

## MITIGATING THE EFFECTS OF CLIMATE CHANGE ON CROP PRODUCTION THROUGH CLIMATE SMART AND DIGITAL TECHNOLOGIES

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### ABSTRACT

*Agriculture particularly crop production is being threatened by the negative effects of climate change. This review thus highlights the negative effects of climate change on crop production as well as the use of climate smart technologies for mitigation. Climate variability and changes are setbacks to vital development goals, such as food security, which results from poor yield, making most farmers to diversify into other livelihood activities to the detriment of agriculture which is under serious strain resulting from climate change and these effects are likely to worsen with time. The effects /impacts of climate change on crop production and food security are many and diverse, they include Reduced food availability and quality, Economic losses for farmers and agribusiness men and women, Negative impacts on human nutrition and health. It was concluded that Climate change has had a profound effects on crop production and therefore requires urgent intervention the effects reflected majorly as a result of drought, increase outbreak of crop diseases, insect infection and damage to crops as well as increase in cost of production and household spending, reduction of farm and non-farm income, loss of harvest. Adaptation and mitigation strategies, such as sustainable agriculture practices, climate-smart Agriculture, digital technologies and ecosystem-based management, can help minimize these effects and ensure food security in the face of climate change. Government should provide agricultural input to farmers with a view to providing solutions to the incidence of pest and disease resulting from climate change and advise farmers on appropriate strategies to cope with climate change.*

**Keywords:** Climate Change, Climate Smart, Crop Production, Digital Technologies, Effects, Mitigation

## 1.0

## INTRODUCTION

As global populations grow and environmental challenges intensify, the need for sustainable and efficient agricultural practices becomes increasingly urgent. (FAO, 2023) Agriculture is one of the most important economic sectors in many developing countries, including Nigeria. Therefore, increasing agricultural production has been one of the essential priorities for agricultural development programs (Hosseini *et al.*, 2010). Agriculture is highly dependent on climate, especially in developing countries like Nigeria. Hence, climate change is expected to have far-reaching effects on agricultural production, food security, health and the rural communities in Nigeria. These effects have made climate change a contemporary issue in the media both for international and national policy processes. Agricultural production have generally been affected by various factors such as the activities of pests and diseases, poor extension service, poor capital and use of unimproved technologies and recently climate change (Hansen, 2019). Climate change is having a profound impact on global food systems, with far-reaching consequences for crop production. Rising temperatures, changes in precipitation patterns, and increased frequency of extreme weather events are affecting the productivity, distribution, and quality of essential food sources (IPCC, 2019). The negative effects of climate change are currently being felt in all spheres of life but the effects are more severe in the agricultural sector (Olorunfemi *et al.*, 2020). This is so because agricultural production performance and livelihoods are on the front burner of governments policies and programmes, no doubt climate variability and changes are setbacks to vital development goals such as food security, which results from poor yield, making most farmers to diversity into other live hood activities to the detriment of agriculture which is under serious strain resulting from climate change and these effect are anticipated to worsen with time.

Banmeke *et al.* (2017) pointed out that the intergovernmental panel on Climate Change (IPCC, 2001) defines climate change as statistically significant variation caused by human and non-human activities that last for decades or longer. Deforestation oil spills and gas flaring are examples of non- human causes. This definition showed that It is caused by human activities and by uncontrollable natural circumstances. It poses significant threat to the highly industrialized and less industrialized worlds. It has also been reported that third world or developing countries are more vulnerable to the effect of climate change, despite the fact that developed counties emit the most carbon and other high-level industrial waste. (Kadurumba *et al*, 2023) West African sub region would also be more vulnerable. Individual farmers, fishermen and other rural dwellers and city dwellers are the most vulnerable group. These high level of risk in Africa and in particular sub-Saharan Africa is obviously the result of high rate of illiteracy, poverty, ignorance, and corruption perpetrated by successive corrupt government which have not had the political will to put in education, Economic and Agricultural policy/interventions they had developed at different times in history as part of the national development plans of their different countries.

For the past few years, world leaders have been pondering on what or how to deal with the greatest threat of the moment, erratic climate variability otherwise known as climate change. These changes negatively affect the overall survival of human race and other living organism on the surface of the earth because the life of all living organism depends on water, humidity air, and soil for survival. Air Pollution caused by the emission of gases from factories vehicle, domestic use of

firewood, etc. significantly affect the ozone layer, thereby leading to reduced pacification, humidity and increase in the concentration of carbon dioxide on the earth, which in turn leads to poor agricultural products. (Igene *et al*, 2023)

Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014). Hence, without adequate mitigation strategies, limiting the effects of climate change in order to achieve sustainable development and equity, or poverty eradication would be grossly impossible

This review examines the effects of climate change on crop production, with a focus on the implications for food security and sustainability, this is apt because crop production seem to be the worst hit amongst the various aspects of agriculture, more so that many parts of Africa are facing food insecurity, due to reduced crop yield, security challenges, climate change effects, rise in population etc, etc. .

## **2.0 METHODOLOGY**

Literature materials as well as case studies were sourced from Journals, Conference proceedings. Magazines, internet, bulletins etc, they were collated and there after reviewed and discussed

## **3.0 REVIEW AND DISCUSSION**

### **3.1 Climate Change Impact on Crop Production**

Climate change is significantly impacting crop production worldwide, posing a substantial threat to global food security.

#### **3.1.1 Rising temperatures and altered precipitation patterns impact yields:**

Warmer temperatures and changing precipitation patterns can lead to reduced crop yields, decreased water availability, and increased evapo-transpiration, resulting in lower productivity (Schmidhuber *et al.*, 2007). For example, a 1°C increase in temperature can lead to a 2-4% decline in wheat yields (Asseng *et al.*, 2015).

#### **3.1.2 Changes in growing seasons and weather extremes (droughts, floods) affect crop quality:**

Shifts in growing seasons and increased frequency of extreme weather events, such as droughts and floods, can impact crop quality, leading to reduced nutritional value, increased contamination, and lower marketability (Lesk *et al.*, 2016). For instance, drought stress can reduce corn yields by up to 20% (Ciais *et al.*, 2005).

### **2.1.3 Increased pest and disease pressure due to warmer temperatures:**

Warmer temperatures can alter the distribution, prevalence, and severity of pests and diseases, leading to increased crop damage and reduced yields (Bebber *et al.*, 2013). For example, warmer temperatures can increase the reproduction rate of aphids, a major pest of wheat, thereby reducing yield by up to 50% (Harrington *et al.*, 2001).

## **3.2 The Implications of Impact of Climate Change**

The effects /impacts of climate change on crop production and food security are many and diverse, they include Reduced food availability and quality, Economic losses for farmers and agribusiness men and women, Negative impacts on human nutrition and health (Hanson, 2019)

It causes the rising of ocean tides, thawing of ice, leading to flooding and erosion which can destroy crops leading to huge losses, there is also increase in crime as farmers and agribusiness men and women sent out of business may resort to crimes such as stealing farm produce, stealing stored produce. Insurgency and banditry, All the above could lead to decline in agri-business practices and food insecurity, which has national security implications (Ayinoko *et al*, 2024)

## **3.3 Case Studies of Mitigation Through Climate-Smart and Digital Technologies**

). Without access to accurate and up to date weather data, ACP small holders have traditionally taken their decisions, but such predictions are becoming increasingly difficult. To foster greater climate resilience among farming communities, in 2016 the CGIAR Research program on climate change, Agriculture and food security (CCAFS) launched the 4year Rwanda climate services for Agriculture (RCSA) programme. Supported by USAID, RCSA aims to improve the supply, communication and use of climate-related services across Rwanda. (Spore Magazine, 2019)

RCSA is building on an existing initiative through which Rwanda's National Meteorological Agency combines data from local, ground-based weather stations from across the country, with rainfall and temperature satellite data. The satellites data, which extends 30-50 years into the past, also provides a historical source of information that allows stakeholders to better understand long-term climate trends. This information is then compiled into 'Maproom' -a freely accessible database of climate data. Providing information on trends in temperature and rainfall across time and at national, regional and district scales.

To improve the dissemination of climate information, and enhance farmers' ability to utilize the data themselves, RCSA has adopted the participatory integrated climate services for Agriculture (PICSA) approach that focuses on supporting small scale farmers in their planning and decision-making. PICSA begins with an initial workshop, where farmers evaluated their current farming strategies with reference to the risk identified using maproom data. Trainers and extension staff use a seasonal forecast to update the risk identified during the first evaluation, and guide farmers to decide on any adjustment for the coming season.

Farmers participation in PICSA helps identify and support differing needs across Rwanda diverse agro-ecology. But the approach has also proven effective at scale, with an estimated 75,000 farmers across the country having received training in PICSA, as of April 2018. The project has also developed a network of trained farmers who are able to pass on their knowledge in the use of climate information to other farmers within their community. (Spore Magazine, 2019)

A recent project assessment revealed that the vast majority of farmers that have received PICSA training found it useful- with seasonal forecasts considered the most useful element of the training, and 93% of respondents having made changes to their farming operations. Anathase Mudenge, a farmer based in Bugesera district, dedicated a small portion of his farm to method learned through PICSA training including planting based in weather forecasting and the use of certified seeds – and witnessed a three- fold yield increase: I now adhere to the planting time once I get the seasonal forecast and I always look for improved seeds.” Mudenge explains.

A prototype irrigation system that prevents the over watering of crops has been developed in Kenya. The automated irrigation Manager system, created by scientist at Jomo Kenyatta University of Agriculture and Technology (JKUAT), can decrease a farm's water usage by more than 25%. The technology uses 6cm sensors to read soil water levels and can be calibrated to adjust the water supply according to the moisture requirement of different crops. Pumps linked to the sensors feed water into the ground when moisture level drops below that needed by the plant. According to Wycliffe Obwoye, a JKUAT agronomist, the method also allows for the precise and economic applications, and boost crop yields by more than 50%.

Aboubacar karim, a 23 year old man from Cote d'Ivoire, has made it his mission to put an end to agricultural losses as a result of poor crop management “we cannot carry out farming the same way our grandparent did, using the hoe and machetes that people have been using for 300 years,

“he says. Karim’s field mapping company, invested, launched its first drone service in May 2017, the firm’s six drones each equipped with multispectral imaging camera and operated by internally trained pilots. Produce agricultural land use maps to pinpoint area of crops disease, poor soil fertility or under-hydration. The company then analyses the data so that farmers can take appropriate action, for instance by fine tuning fertilizer and disease control product dosages or using water and inputs more efficiently. Customers can also log into investiv’s Land management platform to view the latest data on their farms. “to date, we’ve managed more than 5,000 ha of farmland. “says Karim. (Spore Magazine, 2018)

### **3. 4 Artificial Intelligence Potential for Protecting Against Crop Pests**

Besides climate change, pests and diseases are a key challenge for small-scale farmers and is one that will be further exacerbated by climate variability. Each year, according to CABI estimates, about 50% of Africa’s Crop are lost to pest and diseases.

“Hundred of millions of African farmers are already suffering from the effect of climate change, says David Hughes, an entomologist from Pennsylvania State University, and the leader of the project that created Plant Village Nuru, an Android tool, which has been developed to diagnose crop diseases even without an internet connection, Developed by pen States, Plant Village and the International Institute of Tropical Agriculture, Nuru is used in several African countries, including Kenya in collaboration with Self Help Africa to diagnose mite and viral diseases in cassava, as well as to identify fall armyworm infections in maize. Advice from experts – mainly at CGIAR, FAO and government – is sent offline and in local language (currently in swahilli, French, Twi, Hindi, and English). Although still in beta testing, 28,000 cassava farmers across seven countries in Kenya will benefit from the tool this year. “Digital tools are increasingly becoming integral components of identification, monitoring, training, and decision – making of globally-important crop pests and diseases,” Hughes states.

A new AI tool that can predict crop growth and help protect vital food supplies from intensifying heat is being added to Nuru. It uses data from a satellite that tracks a decades worth of information about water availability, along with weather forecasting, to determine crop productivity

### **3.5 Impact Analysis**

#### **3.5.1 Soil conservation:**

Soil conservation technics resulted in 20% higher yield of crops generally in African, Caribbean and Pacific countries (Schmidhuber, 2007). It was reported in Spore Magazine in 2020 that Conservation agriculture through Minimum tillage reduced erosion by 50%. In agroforestry: Alley cropping increases yields by 25%., Resilient crops: Drought-tolerant maize improves survival rates by 30% (IITA, 2023).

30% better drought resistance in crops was also reported.

0.5 tons of CO<sub>2</sub> was reported to have been sequestered

#### **3.5.2 Solar irrigation:**

Solar irrigation has Enabled extra growing cycles leading to more food output, thus helping to contribute to food security goals

Solar irrigation has reduced emissions by 1 ton of CO<sub>2</sub>. ( IPCC, 2019)

### **Conclusion**

Climate change has had a profound effect on crop production and therefore requires urgent intervention the effects reflected majorly as a result of drought, increase outbreak of crop diseases, insect infection and damage to crops as well as increase in cost of production and household spending, reduction of farm and none farm income, loss of harvest

### **Recommendations**

1. Adaptation and mitigation strategies, such as sustainable agriculture practices, climate-smart Agriculture, digital technologies and ecosystem-based management, can help minimize these effects and ensure food security in the face of climate change.
2. Due to the threat posed by climate change to humanity in the society, there is an urgent need to provide the public with adequate and timely information on climate change as these will enable people to build their capacities adaptation or mitigation of the effect of the phenomenon

3. Government at all levels should increase their budgetary allocation to agriculture, accessible credit facilities to farmers to enable them to ensure their farms to minimize the Burden of losses resulting from the effects of climate change
4. Government should provide agricultural input to farmers with a view to providing solutions to the incidence of pest and disease resulting from climate change and advice farmers on appropriate strategies to cope with climate change.

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