Climate change ameliaration and enhancing food security through agriculture in Northern Nigeria

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Graphical Abstract

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Abstract

The climate of northern Nigeria change more significantly during the twenty-first century in terms of temperature, precipitation, storms, and sea levels. This presents a serious threat to the region's agricultural output and food security. Northern Nigeria is the most populous region in the nation and has a majority of its rural residents being agrarians. Much of this can be ascribed to the harsher climate that regions are experiencing. When droughts persist, rainfall is rarely consistent for a long time. A further challenge to the region's agricultural economy was desertification and the removal of vegetation. Agriculture is still stagnant or perhaps declining despite government efforts to supply all agricultural inputs. In Nigeria, poor crop yield and livestock production, desertification, flooding, insect and disease infestation, and weed infestation are all consequences of climate change in agricultural output. The agribusiness entrepreneur is prompted by these challenges to play adaptive roles in mitigating these effects. These roles include agroforestry, harvesting and storing water, managing farm finances, vertical integration with pertinent agencies, and providing timely information for preventive measures. Moreover, agribusiness initiatives in Northern Nigeria contribute to the United Nations Sustainable Development Goals (SDGs) by creating jobs, increasing farmers' incomes, and promoting rural development. These initiatives combat hunger, create decent work opportunities, mitigate climate change effects, and preserve terrestrial ecosystems. The initiative aligns with the Science, Technology, and Innovation Strategy for Africa (STISA-2024), aiming to address socio-economic challenges in Africa. The success of these initiatives can serve as a model for other regions, promoting broader food security and climate improve food security and mitigate these issues, this study looks into how agribusiness to these changes evaluates the present effects of climate change on agriculture in northern Nigeria and looks at methods for advancing resilient food systems and sustainable farming practices

Keywords: Northern Nigeria, Climate change, Amelioration, Agribusiness, Food security and Sustainable Development Goals

1 Introduction

Nigeria's agriculture industry faces serious threats from climate change. Rain-fed agriculture, which is extremely vulnerable to climatic changes and can result in a variety of negative effects like rising temperatures, irregular rainfall patterns, and extreme weather events, is the main cause of the impact in areas like northern Nigeria. In the end, these variables endanger the livelihoods of millions of smallholder farmers and undermine the food security of the entire population by hurting agricultural yields and livestock production. According to Lal (2018), smallholder farmers in developing nations who depend on agriculture for a living are especially vulnerable to the negative effects of climate change on global food security. These farmers are especially susceptible to the effects of climate change because they frequently lack the means and technology to adjust to it (Niang et al., 2014). Climate change can have direct consequences on agricultural output, but it can also increase the frequency and intensity of extreme weather events like storms, floods, and droughts. These events can cause crop failures, livestock losses, and infrastructure damage (Lobell et al., 2019). Smallholder farmers may suffer greatly as a result, falling even deeper into poverty and food insecurity in terms of their income and food security (Lal, 2018; Lobell et al., 2019). Agribusiness, which includes farming, processing, marketing, and distribution, becomes an essential means of accomplishing these goals. Agribusiness may significantly contribute to reducing the effects of climate change on agriculture by incorporating climate-smart practices and technologies such as enhanced irrigation systems, resilient crop varieties, and sustainable land management strategies (FAO, 2019; Ahmed et al., 2020). Through an analysis of Nigeria's current agribusiness situation and the identification of growth prospects and obstacles, plans may be devised to advance environmentally conscious practices and sustainable agricultural development within the nation. Smallholder farmers can become more resilient with the support of adaptation techniques including encouraging crop types that are resistant to climate change, putting water conservation measures into place, and expanding their sources of income. Furthermore, improving the adaptive ability of agricultural systems and guaranteeing sustainable food production in Nigeria depend heavily on investments in climate-smart agriculture practices, such as agroforestry, conservation agriculture, and integrated water management. To increase the agriculture sector's total capacity for adaptation and to help smallholder farmers become more resilient, effective policies and interventions are needed. This could entail encouraging climate-smart farming methods, including investments in environmentally friendly water management, enhancing public access to weather data and early warning systems, and encouraging the creation and use of resilient crop kinds and breeds (Yusuf, 2017). Moreover, addressing the socioeconomic, institutional, and governance components of climate change adaptation should be a part of initiatives to strengthen the agricultural sector's adaptive potential. Increasing the ability of agricultural extension services, encouraging democratic and participatory decision-making procedures, and offering smallholder farmer's financial and technical support to put adaptation measures into place are a few ways to do this (Nkonya, 2015).
Agroforestry is a dynamic, ecologically grounded method of managing natural resources that incorporates trees into agricultural landscapes to increase output diversity and sustainability while providing more social, economic, and environmental advantages for land users at different levels. They contend that we should support farming methods or farming systems that put environmental quality first in addition to guaranteeing food security. There can be negative effects from neglecting to address environmental changes and from

not developing farming systems that offer options for alternate livelihoods. As a result, quick action is needed to lessen the negative effects of these environmental changes (Alao & Shuaibu, 2013). The broad objective of the study is to examine the climate change amelioration and enhancing food security through agribusiness while the specific objectives are to;

- Implement sustainable agricultural practices to reduce greenhouse gas emissions and enhance carbon sequestration.
- Increase agricultural productivity and resilience to climate change to ensure a stable and sufficient food supply.
- Support the development of eco-friendly agribusinesses that utilize renewable resources and minimize environmental degradation.
- Advocate for policies that support climate-resilient agriculture and provide incentives for sustainable agribusiness practices.

2 Impacts of Climate Change on Agriculture in Northern Nigeria

Nigeria's agriculture faces serious obstacles from climate change, which might make the nation's overall levels of poverty and food insecurity worse. The significant effects of climate change on agricultural production have been the subject of numerous studies, which predict significant drops in crop yields due to changes in temperature and precipitation patterns (Udoh, Etim, & Etim, 2020). The bulk of the people in Nigeria still relies on agriculture as their main source of income, hence these developments will have a big impact on the country's primarily agrarian economy. Nigeria's agricultural economy is primarily dependent on smallholder farmers, who are especially sensitive to the negative effects of climate change. They are more vulnerable to dangers associated with climate change because they have restricted access to resources such as land, water, and inputs, as well as a lack of credit and financial support (Adefolalu et al. 2018).

Additionally, smallholder farmers are more vulnerable to the effects of climate change because of their substantial reliance on rain-fed agriculture, which makes them extremely susceptible to variations in seasonal rainfall patterns. In addition, the frequency and intensity of extreme weather events, like storms, floods, and droughts, have increased due to climate change. These occurrences represent serious threats to food security and agricultural productivity (Nzeadibe & Egbule, 2019). Extreme weather events have the potential to cause crop failure, animal losses, and infrastructure damage, which can upend livelihoods and worsen food shortages in the impacted areas. The problems faced by Nigerian farmers are further made worse by the compounding effects of climate change on the deterioration of natural resources, such as soil erosion, deforestation, and biodiversity loss. Addressing the complex interplay between climate change, agriculture, and food security requires coordinated efforts from policymakers, researchers, and agricultural practitioners. The impacts of climate change on agriculture in Nigeria are already being felt, with changes in crop phenology, increased incidence of pests and diseases, and reduced availability of water for irrigation posing significant challenges for farmers (Oluwaseun, 2018). It has been indicated in Fig. 1 below that northern Nigeria has great negative impact of climate change and these impacts not only threaten food production and livelihoods but also exacerbate poverty and food insecurity in the country.

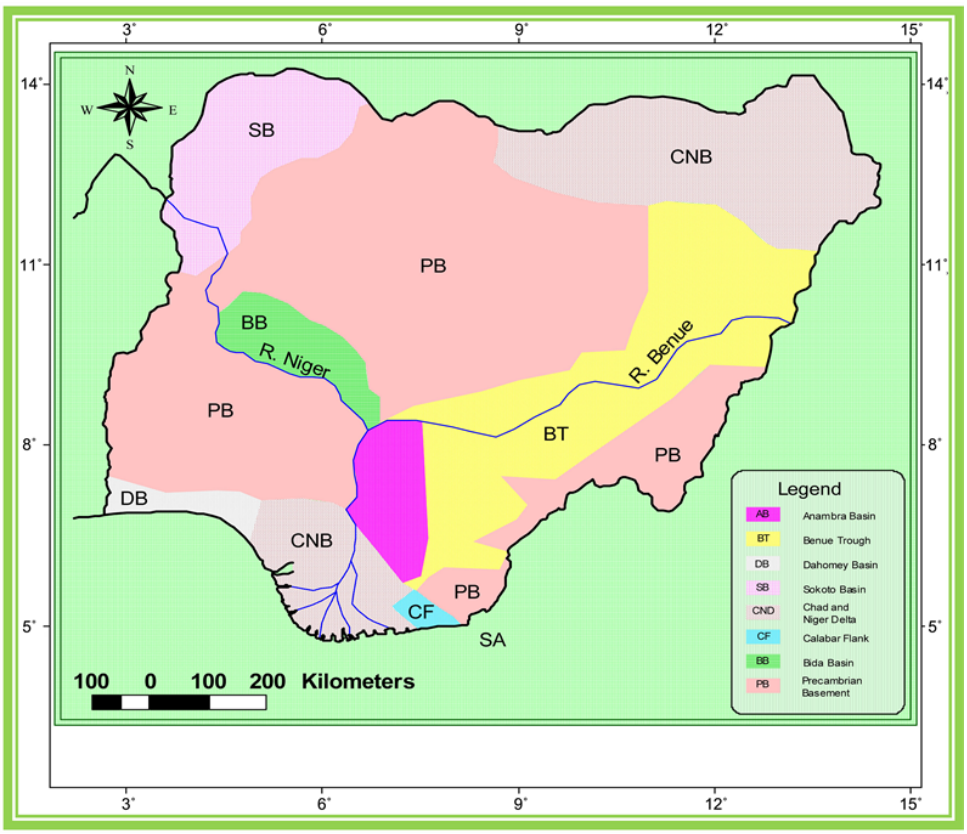

Figure 1: Map of Nigeria showing impact of climate change.

3 Effect of Climate Change on Agricultural Production in Nigeria

The study involved collecting various data essential for model calibration and analysis. These data included:

- **Desertification:** Based on government geological data, sand dunes are expected to rise 400 percent over the next 20 years. Rural residents have long engaged in the regular and widespread practice of continuously felling trees without planting new ones. In Nigeria, overcultivation and deforestation are common practices that encourage the encroachment of the desert (Umeghalu and Okonkwo, 2012).
- **Poor crop and animal yields:** Drought has plagued several northern Nigerian regions since the early 1970s, causing agricultural yields to vary greatly from year to year and from one place to another. This has upset the typical pattern of seasonal water availability (Ekphoh, 2010). The majority of droughts also show signs of false start, late start, sharp breaks during the rainy season, and early end to the rains. These features cause significant changes in the seasonal rainfall distribution pattern, which in turn results in low agricultural yields (Anyanwole, 2007).
- **Flooding (hydrological cycle):** According to hydrological modeling, more than 11,000 square miles of coastal land would be submerged in a 1.5-foot rise in sea level (Onofeghara, 1990). Soil degradation, flooding, and erosion are likely to happen. These are unfavorable signs for fields that could be destroyed by flooding and crops (Umeghalu and Okonkwo, 2012).
- **Pest, diseases, and weeds:** Rainfall would increase due to global warming, lengthening the rainy season and increasing air humidity. When combined with

rising temperatures, this would promote the growth of fungi-related illnesses. Agriculture involving both crops and animals is greatly impacted by this. Trypanosomiasis has a devastating effect on the livestock business in the Nigerian rainforest region, where pasture is plentiful. In the same way, higher humidity and temperatures may result in more insects and disease-carrying organisms exerting pressure. The poultry outbreak in western portions of Nigeria was linked to rising temperatures because of the related heat stress (Adefalolu, 2004).

4 Agribusiness, value chain development and Agrilogistics

Low agricultural productivity in recent decades due to a lack of investment in the agrifood sector has been a severe obstacle to value chain development. The productivity of agriculture is severely hampered by a lack of quality inputs and a basic understanding of effective agricultural techniques. Nonetheless, there is a significant (and unfulfilled) need for food in many parts of Nigeria, especially in the vicinity of major centers. In local markets, the greatest demand is still for inexpensive food, but in urban areas, upscale specialty markets are expanding. To increase production efficiency (producing more output per unit of input) and generate a sufficient surplus for the processing industry, any investment in processing agribusinesses should be accompanied by investments in agricultural productivity (mostly through the combination of offering extension, tailored advice, quality seed, and inputs). Concentrated power in cartels and entrenched interests are characteristics of some value chains. It is challenging for an outsider to invest due to corruption, fragmented value chains, and a lack of market knowledge. Strengthening the short-value chains (fruit and vegetables) that can cater to the local peri-urban markets is advised instead. This might be achieved by improving the training that several TVETs receive in vegetable farming and by making Dutch training modules and materials on vegetable value chains available. Additionally, the development of these value chains may be aided by Dutch expertise and the supply of enhanced vegetable seeds. The emphasis on enhancing particular value chains that are being suggested fits in nicely with the Nigerian Agricultural Promotion Policy (APP), which lists enterprise development support in various commodities value chains as one of its top priorities (FMARD 2016).

5 Climate Change Adaptation

Nigeria's food system is predicted to suffer greatly as a result of climate change, and initial effects are already being seen (FMIC, 2016; Nugent, 2018). It is predicted that temperatures will rise and precipitation will become increasingly erratic. While more severe rainfall that could cause floods is predicted for Nigeria's southern region, the country's northern region is predicted to see less consistent and more unpredictable rainfall (WUR/BZ, 2018). In the meanwhile, both farmers and extension agencies lack fundamental expertise in climate wise agriculture. The majority of farmers in Nigeria can only cultivate their crops during the rainy season because very little of the country's cropland is irrigated. Additionally, this makes communities who lack access to food and farmers vulnerable to the unpredictable and shifting climate. Climate change is expected to have a significant negative impact on Nigeria's food system, with some effects already being felt

(FMIC, 2016; Nugent, 2018). Temperatures are expected to climb, while precipitation is expected to become more unpredictable. Nigeria's northern region is expected to experience less steady and more erratic rainfall, while the country's southern part is expected to experience more severe rainfall that could result in floods (WUR/BZ, 2018). Meanwhile, fundamental knowledge on climate-smart agriculture is lacking for both farmers and extension organizations. Because so little of Nigeria's agriculture is irrigated, most farmers are only able to grow their crops during the rainy season. This also leaves farmers and communities without access to food exposed to an uncertain and changing climate. The identified leverage point is the sharing of data and information (and know-how) on climate change impacts and adaptation strategies for value chain actors, including regional scenarios for climate change impact. This should be combined with the following leverage points:

- Provision of quality inputs (e.g. drought-resistant varieties).
- Technical training on climate change adaptation in value chains (production, processing, storage).
- Strengthen land rights; integrated masterplan on the use of contested natural resources agreed upon with stakeholders.
- Promote low-cost small-scale irrigation and climate-smart agriculture in prioritized sub-sectors.

6 Amelioration of Greenhouse Gas Emissions through Agroforestry and Enhancing Food Security

Agroforestry systems, according to Kiptot and Franzel (2012), not only boost crop yields and food production, but they also significantly improve food security by offering communities more diversified diets and better nutritional outcomes. Agroforestry systems can alleviate hunger and food insecurity by increasing the availability of fruits, nuts, and other nutrient-dense food products through the integration of trees with food crops. Furthermore, agroforestry techniques like alley cropping and intercropping can enhance soil fertility and create resilient and sustainable food production systems (Garrity et al., 2010). It has been demonstrated in Fig. 2 below that agroforestry techniques reduce greenhouse gas emissions by growing trees and crops on the same piece of land. The incorporation of trees into agricultural land contributes to the reduction of greenhouse gas emissions, including nitrous oxide and methane, which are key causes of climate change. Using nitrogen-fixing trees is one method that agroforestry reduces emissions. By helping the soil meet its nitrogen needs, these trees can lessen the need for artificial fertilizers that release nitrous oxide into the atmosphere (van Noordwijk et al., 2014).

Furthermore, by increasing soil fertility and lowering the need for chemical inputs, the agroforestry practice of alley cropping helps to reduce greenhouse gas emissions. Alley cropping lessens emissions related to pesticide manufacture and use by controlling soil health and utilizing organic matter from tree leaves and other organic material. It has been demonstrated that agroforestry techniques reduce greenhouse gas emissions. The incorporation of trees into agricultural land contributes to the reduction of greenhouse gas emissions, including nitrous oxide and methane, which are key causes of climate change. Using nitrogen-fixing trees is one method that agroforestry reduces emissions. These trees can supplement the nitrogen needs of the soil, reducing the reliance on synthetic fertilizers that result in nitrous oxide emissions (van Noordwijk et al., 2014).

Figure 2: Agroforestry practice.

7 Strategies for Climate Change Amelioration through Agribusiness

1. **Sustainable Agricultural Practice:** Crop rotation, agroforestry, and conservation agriculture are examples of sustainable agricultural methods that can improve soil health and climate change resilience. According to FAO (2019), these methods enhance water retention, lessen soil erosion, and boost biodiversity.
2. **Irrigation Systems:** Reducing reliance on rainfall can be achieved through the development of effective irrigation systems. For Kano State, solar-powered pumps and drip irrigation are practical solutions that will minimize water waste and provide a steady supply of water (Ahmed et al., 2020).
3. **Climate-smart Agriculture:** CSA, or climate-smart agriculture, is the adoption of methods that lower greenhouse gas emissions, boost resilience, and increase productivity. CSA methods include integrating livestock with crop production, choosing crop varieties resistant to drought, and scheduling plantings according to the best dates (Mbow et al., 2019).
4. **Agro-processing and Value Addition:** Promoting these two activities can enhance food security by lowering post-harvest losses. Both farmers and consumers profit when agricultural produce is processed into finished items because it extends its shelf life and raises its market value (Adeniji et al., 2018).

8 Adaptive Roles by Nigerian Agribusiness Entrepreneurs to cushion the effect of climate change

- **Improved and more organized techniques of agricultural production:** Owners of agribusinesses must utilize improved animal and crop varieties. Some

Nigerian farmers have diversified their crop farming by planting a range of crops on their farmlands; crops that could be long-duration crops and short-duration to lessen the effects of climate change. Across the country, farmers are also engaged in early farming and produce harvesting (Akor, 2012). Using compost and farm yard waste in conjunction with sustainable agricultural practices is another strategy used by Nigerian farmers to boost yields and avoid farm failures. Crop diversification, or crop substitution, addresses the financial risks and alterations to the environment associated with climate change.

- **Water harvesting and storage:** The majority of farmers need to have access to this technology to preserve the nation's food security. Agribusiness entrepreneurs harvest and store water. In Nigeria, this is also an adaptation strategy; the water is conserved and used for home gardening and other uses (Akor, 2012; Ijeoma, 2012).
- **Farm finance management:** Agribusiness entrepreneurs can use farm-level adaptation options, such as government-backed and private farm income methods, to lower the risk of income loss due to climate change (Smith and Skinner, 2002). In the case of sponsored programs, insurance spreads public exposure to climate-related risks while also reducing revenue loss from reduced crop yields due to droughts, floods, and other climate-related disasters (Smit et al. 1989). In Nigeria, buying insurance to lessen the possibility of income loss due to climate change is not yet common.
- **Vertical integration with pertinent agencies:** To mitigate the effects of climate change, the agribusiness entrepreneur teams up with pertinent organizations. These agencies, which are in charge of coordinating their policy and research-related activities, are the National Emergency Management Agency (NEMA), the Nigerian Meteorological Agency, the National Environmental Standards and Regulations Enforcement Agency, the National Institute for Fresh-water Fisheries Research, the National Water Resources Institute, Kaduna, and the National Center for Arid Zone Studies, Maiduguri (Sayne, 2011).
- **Current information to take preventative action:** An extensive evaluation of all available facts regarding probable climate change impacts and related conflict risks is conducted by the agribusiness entrepreneur. Entrepreneurs in the agribusiness sector who achieve success create a participatory, multidisciplinary assessment process that starts with analyzing resource constraints, secondary effects, and conflict risks related to climate change. Next, they evaluate the viability and affordability of specific adaptation strategies (Sayne, 2011). For future adjustment options to be valuable, the impact of drought on agricultural yields is analyzed along with an assessment of farmers' current reactions to drought (IPCC, 2007).

9 Contribution to United Nations Sustainable Development Goals (SDGs)

- **SDG 1: No Poverty** Agribusiness initiatives in Northern Nigeria reduce poverty by creating jobs, increasing farmers' incomes, and promoting rural development. These initiatives help smallholder farmers increase productivity and profitability, economically empowering them and reducing poverty levels (FAO, 2020).
- **SDG 2: Zero Hunger** Enhancing food security through agribusiness directly combats hunger. Sustainable agricultural practices increase food production and

supply, ensuring food security. Promoting diverse and nutritious crops also improves nutrition and food availability (UN, 2020).

- **SDG 8: Decent Work and Economic Growth** Climate-smart agribusiness creates decent work opportunities in agriculture. Integrating modern technology and sustainable practices attracts investments, promotes entrepreneurship, and stimulates economic growth in rural areas (ILO, 2018).
- **SDG 13: Climate Action** Climate change amelioration strategies in agribusiness mitigate adverse climate effects. Practices like sustainable land management, water conservation, and renewable energy in agriculture reduce greenhouse gas emissions and enhance climate resilience (IPCC, 2019).
- **SDG 15: Life on Land** Sustainable agribusiness preserves terrestrial ecosystems by promoting biodiversity and reducing land degradation. Techniques such as agroforestry, organic farming, and conservation agriculture contribute to healthier ecosystems and improved soil quality (FAO, 2020).

10 Coordination with Science, Technology, and Innovation Strategy for Africa (STISA-2024)

The Science, Technology, and Innovation Strategy for Africa (STISA-2024) aims to harness science, technology, and innovation to address Africa's socio-economic challenges. The initiative on climate change amelioration and food security in Northern Nigeria aligns with several STISA-2024 objectives:

10.1 Priority Area 1: Eradication of Hunger and Ensuring Food and Nutrition Security

By leveraging agribusiness to enhance food security, the initiative supports eradicating hunger and ensuring food and nutrition security. Innovative agricultural practices and technologies increase food production and improve nutrition (AU, 2014).

10.2 Priority Area 2: Prevention and Control of Diseases

Agribusiness initiatives can include cultivating medicinal plants and producing nutritious foods that boost immunity, contributing to disease prevention and control. Healthier agricultural practices reduce harmful pesticide use, promoting better health outcomes (WHO, 2020).

10.3 Priority Area 3: Communication (Physical and Intellectual Mobility)

The initiative can promote the dissemination of agricultural innovations and best practices through digital platforms and farmer networks. Improved communication and knowledge sharing enhance farmers' capacity to adopt sustainable practices (AU, 2014).

10.4 Priority Area 4: Protection of our Space

Sustainable agribusiness practices contribute to environmental protection by reducing carbon footprints, conserving biodiversity, and preventing land degradation. This aligns with broader goals of environmental protection and sustainable resource management (AU, 2014).

11 Potential Impact on Post-STISA Initiatives by the African Union

The success of climate change amelioration and food security initiatives in Northern Nigeria can serve as a model for other regions in Africa. Key potential impacts include:

11.1 Scaling Up Innovations

Successful agribusiness models and climate-smart practices can be scaled up and replicated across Africa, contributing to broader food security and climate resilience efforts.

11.2 Socio-economic Data

Information on farming practices, land tenure, and community demographics was collected through surveys and interviews with local farmers and stakeholders. This data helped to understand the social and economic context of land management practices. The farmers also gave suggestions on future land use practices that they considered practical for model simulations.

11.3 Socio-economic Data

Positive outcomes from these initiatives can inform policy decisions and encourage the adoption of supportive policies at national and continental levels, promoting sustainable agriculture and climate action (AU, 2014).

11.4 Policy Influence

Information on farming practices, land tenure, and community demographics was collected through surveys and interviews with local farmers and stakeholders. This data helped to understand the social and economic context of land management practices. The farmers also gave suggestions on future land use practices that they considered practical for model simulations.

11.5 Capacity Building

Building the capacity of farmers and agribusinesses through training and knowledge transfer creates a skilled agricultural workforce, ready to implement innovative and sustainable practices (AU, 2014).

11.6 Regional Cooperation

The initiative can foster regional cooperation by sharing best practices, technologies, and resources among African countries, strengthening collective efforts towards achieving the SDGs and STISA-2024 goals (AU, 2024).

12 Conclusion

Climate change poses significant threats to Nigeria's agriculture industry, particularly in northern Nigeria, where rain-fed agriculture is highly vulnerable. This vulnerability leads to rising temperatures, irregular rainfall patterns, and extreme weather events, endangering the livelihoods of millions of smallholder farmers and undermining food security. Agribusiness, including farming, processing, marketing, and distribution, can contribute to reducing climate change's effects by incorporating climate-smart practices and technologies. Investments in climate-smart agriculture practices, such as agroforestry, conservation agriculture, and integrated water management, are crucial for improving agricultural systems and ensuring sustainable food production in Nigeria. Effective policies and interventions are needed to increase the agriculture sector's capacity for adaptation and help smallholder farmers become more resilient. Agroforestry systems can improve crop yields, and food security, and reduce greenhouse gas emissions. Nigerian agribusiness entrepreneurs can mitigate the effects of climate change by utilizing improved animal and crop varieties, water harvesting and storage, farm finance management, and vertical integration with relevant agencies.

13 Recommendation

- Develop a comprehensive stakeholder engagement plan that includes local communities, government agencies, private sector partners, and international organizations. This will ensure broad support and collaboration, enhancing the initiative's effectiveness and sustainability.
- Incorporate Local Knowledge and Practices by integrating indigenous knowledge and traditional agricultural practices with modern techniques to create context-specific solutions. This approach respects local cultures and enhances the relevance and acceptance of the initiative.
- Monitor and Evaluate Impact This can be done by establishing robust monitoring and evaluation frameworks to assess the impact of agribusiness practices on food security and climate resilience. Use data-driven insights to continuously improve strategies and demonstrate progress to stakeholders.
- Ensure that the initiative promotes gender equality by providing equal opportunities for women in agribusiness. Implement targeted programs to support female farmers and entrepreneurs, addressing specific barriers they face.
- Facilitate access to financial services for smallholder farmers and agribusinesses. Provide training on financial literacy and develop innovative financing models to support investments in sustainable agriculture.
- Strengthen Infrastructure by investing in rural infrastructure such as roads, storage facilities, and irrigation systems. Improved infrastructure will enhance market access, reduce post-harvest losses, and increase the efficiency of agricultural value

chains.

- Foster Research and Development by supporting research and development in climate-resilient crops, sustainable farming techniques, and agribusiness innovations. Collaborate with research institutions and universities to drive scientific advancements that benefit agriculture.
- Advocate for supportive policies that promote sustainable agriculture and climate action. Engage with policymakers to ensure that regulations and incentives align with the goals of the initiative.

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