Review Article

ISSUES IN CLIMATE SMART AGRICULTURE IN SOUTHEASTERN NIGERIA

Abstract

Farming is a prime livelihood activity of people of Southeast (SE) Nigeria. In the age of climate change, farmers have to cope with highly variable, short and unpredicted rainfall to sustain their enterprise. This study reviews the effects of climate change on agriculture production, identify farmer's view on the impact of climate change on crop production in the southeast, reviews adoption of CSA in Nigeria and identify the importance of climate information service in agriculture in Southeast Nigeria. From the review, farmers within the SE are aware of climate change and they have adopted improved innovative strategies to adapt to the negative implication associated with climate change and variability but more awareness is needed in the area of climate information services (CIS) to assist them to cope better. Therefore, this study recommends the Participatory Integrated Climate Services for Agriculture (PICSA) approach to educate farmers more on how to manage their enterprise in the face of climate change and variability.

Keyword climate-smart, agriculture, farmers, mitigation, adaptation

1.0 Introduction

Nigeria and several other parts of Africa, (the agricultural production system is predominantly rain-fed) more than 60% of essential foods are produced from rain-fed agriculture which is practiced by more than 80% and 90% [1]. Increasing temperature and changes in rainfall distribution (interseasonal fluctuations and erratic rainfall patterns) has become a critical food production risk to farmers. [2] opined that over 70 percent of the Nigerian population is engaged in one form of agriculture as their primary means of livelihood. According to the Food and Agriculture Organization (FAO) [3] reports, climate change is likely to cause significant crop yield losses thereby adversely affecting smallholder livelihoods in Africa. As a result, food security and income generation opportunities for the farming households that rely on agriculture are in danger. [4] document that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change. More than one-third of crop yield variation on a global level is due to variation in climate and weather, and in large areas of the breadbaskets of the world, more than 60% of crop yield variation depends on climate variation [5]. [6] observed that an increase of 1°C would be more severe for global maize yield (7.4% decrease) than for rice (3.2% decrease) and decreases in maize yield in the United States would be twice those grown in India (10.3 and 5.2%, respectively). To reduce the negative impact of climate change on agriculture, adaptation is considered a vital component in response to climate change [7,8]. Although the choice of adaptation interventions is determined by the country's peculiar circumstances.

Department of Environmental Affairs (DEA) [9], outlined adaptation measure to include: research and development of indigenous knowledge and technology; identification of groups and communities most vulnerable to climate change impacts; sensitization of the public on climate change; improvement of irrigation and drainage system; groundwater management and sustainable farming systems among many others. Consequently, the increasing focus on the adaptation of agriculture to climate change indicates the need for climate-smart agricultural (CSA) practices which could see to the reduction of greenhouse gas emissions and their negative effects.

In sub-Saharan Africa, there is an increased level of investment of CSA by the organization within the next decade [10]. Organizations such as the New Partnership for Africa's Development (NEPAD) have targeted to reach 25 million farmers by 2025 with climate-smart agriculture technologies and approaches through its Alliance for Climate-smart Agriculture (ACSA). However, there is very limited direct data available to show how increased climate risk (e.g. drought and heat stress) will affect specific cropping system performance in Nigeria. For the adoption of CSA in Nigeria especially in the Southeast part, climate information service must be readily available for farmers to identify the trend of climate to enable them to select appropriate climate smart options to increase their yield. Based on this, the study identifies CIS as an effective means to encourage farmer's production in Southeast Nigeria.

1.1 Objectives of the study

i. To review the effects of climate change on agriculture production.
ii. To identify farmers view on the impact of climate change on crop production in south eastern Nigeria
iii. To reviews adoption of CSA in Nigeria,
iv. To identify the importance of climate information service in agriculture in South eastern Nigeria.

2.0 Literature Review

2.1 Impact of Climate Change on Crop Agriculture production

Climate and weather influence crop production in different ways, for instance changes in temperature, atmospheric carbon dioxide (CO_2), and the frequency and intensity of extreme rainfall have significant impacts on crop yields. For any crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction [11]. The overall effect of climate change on agriculture could be positive or negative; the degree of impact varies from very low to very high, depending on regional or geographical location and status of socioeconomic development [12]. [13,14] found that a 1°C increase in temperature and a 0.2-meter rise in sea-level had a positive impact in member-countries of the Organization for Economic Co-operation and Development (OECD), Middle East countries, and China. In China there is a rapid increase in temperature since the early 1980s, conversely, the number of frost days has decreased across most cropland regions [15], leading to the development of multiple cropping systems in the middle and high latitude regions. Other regions like African experience the negative impact, temperature is increasing and rainfall is erratic. The increase in temperature also increases evapotranspiration, which has a negative impact on crop yields. During the growth cycle of the plant, water is needed at the initial stages of production, but not during the final stages. Low levels of precipitation have a negative effect on the germination of the seeds. Dry conditions, frequency and severity of dust storms all result in decreased production of major grains. Given the potential changes in production variables [16], estimated that the average potential crop yields may fall by 10-30% across the prairies crops but it will vary based on locations. [17], posit that the future climate change will likely have negative effects on crop production in low latitude countries, while effects in northern latitudes may be positive or negative. Therefore, the effect of climate change on agriculture is linked to variabilities in local climates rather than in global climate patterns. [18] provided empirical support for the distributional impact of climate change by investigating the impacts of climate change between poor and rich countries. Findings from the study, revealed that the poorest half of the world's nations suffer the majority of the damages from climate change, while the wealthiest nations experience almost no net impact. [18] emphasized location as the main reason—poor nations bear the brunt of climate change damages mainly because they are located in the low latitudes, which are already very hot. [19], confirmed the findings of [18] and noted that the effects of climate change on farming would be most severe in low-income, agriculture-dependent, tropical countries because these countries are least equipped to manage climate change. For instance, in Nigeria, where temperature has been increasing and is economically less developed—fits in Mendelsohn et al.'s classification.

2.2 Farmers perception of climate change in South East and their adaptation strategies

Climate change impacts countries, regions, and communities in different ways and thus their adaptation strategies differ [20]. The factors responsible for the variation in adaptive responses across counties are the agro-ecological system, socio-economics, climatic impact, and existing infrastructure and capacity [20,21]. Therefore, adaptation approaches that are vital to aid the local communities to cope with extreme weather conditions and related climatic variations [20,22]. The strategies are, however, not likely to be effective without an understanding of the farmer's perceptions of climate change and access to appropriate technology, institutions, and policies [20]. For instance, climate change perceived by farmers in Nigeria are expressed in high temperature, frequent floods, erratic rainfall and droughts these posed constraints on agriculture [23]. The smallholder farmers who are the major producer of food crops are increasingly finding it difficult to cope with the threats of climate change and variability because higher temperatures and lower rainfall reduces agricultural farmland and lower crop productivity [24]. [25] observed that erratic rainfall, heat stress and drought can cause food insecurity which will result in food shortages. [26], opined that the durations and intensities of rainfall have increased, producing large runoffs and flooding in many parts of Nigeria. [27], maintained that farmers in Ebonyi state have noticed the impact of climate change in rice cultivation. The farmers observed an increase in swamp size implying more land area available for swamp rice cultivation. The increase was attributed to climate change by the majority of rice farmers resulting from the increase of rainfall in recent times as compared to previous years. [28] observed that the majority of farmers in Imo state opined that in recent times, flooding had increased which is an indication of climate change. [29] noted that the decline of crop yields, soil fertility, drought events and increased heatwave were the perceived impacts of climate change on agriculture in Imo state. [30] explained that temperature and rainfall have exhibited increasing trends within southeast Nigeria, thus farmers in the area have commenced planting of choice cropping systems, and cover crops. [31] noted that there is an uneven distribution of seasonal rainfall from 2007-2016 in Anambra state and there are wide variations in dates of onset and cessation of rainy season, men and women responses show that there were statistically significant changes in the onset of the rainy season, early cessation of annual rainfall; shift of growing seasons; recurrent flooding and drought. Women felt more impact on food insecurity, water shortage and the burden of migration due to changes in rainfall. [26], stated that all traditional crops in Enugu with the exception of cassava and pepper had a significant field decrease as rainfall continue to be more erratic. [32] identified eight major constraints faced by cocoyam farmers in adapting to climate change: the high cost of farm inputs and low soil fertility, land and labor challenges, poor access to information and incompetence of cooperatives, poor access to fund and credit facilities and poor government support, lack of improved varieties of cocoyam, the poor value attached to cocoyam, poor infrastructural capacity and technology know-how and transportation challenge. The key impact of climate change on cocoyam production includes the decline in yield of cocoyam, reduction of soil fertility, stunted growth, uncertainty in planting and harvesting date, increase in the decay of planted corms and increase loss during storage in the barns.

2.3 Nigeria and Climate Smart Agriculture

According to [33], CSA as a method of agriculture that sustainably increases production, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and developmental goals. CSA aims to simultaneously increase agricultural production, food security, and farmers' adaptive capacity to climate extremes, while also lowering greenhouse gas emissions [34]. Three key pillars of the CSA approach: the sustainable increase in agricultural productivity and incomes, adapting and building resilience to climate change, and reducing and/or removing greenhouse gas emissions. Therefore, agriculture is considered to be "climate-smart" when it achieves these three objectives. The concept of CSA is not only a technology per se but a set of technologies, approaches and management practices that together make a landscape climate-smart [35].

International Assessment of Agricultural Knowledge, Science, and Technology for Development [36], suggests that the adoption of CSA practices in the Northern part of Nigeria will improve indigenous agricultural systems as well as improve the practice of agro-ecological agricultural systems. However, it has not been empirically established but there are few studies supporting this assertion. For this reason, the establishment of the potential application of climate-smart agriculture in the context of developing societies is critical in creating its wide uptake by farmers and enhances the political will that is required to motivate deep transformations within the policy sector.

Table 1: Selected climate smart options for farmers' preferences.

	Technology	Adaptation/mitigation potential
1	**Water-smart**	**Interventions that improve water use efficiency**
	• Rainwater Harvesting (RH)	Collection of rainwater not allowing to run-off and use for agricultural in rainfed/dry areas and other purposes on-site.
	• Drip Irrigation (DI)	Application of water directly to the root zone of crops and minimize water loss
	• Laser Land Levelling (LL)	Levelling the field ensures uniform distribution of water in the field and reduces water loss (also improves nutrient use efficiency)
	• Furrow Irrigated Bed Planting (FIBP)	This method offers more effective control over irrigation and drainage as well as rainwater management during the monsoon (also improve nutrient use efficiency)
	• Cover Crops Method (CCM)	Removal of excess water (flood) through water control structure
2.	**Energy smart**	**Interventions that improve energy use efficiency**
	• Zero Tillage/Minimum Tillage (ZT/MT)	Reduce amount of energy use in land preparation. In long-run, it also improves water infiltration and organic matter retention into the soil
3.	**Nutrient-smart**	**Interventions that improve nutrient use efficiency**
	• Site Specific Integrated Nutrient Management (SINM)	Optimum supply of soil nutrients over time and space matching to the requirements of crops with right product, rate, time and place
	• Green Manuring (GM)	Cultivation of legumes in a cropping system. This practice improves nitrogen supply and soil quality.
	• Leaf Color Chart (LCC)	Quantify the required amount of nitrogen use based on greenness of crops. Mostly used for split does application in rice but also applicable for maize and wheat crops to detect nitrogen deficiency.
	• Intercropping with Legumes (ICL)	Cultivation of legumes with other main crops in alternate rows or mixed. This practice improves nitrogen supply and soil quality.
4.	**Carbon-smart**	**Interventions that reduce GHG emissions**
	• Agro Forestry (AF)	Promote carbon sequestration including sustainable land use management
	• Concentrate Feeding for Livestock (CF)	Reduces nutrient losses and livestock requires low amount of feed
	• Fodder Management (FM)	Promote carbon sequestration including sustainable land use management
	• Integrated Pest Management (IPM)	Reduces use of chemicals
5.	**Weather-smart**	**Interventions that provide services related to income security and weather advisories to farmers.**
	• Climate Smart Housing for livestock (CSH)	Protection of livestock from extreme climatic events (e.g. heat/cold stresses)

	• Weather based Crop Agro-advisory (CA	Climate information based value added agro-advisories to the farmers
	• Crop Insurance (CI)	Crop-specific insurance to compensate income loss due vagaries of weather
6.	**Knowledge-smart**	**Use of combination of science and local knowledge**
	• Contingent Crop Planning (CC)	Climatic risk management plan to cope with major weather related contingencies like drought, flood, heat/cold stress during the crop season
	• Improved Crop Varieties (ICV)	Crop varieties that are tolerant to drought, flood and heat/cold stresses
	• Seed and Fodder Banks (SFB)	Conservation of seeds of crops and fodders to manage climatic risks

Source: [37].

Note: These technologies, practices and services directly or indirectly contribute to improve productivity, enhance resilience and reduce GHG emission. Technologies/practices that help to improve at least one component can be considered as CSA. Same technology can help to improve all three elements of CSA.

In accessing farmer's prioritization of climate smart agricultural technologies, [38] revealed that in Nigeria CSA involves participation and sustainable use of resources but it is weak in the aspect of compensation and equal distribution of benefits and cost. Consequently, the practice of CSA lacks a coherent climate mitigation approach and poor institutional structures. However, sustainable agriculture in the form of CSA requires a wider societal change towards appreciating the balance between agriculture and environmental change. A study by [39] reported 68.1% of farmers are willing to pay N126.32 per year for CIS with factors like farmer's level of experience, level of education, rainfall variability etc. as major determinants of willing to pay in South-Western Nigeria. In SE, South South (SS) rainfall is significant for farming activities, excess rains cause flooding and erosion on farmers' fields causing crop destruction and removal of topsoils. [40] shows that the use of innovative approaches such as stone bund and contour/tie ridges for reducing erosion and collecting run-off water for farming activities have become popular among farmers in SE Nigeria. [41] opined that irrigation had a positive and significant impact on agricultural production including other agricultural subsectors. The findings recommend the need to minimize of the impact of climate-induced agricultural production risks through CSA which involve complementary development of more arable land areas under irrigation in Nigeria. This will enhance agricultural water management and thereby increase food security and sustainable agricultural production under prevalent climate change and variability.

[42] emphasized that the major determinants of CSA in SE include: income, extension, credit, education, farming experience, the land area cultivated, livestock ownership, distance to the market and gender, household size, water resources, leadership position, risk orientation, mass media exposure and land ownership.

2.4 Climate Information Services for Agriculture in Southeast Nigeria

Climate information services are a piece of information that provide a full range of advice concerning climate, its impacts on crops, livestock, fisheries and management practices to be followed by farmers to prevent, reduce and manage climate risks in agricultural production. This tailored information supports farmers to make management decisions that will lessen the risks and increase benefit from the opportunities of our variable and changing climate. Farmers are the key final or end users of climate services considering that agriculture is one of the sectors of importance for the economies of African countries. Climate services constitute an important element of the climate adaptation agenda. It provides proof on the value-added of modifying climatic information in the hands of users based on improved forecasting capability.

According to World Meteorological Organization (WMO), climate service could be effective only when it meets the prerequisite of end users. The quality that helps to define the usefulness of climate service includes availability, timeliness, dependable, usable, credible, authentic responsive and flexible [43, 44]. The basic criteria for measuring the benefits of climate service include economic benefits such as increasing household economic status and welfare, reducing the cost of key commodities, land, insurance and agricultural costs; and providing benefits to health, well-being, and livelihoods [45]. The service requires an appropriate commitment to producing an optional significant to the needs of the user to aid decision-making under uncertainty and facilitate early guide action and preparedness. It also implies the effective access and delivery mechanism of all the climate services to respond to the user's needs [46].

For climate service to be useful, it must be integrated into a farm-level decision, for this reason, climate information must be provided well ahead of the agricultural season. However, most farmers do not receive forecast information early enough, and in formats they can understand through communication channels they find relevant or with content they find salient, thus limiting the possibility of realizing the full value of the forecast, and measuring outcomes or impacts [47, 48], the scale of information about the forecasts and models must be local so that farmers can understand it well and make their decisions on crop cultivation, land conservation, fertilizer and other inputs, and planting dates that relate specifically to their livelihoods and their farms [49, 47].

In Enugu State Nigeria, [50] identify poor extension services and infrastructure as the major constraints to effective communication of climate change information to farmers. [51] posit that Nigerian media has not given adequate and efficient information on climate change issues to farmers. [52] further explained that the degree of information available to farmers impacts their level of awareness. When adequate and reliable weather information is given to farmers there can easily make their decisions, choice and plans. Therefore, access to detailed weather information, early warning and forecast technologies can assist farmers to develop and readjust coping or adaptation strategies [53]. [54] ascertain that when rainfall is erratic, it becomes challenging for farmers to plan their operations.

In SE Nigeria farmers prefer information that relates to what works on their farm, rather than blanket generalizations, especially when environmental conditions are extremely variable. Therefore, increasing access to print or digital media would help in spreading awareness of climate change and associated production risk among farmers but most important is training farmers with meteorological information will be the best option before the commencement of the farming season. These climate information services could play a vital role in forming correct perceptions of farmers and a major strategy for climate risk mitigation [55]. [56, 57] attest that critical planning decisions such as when to start land preparation, when to plant, crop variety selection, plans for fertilizer application are all connected to receiving downscaled seasonal forecast information. [58] states that scientific community has continued to improve the coverage and quality of observational networks, and the advancement of skill for forecasts across timescales but, there are several scientific and practical barriers which impact the utility and uptake of climate information for farmers in Africa and India [59].

3.0 Study Area

The southeast region of Nigeria comprises of five states: Abia, Imo, Anambra, Enugu and Ebonyi States. It is the home of Igbo speaking language in Nigeria. It is located within latitudes 4° 47‟ 35‟‟‟‟N and 7° 7‟ 44‟‟‟‟N, and longitudes 7° 54‟ 26‟E and 8° 27‟ 10‟E. in a tropical rainforest zone. The annual mean temperature is 27oC, and total annual rainfall exceeding 2500mm [60]. According to NPC (2006), the zone occupies a total landmass of 10,952,400 hectares with a population of 16,381,729 comprising 8,075,423 females and 8, 306,306 males, making a ratio of 50.70 males to 49.30 females for the zone [61]. There are two major seasons in this zone—the dry season and the rainy season. it experiences dry season between November and March while the rainy season occurs from April and October. The climate encourages the cultivation of food crops like yam, cassava, vegetables, rice, etc., and livestock production. According to [61] the sex ration in Abia, Imo and Anambra is dominated by the male while Ebonyi and Enugu are dominated by females.

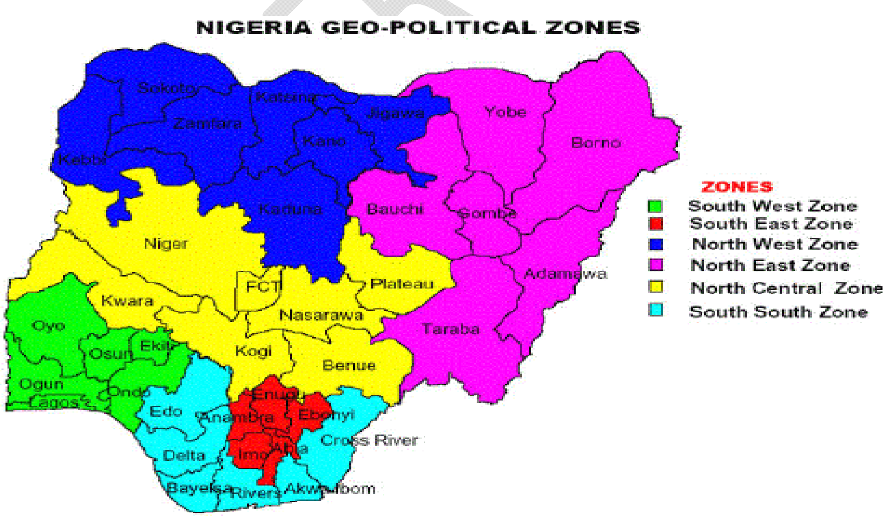

Figure 1: map of Nigeria showing Southeast
Sources:

4.0 Findings and Recommendation

The following are the findings of this study:

i. Farmers within SE agreed there is a climate change but they do not have documented evidence of climate change

ii. Adaptation methods are based on experience. In most cases, it does not correspond with meteorological data.

iii. Lack of access to credit facilities and funds.

iv. Inadequate extension services/workers within the SE to support farmers.

v. No training/education services for farmers.

The study recommends a PICSA approach makes use of historical climate records, participatory decision-making tools and forecasts to assist farmers to identify and plan better livelihood options that are suitable to local climate features and farmers' own circumstances. The approach enabled farmers to make a premeditated plan long before the planting season, based on their improved knowledge of local climate features. The uniqueness of PICSA this that the facilitator uses historical climate records (at least the past 30 years) for joint training and examination with farmers, this will enlighten their decision-making as it is done long before the planting season starts, with the purpose of developing farming approaches for 'any season'.

In the face of climate change, there should be an operational climate information service center for farmers in each state, this will enable extension staffs to work effectively with farmers in a participatory and facilitating manner and to support their decision making and planning that takes into account of local climate together with other constraints and opportunities that farmers have. Consequently, detailing how the provision of climate services for agriculture helps improve the management of climate risks and can help to shape future initiatives with these farmers' perception of climate change can be documented.

The government both the Federal, State and Local should support private insurance firms through policies that would encourage agricultural partnerships since agricultural products are basis for life. Access to credit facilities through microfinance institutions, especially to the poor farmers, this will enable them adapt to climate change.

5.0 Conclusion

The aim of agriculture is to increase food production in the face of an increasing population. This difficult challenge is exacerbated by climate change which has a significant impact on food security. In Nigeria, challenges associated with climate change are not the same across the country, Southwest and Southeast are less vulnerable than other parts of the country. To help farmers manage their enterprises in the face of climate variations and change hence the need for the adoption of climate smart agriculture but CSA faces a number of challenges in SE Nigeria: financing, policy, climate information service, etc but recently a new approach to extension and climate information services, namely Participatory Integrated Climate Services for Agriculture has been developed. PICSA makes use of participatory decision-making tools and historical climate records to make forecasts that help farmers to identify and better plan livelihood options that are suitable to local climate features and farmers' own environments.

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