pest and disease pressure.
- ❖ Providing soil cover: Using cover crops or crop residue to protect the soil from erosion and maintain moisture.
- ❖ Maintaining living roots all year round: Keeping living roots in the soil for as long as possible to feed soil microbes and sequester carbon.
- ❖ Integrating livestock: Thoughtful grazing practices that benefit soil health.

Impact and Successes

i. Carbon Project: Supported the establishment of a special purpose vehicle to design a carbon project and seek seed and 1st phase funding for a certified carbon project. The carbon project is the first of its kind in Nigeria and will support the regeneration of 100,000 hectares of land reducing millions of tons of carbon emissions over 30 years.

ii. Farmer Training: Developed training materials and train farmers on regen ag practice and principles, and trained 21,503 farmers in regen ag principles. Created 6,573 jobs for men and women so far. Increased the incomes of 24,624 men and women. Supported over 15,000 farmers to adapt to impacts of climate change

ii. Technological innovation: Building an online platform to onboard 30,000+ farmers and map their land, socio-economic and environmental data.

iv. Restoring degraded lands: The project's focus on soil regeneration and biodiversity was particularly relevant in northern Nigeria, where land is being lost to wind erosion and desert encroachment.

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Challenges

Despite its significant successes, the LINKS project faced challenges, most notably its premature closure due to budget cuts. This highlights a persistent challenge for many development projects in terms of sustainability and long-term funding. Nevertheless, the project's achievements in training thousands of farmers, increasing crop yields, and demonstrating the viability of both SRI and regenerative agriculture have had a lasting impact. The LINKS project is a clear example of how targeted, context-specific CSA initiatives can not only improve farmer livelihoods and food security but also contribute to broader environmental goals, such as reducing greenhouse gas emissions and restoring degraded land.

2.3 AGRA, Nestlé, and TechnoServe's StreFaS Initiative

In a major collaborative effort to build a climate-resilient agricultural sector in Nigeria, the Alliance for a Green Revolution in Africa (AGRA), Nestlé Nigeria, and TechnoServe have launched the Strengthening Farmers' and SMEs' Resilience through Climate Smart Grain Production and Accessing the Structured Markets (StreFaS) initiative. This initiative represents a significant public-private partnership aimed at transforming the agricultural value chain, with a specific focus on regenerative agriculture.

Duration: The three-year initiative runs from June 2024 to October 2027.

Crops: The project focuses on the sustainable production of key grains, including maize, soybean, rice, and sorghum.

Objective: aims to build a climate-resilient agricultural sector by integrating regenerative agriculture into the value chain. To support 25,000 smallholder farmers and eight aggregators across Kaduna and Nasarawa States.

Practices Promoted: The project emphasizes practices that improve soil health, lower greenhouse gas emissions, and increase biodiversity. It specifically focuses on empowering youth and women in the process.

Impact: Since inception, StreFaS has engaged 12,373 farmers with 40% youth participation, established 270 demonstration farms showcasing regenerative practices, aggregated 74,223.53 metric tons of produce from SHF,and supported smallholders in dedicating 1,853 hectares to regenerative agriculture practices.

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The Role of Each Partner

AGRA: As a co-funder and key partner, AGRA is a driving force behind the initiative. Its role aligns with its core mission of building sustainable and resilient food systems in Africa. AGRA provides the strategic vision and expertise in agricultural development, ensuring that the project's practices are effective and scalable.

Nestlé Nigeria: Nestlé is a major co-funder and a critical market partner. The initiative is a core part of Nestlé's global commitment to sustainable sourcing and decarbonizing its value chain. By 2030, Nestlé aims to source at least 50% of its key ingredients from farmers practicing regenerative agriculture. This project creates a direct link between farmers and a structured market, offering premium pricing for their climate-smart produce.

TechnoServe: As the implementing partner, TechnoServe brings its proven expertise in building market-driven solutions for rural prosperity. The organization is responsible for the on-the-ground implementation of the project, including farmer training, technical support, and linking farmers and aggregators to Nestlé's supply chain.

Key Practices of Regenerative Agriculture in The StreFaS initiative

The StreFaS initiative promotes regenerative agriculture, which is a set of practices designed to improve soil health, lower greenhouse gas (GHG) emissions, and increase biodiversity. The practices include:

a. Improved Soil Health: Practices such as minimum tillage, cover cropping, and crop rotation are used to enhance the soil's organic matter, fertility, and ability to retain water.

b. Reduced GHG Emissions: By improving soil health and using efficient farming methods, the project aims to reduce the carbon footprint of grain production.

c. Increased Biodiversity: Encouraging diverse cropping systems and integrating livestock can lead to a healthier and more resilient ecosystem.

d. Water Management: The project promotes techniques that improve water retention in the soil, making farming systems more resilient to drought and erratic rainfall.

Impact and Successes

Since its launch, the StreFaS initiative has already shown promising results:

i. Farmer Engagement: The project has engaged thousands of farmers, with a strong focus on youth participation.

ii. Demonstration Farms: Hundreds of demonstration farms have been established to showcase the effectiveness of regenerative agriculture practices and encourage wider adoption.

iii. Market Linkages: Farmers who adopt the new practices are connected to a formal market, specifically Nestlé's supply chain, which provides them with stable demand and premium prices for their produce.

iv. Economic Resilience: By improving yields and providing market access, the initiative helps to strengthen the economic resilience of smallholder farmers and their communities. A participating farmer, for example, has reported that his yields doubled after adopting the new strategies introduced through the project.

The AGRA, Nestlé, and TechnoServe partnership in Nigeria is a powerful model for promoting climate-smart agriculture. It demonstrates how a collaborative approach, combining the strategic expertise of an organization like AGRA, the market power of a global company like Nestlé, and the on-the-ground implementation skills of an NGO like TechnoServe, can create a sustainable and profitable agricultural system. The StreFaS initiative is a clear example of a project that not only addresses environmental challenges but also creates economic opportunities, especially for youth and women, paving the way for a more resilient and prosperous agricultural sector in Nigeria.

2.4 Mercy Corps' Borno Agricultural Development Initiative (BADI)

Mercy Corps has a strong presence in Nigeria, particularly in the northeast, where it implements various programs to address the humanitarian crisis, build peace, and foster economic resilience. A key component of this work is their focus on agricultural development, which is crucial for communities affected by conflict and climate change. Borno Agricultural Development Initiative (BADI) was a project funded by the Bill and Melinda Gates Foundation aimed at strengthening the resilience of vulnerable households in Borno State. The initiative focused on helping farmers cope with the shocks and stresses of climate change and food insecurity by introducing them to sustainable and smart agricultural practices.

Objective: This project, supported by the Bill and Melinda Gates Foundation, worked to strengthen the resilience of vulnerable households in Borno State to climate shocks.

Practices Promoted: Mercy Corps introduced communities to a range of context-appropriate and smart agricultural practices, including hydroponics fodder production for livestock, distribution of irrigation equipment for dry-season farming, and training on permaculture and micro-gardening.

- Sustainable and context-appropriate agriculture: The project introduced a variety of practices tailored to the specific needs of the communities.
- Market-based approach: Mercy Corps focused on developing market systems for quality seeds and other agricultural inputs. This included training farmers on community seed production and linking them to local agro-dealers to ensure a sustainable supply of inputs.
- Innovation in Farming: The initiative introduced innovative practices like hydroponics for fodder production, which is a method of growing plants using mineral nutrient solutions in water without soil. This is particularly useful in arid and semi-arid regions.
- Dry Season Farming: Mercy Corps distributed irrigation equipment to smallholder farmers to enable them to farm during the dry season, a crucial adaptation strategy to unpredictable rainfall.
- Permaculture and Micro-gardening: Training was provided to agricultural extension workers and lead farmers on permaculture and micro-gardening, which are sustainable systems for food production that work with natural ecosystems.

Impact: The BADI project was able to strengthen the resilience of hundreds of farmers in Borno State by providing them with the necessary skills and linkages to suppliers of agricultural inputs. This helped them to become more resilient to future shocks and stresses caused by climate change. Specifically, the BADI project had the following impacts

- Signed Memorandum of Understanding (MoUs) and agreement with four partners from the public and private sectors.
- Linked input suppliers to Contec Global Agro Ltd bio inputs.
- Seven demonstration farms identified and developed across the project locations in Biu and Damboa LGAs.

- Trained seven agricultural extension workers and seven lead farmers as trainers on Good Agricultural Practices (GAP) in Biu and Damboa.
- Trained eight village agents (VAs) (one female and seven male) on village savings and loan association (VSLA) methodology in Biu.
- Distributed agro-inputs to 570 participants (272 female and 298 male) across seven project communities in Biu and Damboa.
- Trained 120 smallholder farmers (59 female and 61 male) on hydroponics fodder (known as the best livestock feed) production for ruminant animals
- Distributed Noiler birds to 184 smallholder farmers (92 female and 92 male).
- Distributed fodder materials to 120 smallholder farmers (59 female and 61 male).
- Distributed irrigation equipment to 182 smallholder farmers (45 female and 137 male) for dry season farmers.
- Trained 10 agriculture extension workers (AEW), lead farmers, and two partner staff on (four female and six male) permaculture and micro gardening.
- Distributed permaculture and micro gardening materials (multi-nutrients, PVC pipes and accessories, coco coir, stools, rice hulls, buckets, seeds, seed trays) to 180 project participants (76 female and 104 male).

2.5. The Rural Resilience Activity (RRA)

The RRA is a five-year (2019 to 2025) USAID-funded program that Mercy Corps leads in partnership with Save the Children International (SCI) and the International Fertilizer Development Center (IFDC). It operates in conflict-affected areas of Northeast Nigeria, aiming to facilitate economic recovery and growth. This program seeks to facilitate economic recovery and growth in vulnerable, conflict-affected areas by promoting systemic change in market systems. The Activity is part of the U.S. Government's global hunger and food security initiative aimed at developing the agriculture sectors and breaking the vicious cycle of poverty and hunger in some of the world's poorest countries. The Activity empowers vulnerable households,

communities, and systems to cope with current shocks and stresses and to be prepared to withstand future ones.

Practices Promoted: The RRA adopts a "market systems development" approach, which focuses on making markets more resilient and inclusive. This involves:

- Adopting Best Practices: The program stimulates the adoption of good agricultural practices to improve productivity and sustainability.
- Strengthening Market Linkages: It works to build relationships between various market players, from smallholder farmers to micro-enterprises and grain aggregators.
- Climate-Resilient Practices: A key component is promoting practices that help farmers adapt to climate change, such as the use of improved seeds and fertilizers.
- Cash Transfers and Support: The program has delivered cash transfers to smallholder farmers and microenterprise owners to help them cope with economic shocks and invest in their livelihoods.

Impact: The RRA has reached tens of thousands of households, helping them to move out of chronic vulnerability and poverty. It has been instrumental in strengthening market systems and building the resilience of the agricultural sector in a region facing multiple crises. To date, the Activity has reached 506,425 million people - men, women, youths, persons with disabilities, and internally displaced persons in Nigeria - through partners' activities and direct implementation. The Activity has built partnerships with 80 private sector partners, out of which 31 of them have received catalytic grants to scale or expand their businesses in Northeast Nigeria. This has resulted in the creation of 12,256 jobs and the facilitation of US$51,974,962 in sales and US$14,878,253 in loans (access to credit) by participants. The Activity has also mobilized US$6,768,059 in leverage - monies contributed by private-sector partners to the Activity's goals.

2.6Noteworthy Initiatives by Mercy Corps

Mercy Corps's agricultural development initiatives in Nigeria are characterized by a holistic approach that integrates humanitarian aid, peacebuilding, and economic development. By focusing on market systems, capacity building, and innovative, climate-smart practices, Mercy Corps is helping vulnerable communities not only to survive but also to thrive in the face of ongoing conflict and the growing threat of climate change. Their projects demonstrate a

commitment to building long-term resilience and creating sustainable livelihoods for some of Nigeria's most marginalized populations. Mercy Corps implements a range of other projects that incorporate climate-smart practices across Nigeria:

a. Partnership with ThriveAgric: This collaboration focuses on "Preventing the Impacts of Climate Change on Agriculture" in North-East Nigeria. It provides thousands of farmers with comprehensive training on best practices for storage, drying, and packaging, as well as water harvesting techniques, building terraces to combat erosion, and adopting drought-resistant crop varieties.

b. AgriFin Program: Through its AgriFin program, Mercy Corps leverages digital technology to provide farmers with essential services. In Nigeria, this includes providing weather and market information through digital platforms, helping farmers make informed decisions and manage their farms effectively.

c. Solar-Powered Irrigation: In states like Adamawa, Mercy Corps has installed and supported solar-powered irrigation systems. This sustainable method allows farmers to water their crops throughout unpredictable dry seasons, significantly improving their food security and income.

2.7 SEFFA's Greenhouse Technology Project

The Sustainable Environment, Food and Farming Advancement (SEFFA) Initiative is a non-governmental organization in Nigeria that is making significant strides in promoting climate-smart agriculture, particularly through its use of greenhouse technology. SEFFA's projects are a compelling example of a locally-led adaptation solution that is not only addressing food security but also empowering communities with new skills and income streams. The SEFFA Greenhouse Initiative is a powerful example of a small-scale, locally-led project with a big impact. By harnessing the power of greenhouse technology and integrated farming systems, SEFFA is not only helping communities in Plateau State to adapt to climate change but is also creating a model for how to build a more resilient, prosperous, and food-secure future. The project's emphasis on training, capacity building, and creating multiple income streams ensures that its benefits are lasting and that communities are well-equipped to face the challenges of a changing climate.

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Objective: A small-scale initiative supported by the UNDP, the SEFFA project "Building Resilience to Climate Change through Integrated Climate Smart Agriculture and Greenhouse Technology Skills" empowers local communities in Plateau State.

Practices Promoted: The project harnesses the power of integrated CSA and greenhouse technology, which provides a controlled environment for year-round farming and reduces dependency on rain-fed systems.

Impact: This project has enabled farmers to realize income from multiple streams, increase farm production, and boost food security. It has also created new jobs and helped the community to harvest crops like rice from their own fields.

Core Focus: Integrated Greenhouse Technology

SEFFA's central strategy revolves around an "integrated climate-smart agriculture and greenhouse technology skills" project, which is supported by the United Nations Development Programme (UNDP) through the Adaptation Fund Climate Innovation Accelerator (AFCIA) program.

Greenhouse Technology: The use of greenhouses is a crucial climate-smart practice. It provides a controlled environment that allows for year-round farming, significantly reducing dependence on rain-fed systems and protecting crops from unpredictable weather events like drought, floods, and extreme temperatures.

Integrated Systems: A key innovation of the SEFFA project is its integration of various farming systems, such as combining vegetable cultivation with fish tanks inside the greenhouse. This approach, sometimes known as aquaponics, creates a symbiotic ecosystem where fish waste serves as fertilizer for the plants, and the plants in turn help to purify the water for the fish. This creates multiple income streams and increases the efficiency of resource use.

Key Practices and Outcomes

SEFFA's projects demonstrate a multi-faceted approach to building resilience and prosperity:

i. Capacity Building and Training: The initiative's primary focus is on empowering local communities through hands-on training and workshops. Community members learn about the intricacies of greenhouse farming, including production, processing, and marketing of crops. This

knowledge transfer is essential for ensuring the sustainability of the project and enabling beneficiaries to replicate the technology on their own.

ii. Community Empowerment: SEFFA has built and is using greenhouses and a processing hub to train and empower communities in areas like Jos South Local Government Area. This helps to create a new generation of "climate-smart ambassadors" who can drive change in their communities.

iii. Increased Productivity and Income: The use of greenhouses has enabled farmers to significantly increase their farm production. For example, a project beneficiary in the Gurupwana community shared how the initiative enabled her to rear fish, cultivate vegetables, and trade in the market, leading to a substantial increase in income.

iv. Creation of Jobs: The projects have a direct impact on employment. For instance, an initiative with two greenhouses and solar-powered boreholes has a target of creating 150 new jobs, demonstrating the potential of this technology to generate employment and economic opportunities.

v. Technology Transfer: The initiative goes beyond providing infrastructure by equipping communities with new technologies that were previously foreign to them, such as solar-powered boreholes. This reduces the reliance on traditional energy sources and enhances the sustainability of the farming practices.

vi. Collaboration: SEFFA has a history of collaborating with institutions, such as the Federal College of Veterinary Research and Medical Laboratory Technology in Vom, to build greenhouse facilities for training students, staff, and farming communities. This kind of public-private partnership is crucial for scaling up the technology and its benefits.

2.8 AATF Project on CSA in Nigeria

The African Agricultural Technology Foundation (AATF) is a non-profit organization that plays a pivotal role in enabling smallholder farmers in Africa to access and utilize appropriate technologies to improve their productivity and livelihoods. In Nigeria, AATF's work is particularly focused on developing and commercializing climate-smart crops, often through the use of biotechnology. Their projects are a key example of how innovative science can be applied to address the challenges of food insecurity and climate change.

Objective: developing and promoting genetically modified crops that are climate-resilient and pest-resistant.

Practices Promoted: Pod Borer Resistant (PBR) Cowpea: This crop is resistant to pests, reducing the need for chemical inputs and leading to higher yields. TELA Maize: This variety is drought-tolerant and resistant to the Stem borer pest, helping farmers reduce costs and increase harvests.

Impact: These new crop varieties are "rewriting Nigeria's farming story" by providing farmers, with a reliable way to boost productivity and income, even in the face of climate change.

Pod Borer Resistant (PBR) Cowpea (SAMPEA 20-T)

Cowpea is a critical protein source for millions of Nigerians, but its production is severely threatened by the legume pod borer (Maruca vitrata), a pest that can cause up to 80% yield loss. AATF, in collaboration with the Institute for Agricultural Research (IAR) at Ahmadu Bello University and other partners, developed a genetically modified (GM) cowpea variety known as PBR Cowpea, or SAMPEA 20-T. This crop has a gene from a common soil bacterium (Bacillus thuringiensis, or Bt) that provides built-in resistance to the pod borer. The in-built resistance means farmers no longer need to apply multiple insecticide sprays (from an average of 6-8 sprays to only two targeted sprays per season). This significantly reduces production costs, protects farmer health, and lessens the environmental impact. Farmers can achieve a more reliable harvest with an average yield increase of 20%, and much higher under severe pest pressure. This translates to higher income and improved food security for farming households. The PBR Cowpea, being protected from a major pest, is more resilient and can thrive in various conditions, making it a reliable crop for farmers facing the uncertainties of climate change. Nigeria was the first country in the world to approve the commercial release of this GM cowpea, making it a pioneer in this agricultural breakthrough.

TELA Maize

Maize is another staple crop whose production is hampered by a combination of pests and abiotic stresses, particularly drought. The TELA Maize project is a public-private partnership coordinated by AATF to address these challenges. TELA Maize is a transgenic maize variety that is both drought-tolerant and insect-protected. It builds on the success of the Water Efficient Maize for Africa (WEMA) Project and incorporates genes that provide resistance against the

stem borer and fall armyworm, two devastating pests. The project's maize varieties are specifically bred to perform well under moderate drought conditions, a major adaptation strategy for a climate with increasingly erratic rainfall. The built-in insect protection reduces the need for costly and harmful chemical insecticides, leading to better grain quality and higher yields. By eliminating the "twin challenge" of drought and pests, TELA Maize helps farmers achieve more reliable harvests and higher income, strengthening their economic resilience. The project's goal is to increase maize production and contribute to Nigeria's food security by providing farmers with a technology that ensures consistent yields.

Collaboration with NiMet

AATF has also entered into a strategic partnership with the Nigerian Meteorological Agency (NiMet) to advance climate-resilient agriculture. This collaboration highlights AATF's holistic approach to CSA, which extends beyond crop genetics.

Objective: To provide farmers with timely and accurate climate information and to promote technologies that strengthen agricultural value chains against the impacts of climate change.

Key Activities: The partnership aims to develop weather tools that are tailored to the needs of farmers, helping them make informed decisions on planting, irrigation, and other farm management practices. Both organizations will work together to build the capacity of farmers to use climate information and adopt other climate-smart technologies.

AATF's projects in Nigeria are a clear example of a technology-driven approach to climate-smart agriculture. By leveraging genetic modification to develop drought-tolerant and pest-resistant crops like PBR Cowpea and TELA Maize, AATF provides farmers with powerful tools to increase their productivity, reduce costs, and build resilience to climate change. Their recent partnership with NiMet further demonstrates a commitment to a comprehensive strategy that combines cutting-edge agricultural technology with crucial climate information to ensure a more sustainable and food-secure future for Nigeria.

3.0 Successes of Climate-Smart Agriculture Interventions in Nigeria

Despite significant challenges, several case studies and projects demonstrate the successful implementation of CSA in Nigeria:

a. Increased Productivity and Income: Farmers who have adopted CSA practices have reported an increase in crop yields and income. This is often achieved through the use of drought-

resistant and early-maturing crop varieties, improved irrigation techniques, and better soil management.

b Improved Resilience: Case studies from states like Ebonyi show that farmers who have access to Climate Information Services (CIS) through radio and extension workers are better equipped to adapt to climate change. They use this data to make informed decisions on planting, irrigation, and pest control, improving their resilience to climate shocks.

c. Adoption of Indigenous Knowledge: Many farmers in Nigeria are successfully integrating indigenous knowledge with modern CSA practices. This includes adjusting planting dates and using natural methods for pest control, which are often more affordable and culturally relevant.

d. Technological Innovations: The introduction of technologies like Pod Borer Resistant (PBR) Cowpea and TELA Maize has shown promising results. These genetically modified crops are resistant to pests and can thrive in harsh environmental conditions, reducing the need for chemical inputs and increasing yields.

e. Farmer Training and Empowerment: Organizations and projects, such as the LINKS team in northern Nigeria, have successfully trained thousands of farmers, including a significant number of women, on CSA methodologies like the System of Rice Intensification (SRI). This has led to a 100% average increase in yield compared to traditional practices and a net reduction in GHG emissions.

4.0 Challenges to Adopting Climate-Smart Agriculture in Nigeria

The scaling up of CSA in Nigeria faces several significant hurdles

i. Financial Constraints: Many smallholder farmers lack the capital to invest in CSA technologies, such as improved seeds, irrigation equipment, and fertilizers. Poor access to credit facilities further exacerbates this problem.

ii. Lack of Awareness and Technical Skills: Farmers often lack the necessary education, information, and training to understand and implement CSA practices. The unavailability of sufficient extension workers is a major barrier to the transfer of knowledge and technology.

iii. Policy and Institutional Gaps: There is a need for a more explicit national agricultural policy framework that supports and promotes CSA. A lack of synergy, coordination, and collaboration

among stakeholders including government agencies, NGOs, and the private sector can lead to duplication of efforts and inefficient resource allocation.

iv. Inadequate Infrastructure: Deficiencies in essential infrastructure, such as irrigation systems, drainage, and weather forecasting services, hinder the effectiveness of CSA.

v. Societal Norms and Gender Inequality: In some regions, social norms and limited decision-making power for women restrict their participation in agricultural activities and their ability to adopt new farming practices.

5.0 Opportunities for Climate-Smart Agriculture in Nigeria

Despite the challenges, there are numerous opportunities to expand the reach and impact of CSA in Nigeria:

a. Public-Private Partnerships: Collaborative efforts between the government, private sector, and non-governmental organizations (NGOs) can help to address financial and technological barriers. The private sector can play a key role in providing access to improved seeds, equipment, and market linkages.

b. Digital Technologies: The use of Information and Communication Technologies (ICTs) and digital platforms, such as Early Warning Systems (EWS), can provide farmers with real-time weather alerts and crucial agricultural advice. This can help them make timely decisions and mitigate risks.

c. Access to International Climate Finance: Nigeria can leverage international climate finance from sources like the Green Climate Fund and the Global Environment Facility to fund CSA initiatives. Mechanisms like the National Agricultural Resilience in Nigeria can help direct these funds to relevant projects.

d. Capacity Building and Extension Services: Investing in the training of community facilitators and agricultural extension officers is critical. These individuals can serve as a vital link between researchers and farmers, helping to cascade knowledge and skills to local communities.

e. Integration of Sustainable Practices: There is an opportunity to promote and scale up a range of sustainable practices that fall under the CSA umbrella, such as agroforestry, soil and water management, and the use of drought-tolerant and early-maturing crop varieties.

Conclusion

Agriculture in Nigeria is particularly vulnerable to the impacts of climate change such as erratic rainfall patterns, rising temperatures, and extreme weather events. Notwithstanding, climate-smart agriculture is gaining traction in Nigeria; actively implementing adaptation and mitigation strategies as well as coordinating climate-smart interventions. Amidst challenges, several climate-smart interventions have recorded successes with hopes that many more ongoing interventions will make Nigerian agriculture more resilient and sustainable.

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