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Climate-Smart Agriculture for Sustainable Agricultural Development in Nigeria: An Empirical Review

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ABSTRACT: Feeding over 200 million people in Nigeria requires a radical transformation in agricultural sector. These therefore require growing more food and achieve food security. Meanwhile, the resources needed for sustainable food security in Nigeria are already stretched, coupled with a negative effect of climatic change on agricultural production and food storage in developing countries like Nigeria, where the capacity to adapt to changes in climate is weak. Therefore, the paper reviewed climate-smart agriculture for sustainable agricultural development and establish that climate-smart agriculture can increase agricultural productivity, increases farm incomes, food security and agricultural development in a sustainable manner while building resilience of agricultural products to climate change and reducing greenhouse gas emissions from agriculture. The noticeable climate-smart agriculture practice adopted by the farmers in Nigeria includes the use of improved crop varieties, laser land leveling, zero tillage, residue management, nutrient management, and crop diversification. Nigerian farmers should be adequately trained in climate-smart agriculture by government at all levels and motivated to adopt its practices for mitigation and adaptation measures to climate changes. Also, adequate information and communications channels should be established in order to pass weather forecast information to farmers in Nigeria. Likewise, Socio-economics characteristics of the farmers should be considered in making any agricultural policies in Nigeria.

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Climate change which is caused by green gas carbon emission is a great threat to Agriculture in Nigeria. Agriculture is one of the sectors that is vulnerable to climatic change because of its high dependent on climate variables (Lavhelesani and Nolitha, 2016). Fluctuations in weather, temperature and other climatic factors directly or indirectly affect the quantity, quality and availability of food crops (Ekpa *et al*., 2017). Global warmings affect rainfall patterns thereby causing extreme events such as floods, droughts, and forest fire resulting in poor and low yields of food crops and making the farmers more vulnerable (Spear *et al.*, 2015). Poor farmers are then faced with the probability of total or partial crop failures, low crop productivity, poor market sales, hunger and malnutrition. Apart from its effect on crop, climate change also affects animals through low quantity and quality of feeds and water availability, low feed intake and conversion efficiency, low rates of weight gain, reproductive and lactation performance, diseases and pest infestations, heat stress, morbidity and high mortality rates of the animal (Seo 2015;

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Michalk *et al* 2018). Therefore, climate change generally has a great effect on the food security, and the livelihood of the people (Botai and Mabhaudhi, 2021). Given the fact that agriculture is one of the sectors that is highly affected by climate change in Nigeria, it is therefore necessary that farmers respond with strategies that will adequately mitigate the problems caused by climate change in a sustainable manner (Enete and Onyekuru, 2011). Farmers have over the years adopts different strategies to cushion the effects from extreme weather or climate change. Among the strategies used by the farmers are income diversification, migration, and the use of technology (Karamba *et al*., 2011; Ogada *et al* 2018). While, most times, farmers in Nigeria rely on indigenous knowledge and trial and error method to cope with the effect of climatic change. These strategies adopted by the farmers are less effective and unsustainable (Ogada *et al* 2018), because farmers in Nigerian lack information on the precise nature of variability and changes in climate. Therefore, there is a need for farmers to respond with the strategies that are most effective and sustainable, and these sustainable strategies are what adopting Climate-smart agriculture (CSA) can offer. Climate-smart agriculture is agricultural approach that seeks for sustainability in productivity increase, enhances adaptation, reduces greenhouse gas and enhances achievement of food security (FAO, 2019; FAO, 2021). Thus, application of the concept of CSA to farming will eliminate potential threat in food security. Although, climate-smart agriculture objectives are well documented and supported at both global and local level, adoption and implementation of climate-smart agriculture strategies vary among countries and regions (Lipper et al., 2014). Climate-smart agricultural approach contributes efficiently to food security and poverty reduction. This is achieved by addressing different aspects of current and projected impact of climate change through adaptation and mitigation actions. Mitigation involves minimizing future climate change by emissions reduction through weakening the economic growth and carbon emissions linkages (Hindering, 2011). Thus, the greenhouse gases can be reduced by managing the flows of carbon and nitrogen in agricultural ecosystems (Lavhelesani and Nolitha, 2016). On the other hand, adaptation involves the changes in management activities, institutional settings and infrastructure for effective response to anticipated climatic change (Klein *et al*, 2014) or any activity or activities that reduces the damages caused by the climate change (Lazkano *et al*, 2016).

Climate-Smart Agriculture (CSA) and Agricultural Sustainability: Sustainable development in Nigeria is unachievable without a major contribution from agriculture. People must be fed, and agriculture has the mandate of providing food for a rapidly growing Nigerian population while maintaining the resource base of the country. Sustainable agriculture must involve production of food, resources conservation and protection of the natural environment so that the needs of people living today can be met without compromising the ability of future generations to meet their own needs. Therefore, sustainable agriculture can be defined as a commitment to satisfy human food and fibre needs and to enhance the quality of life for farmers and society, now and into the future (Abubakar, and Attanda, 2013). Also, sustainable agriculture is defined as the production for today without compromising the ability of the future generations to do the same (Ogemah, 2017). Therefore, agriculture development can be sustained only if the environment protection is guaranteed. Otherwise, climate change resulting in erosion or gradual soil degradation of the soil and the environment, leads to low productivity and food insecurity. FAO (2021), noted that agricultural transformation can only be achieved through integrated, multi sectoral approaches that are gender inclusive and pro-poor, and harness synergies such as those between climate change adaptation and mitigation. Agriculture is one of the major sources of climate change globally, and in Nigeria (Farauta *et al*., 2011; UNFCCC, 2014; FAO, 2021). Nigerian government over the years have attempted to mitigate the impacts of climate by implementing policies such as National Erosion and Flood Control Policy, National Environmental Sanitation Policy, National Drought and Desertification Policy, National Policy on E-Waste Control and Management among others (Medugu, 2012), but these policies failed to address the issues of unsustainable agricultural practices, low crop productivity, emission of greenhouse gases and farmers coping strategies to climate change. Therefore, in recent time, several African countries have begun to endorse CSA as a means of addressing agricultural productivity challenges, supporting adaptation strategies and building resilience to the effect of climate change.

It is noted by the researchers that the greater effect of climatic change are bore by the farmers through scarcity of agricultural land, low soil fertility, low crop yields and poor access to market (Ogada *et al*., 2018; FAO, 2021). The wellbeing of most farmers in Nigeria is tied to the productivity of their crops and livestock (Fanen, and Olalekan, 2014). Most of the farmers in Nigeria are living in the rural area where agriculture is the major occupation, as such poverty, food insecurity and livelihood challenges are more pronounced in the rural and remote communities (United Nation, 2017).

It is estimated that by 2050, if nothing is done the living conditions of about 9 billion people in the world will be worse, while hunger and poverty will be taking the lead, making it hard for these people to put foods on their table (Botai and Mabhaudhi, 2021). This is because agricultural production is vulnerable to climatic change. Agricultural production is usually affected by high temperatures, low rainfall and long dry seasons, poor soil fertility due to increasing land degradation. Thus, resulting in total or partial crop failures, low food crop productivity, hunger and food insecurity. Meanwhile, literature has established that Climate-Smart Agriculture increases the productivity of agricultural products in a sustainable manner, thereby achieving food security and developmental goal (Lavhelesani and Nolitha, 2016; Ogada *et al* 2018).

MATERIALS AND METHODS

Research works conducted on climate smart agriculture in Nigeria and other relevant works outside Nigeria were the works selected for this study. We carried out a literature review on the selected works on climate smart agriculture in Nigeria and the world at large. The empirical research works used in this reviewed work were collected from the worldwide Web using google search engine. The selection procedure involves conducting a keyword search in Web to yield relevant articles, while the articles outside the area of the study interest were excluded. Second, a keyword search was conducted to further screen the retrieved papers for relevance in the areas of interest and focus of this study. The main purpose was to achieve greater accuracy in identifying only those studies exclusively focused on farmers and climate smart agriculture. A total of 30 research works was reviewed for this study.

Empirical Reviews on Climate smart agriculture: Several reviews on climate smart agriculture were discussed in this study. According to Wekesa, (2017) in his work on effect of climate smart agricultural practices on food security of small-scale farmers in Teso North Sub-Country observed that CSA practices had a great potential to solve food security challenges. He observed that complete package of CSA with crop management, field management, farm risk reduction and specific soil management practices had the highest implication to food security. Akrofi-Atitianti *et al*, (2018) who assesses the potential of CSA conventional cocoa systems to enhance production, mitigate and/or remove GHG emissions and build resilience, in addition to understanding key determinants influencing CSA practices. Using a mixed methods approach concluded that a farm budget analysis of productivity and economic performance shows that CSA practitioners had a 29% higher income per hectare compared to the conventional farmers.

Ekpa *et al*, (2017) in their work on investigating climate smart agricultural practices in livestock production in Sokoto state, Nigeria observed that the determinants of using climate smart agricultural practices in livestock production were education and communication equipment. They observed that informal education had their indices of climate smart agricultural practices for livestock enterprise lower by 33.59% when compared with their counterparts with formal education. Also, they conclude that a unit increase in farm size will lead to corresponding increase in the indices of climate smart agricultural practices by livestock farmers. Oyewole *et al*, (2019) in their paper on what drives the adoption of climate smart agricultural practices? Evidence from maize farmers in northern Nigeria establishes that the likelihood of CSA practices' adoption is influenced by land ownership, social capital, gender, off-farm work participation and plot distance from homestead. They concluded that these factors must be considered when designing policies to promote CSA towards the achievement of sustainable livelihoods among farm households in Nigeria. Nyong, and Bassey, (2019) in their work on analysis of adaptation of climate smart agricultural (CSA) practices of yam farmers in Akwa Ibom State, Nigeria observed that 61% of the farmers were involved in average climate change adaptation, 26% in low climate change adaptation while 13% in high climate change adaptation. Also, they observed that the factors that encouraged climate smart agricultural were level of education, age, household size, farm distance from home, land tenure security, access to credit and non-farm income, farm size, membership of cooperative societies and farm income. Adebayo, and Ojogu, (2019) who work on assessment of the use of climate smart agricultural practices among smallholder farmers in Ogun state observed that farmers have received training on CSA practices which includes minimum tillage, crop rotation, use of mulching, and use of organic manure. These practices have increased the productivity of food crop in Ogun state.

Likewise, Ekpa *et al*, (2018 in their work on the effect of climate smart agricultural practices on poverty status of maize rural farming household in Sokoto state, Nigeria discovered that climate smart agricultural practices has effect on poverty status of maize rural farming household in Sokoto state. The climate smart agricultural practices decrease the odds of Sokoto maize farmers being poor. Igberi, *et al*. (2022), in their work on Assessment of Prioritized

Climate Smart Agricultural Practices and Technologies of Household Farmers in Southeast, Nigeria, identified some of the climate change effect in the study area as:- decrease in overall productivity due to increased extreme weather events (0.97); decrease in crop production due to changes in average rainfall (0.94); decrease crop production due to increase in temperatures and rainfall variability (0.79); rapid migration of some pests and diseases (0.72); among others. While, they noted that the farmers in the study area adopted various CSA practices for sustainable agricultural production and mitigating against the effect of climate change. These adopted strategies includes:- growing a single crop, using a mixture of appropriately chosen genotypes of a given species (46.6%), use of quality seeds and planting materials of well-adapted crops and varieties (77.9%), crop rotation and diversity (41.1%) integrated pest management (47.5%), improved water use and management (26.4%). All these studies portraits the fact that the effect of climate change is much on agricultural production, and that Climate Smart Agriculture can provide a lasting or sustainable solution to it. Therefore, adopting Climate Smart Agriculture practices can sustainably impact on agricultural production.

The global and local agricultural researchers and policy makers are of the opinion that climate-smart agriculture should be adopted by the farmers in order to improve their adaptation to climate changes and reduces the adverse effect of climate on agricultural production and food storage. The noticeable climate-smart agriculture practice adopted by the farmers in Nigeria includes: - the use of improved crop varieties, laser land levelling, zero tillage, residue management, nutrient management, and crop diversification. However, problems of viability and sustainability have been raised by several authors who argue that there are barriers, limits and costs in climate smart agriculture, which may hinder its adoption by the farmers (Nciizah, and Wakindiki, 2015).

It was argued by the policy makers that climate-smart agriculture has the ability that enables food crops attains its potential yield, achieve food security and sustainable agriculture. Several strategies have been suggested in order to achieve sustainable agriculture through climate smart agriculture. These strategies include the use of integrated renewable energy technologies for farming like windmills, solar panels, pyrolysis units and bio energy-operated water pumps. site-specific nutrient management, residue management, intercropping with legume, resource conservation technologies like zero tillage, improved varieties which are tolerant to heat, drought and salinity, agro-forestry and crop diversification. Early weather forecast to minimize the threats of climate losses. Adequate information and communications to farmers (Amin, *et al*, 2015)

Farmers can therefore implement a range of climate smart agricultural (CSA) practices in order to minimize the adverse effects of climate change and variability on the crop (Lan, *et al,* 2018). Lavhelesani and Nolitha, 2016; Ogada *et al* 2018; Lan, *et al*, 2018 noted that implementation of Climate-smart agriculture practices can help minimize negative impacts of climate to some extent and strengthen farmers by sustainably increasing productivity and income thereby achieving agricultural sustainability. Therefore, with the right practices, policies and investments, the agriculture sector can move into CSA practices, resulting in increased food security, poverty reduction in the short run while reducing climate change as a threat to food security and sustainable agriculture in the long run. Below are tabulated Climate-smart agriculture practices for sustainable agriculture as adapted by (FOA, 2013).

Table 1: Climate-smart practices useful for agricultural sustainability.

Livestock management	**Crop management**	**Soil and water management**	**Agroforestry**	**Integrated food energy systems**
•Improved feeding strategies • Rotational grazing • Fodder crops • Grassland restoration and conservation • Manure treatment • Improved livestock health • Animal husbandry Improvements	•Intercropping with legumes • Crop rotations • New crop varieties (e.g. drought resistant) • Improved storage and processing techniques • Greater crop diversity	•Conservation agriculture (e.g. minimum tillage) • Contour planting • Terraces and bunds • Planting pits • Water storage (e.g. water pans) • Alternate wetting and drying (rice) • Dams, pits, ridges • Improved irrigation (e.g. drip)	•Boundary trees and hedgerows • Nitrogen-fixing trees on farms • Multipurpose trees • Improved fallow with fertilizer shrubs • Woodlots • Fruit orchards	•Biogas • Production of energy plants • Improved stoves

Source: Food and Agriculture Organization. (FAO, 2013).

Conclusion: The paper concludes that noticeable climate-smart agriculture practice adopted by the farmers in Nigeria includes the use of improved crop varieties, laser land leveling, zero tillage, residue management, nutrient management, and crop diversification. However, problems of viability and sustainability have been raised by several authors who argue that there are barriers, limits and costs in climate smart agriculture, which may hinder its adoption and sustainability. There are indications that climate-smart agriculture can increase agricultural productivity, increases farm incomes, achieve food security, and agricultural development in a sustainable manner while building resilience of agricultural products to climate change and reducing greenhouse gas emissions from agriculture, but Nigerian farmers should be adequately informed and trained in climate-smart agriculture by stake holders in agriculture at all levels.

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