Publishing Real Time

Colloquia Series

Available online at www.publishingrealtime.com

Colloquia SSSN 44 (2020)

Proceedings of the 44th Conference of Soil Science Society of Nigeria on Climate-smart soil management, soil health/quality and land management: synergies for sustainable ecosystem services

Agricultural engineering techniques and climate smart farming practices as tools in combating climate change and food insecurity.

Agbapuonwu, F

Nigeria Institute of Soil Science, Abuja Nigeria

Abstract

The effects of global warming are already bringing harm to human communities and the natural world. Human activities can also change the earth's climate and are presently driving climate change through global warming. Due to the high levels of adaptation and mitigation, which makes farmers more vulnerable, climate change affects agriculture in many ways, directly impacting food production and unpredictable yields. A growing global population and changing diets are driving up the demand for food. Production is struggling to keep up as crop yields level off in many parts of the world, ocean health declines, and natural resources including soils, water and biodiversity are stretched dangerously. The world's population is estimated to be at 9.7 Billion persons by the year 2050. Therefore, agriculture must change according to the present situation to meet the need for food security and withstanding under changing climatic situation. Climate change's effects are already felt in reduced yields and more frequent extreme weather events, affecting crops and livestock alike. Annual greenhouse gas emissions (GHGs) originating in "Agriculture, Forestry, and other Land Use" (AFOLU) are caused mainly by deforestation, rice cultivation practices, livestock production, soil and nutrient management. Climate change is emerging as a significant threat to agriculture, food security and means of livelihood of people worldwide. With the increased rate of human-made activities such as construction, soil disturbances which release trapped carbon in the soil to the atmosphere, stringent measures from the use of climate-smart farming practices and agricultural engineering techniques need to be looked at to combat further degradation of the soil and in turn, increase food production.

Keywords: Climate change, Food insecurity, Agriculture, Agricultural engineering, Climate Smart Agriculture.
Corresponding Author's E-mail Address: Francisnnamdi@niss.gov.ng: Phone: +2347065027700
https://doi.org/10.36265/colsssn.2020.4421

Peer-review under responsibility of 44th SSSN Conference LoC2020.

1.0 Introduction

Worldwide, billions of farmers and their families face significant climate change challenges because the agricultural sector is the most vulnerable sector affected by the effects of climate change. Climate change is the defining issue of our time, and we are at a defining moment. From shifting weather patterns that threaten food production to rising sea levels that increase the risk of severe flooding, climate change impacts are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly. According to the Australian Academy of Science, climate change is a change in weather patterns, and related changes in oceans, land surfaces and ice sheets, occurring over time scales of decades or longer. It is no longer doubt that climate change is real even in Nigeria. The black flood of 2012 in Nigeria remains a very remarkable and memorable experience that supports the evidence f climate change in Nigeria as more than half of the country from the North to the South was submerged during the rainy season (Adamu et al., 2019). The continuous variability, and unpredictable nature of the present climate combined with the threat it poses to humankind and his environment had led to the quest for climate-smart tools that can effectively predict seasonal rainfall particularly in Nigeria where farmers majorly practice rain-fed agriculture (Kerandi and Omotosho, 2008; Omotosho et al. 2000).

Climate change affects agriculture in many ways, directly impacting food production, low and unpredictable yields, thereby making farmers more vulnerable, particularly in

Africa due to low levels of adaptation and mitigation (IPCC, 2015). Experts agree that the industrial revolution was the turning point when emissions of greenhouse effects gases entering the atmosphere began to soar. The industrial revolution was itself borne out of smaller revolutions: agricultural, technological, demographic, transport, finance, creating a new model of production and consumption. The global temperature increase brings disastrous consequences, endangering the earth's flora and fauna's survival, including human beings. The worst climate change impacts include the melting of the ice mass at the poles, which in turn causes rising sea level, producing flooding and threatening coastal environments through which small island risk disappearing entirely. Climate change also increases the appearance of more violent weather phenomena, drought, fires, the death of animals and plant species, flooding from rivers and lakes, the creation of climate refugees and destruction of the food chain and economic resources, especially in developing countries, Nigeria not being an exception.

The term climate change is also used synonymously with global warming. The Oxford dictionary of science (2005), defines global warming as an increase over time of the average air temperature on the earth. The dictionary further stated that there had been periodic fluctuations between warmer and cooler periods on a wide range of time scales throughout the geological history of the earth. According to the different assumption about the future behaviour of humankind, a projection of current trends as represented by several different scenarios, suggest that the earth's temperature would rise from 0.6˚ Celsius (1.1 Fahrenheit) in the 20th century to about 3˚ to 5˚ Celsius (5˚ to 9˚ Fahrenheit) by the year 2100 or soon afterwards. The causes of climate change are complex. Factors include the external processes of solar emissions, variations of the earth's orbit, volcanic eruptions, mountain building and tectonic movements, and anthropogenic (human-induced) processes. According to Okebukola and Akpan, (2009), the causes of climate change can be divided into two categories, those that are due to natural causes and those that are created by humans. In Nigeria, Eze, Ikeogu, Iwu and Nwakama (2012) affirmed that environmental devastation arising from climate change is becoming rampant in many parts of the country. For instance, they noted that current environmental problem in the Niger Delta is flooding which comes from rainfall and runoff from rivers and urban chains, tidal movement and wind. Nigeria's situation was vividly captured when they stated thus: "Climate change or global warming has become a new reality with deleterious effects: seasonal cycles are disrupted as are ecosystems; and agriculture, water needs and supply, and food production are adversely affected. Global warming (climate change) also leads to sea-level rise with its attendant consequences, including fiercer weather, increased frequency and intensity of storms, floods, hurricanes, droughts, increased frequency of fires, poverty, malnutrition and series of health and socioeconomic consequences".

Food security is an indispensable prerequisite for humankind's survival and his economic activities, including food production Otaha, (2013). Food security is a difficult concept to measure since it deals extensively with the production, distribution and consumption of food. Food insecurity, on the other hand, lends itself more readily to measurement and analysis. It should be stressed that food security and famine and hunger are not to be confused. Food security refers to the availability of food, whereas famine and hunger are the consequence of the non-availability of food; in other words, the result of food insecurity. The Food and Agriculture Organisation (FAO), defines food insecurity as a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for average growth and development and active and healthy life. Any analysis of food security will examine whether a change from security to insecurity or insecurity to security occurs and the probability of such a change happening. Factors that may lead to food insecurity include non-availability of food, lack of access, improper utilization and instability over a specific period.

Food insecurity exists when people lack sustainable physical, or economic access to enough safe, nutritious and socially acceptable food for a healthy and productive life. Food insecurity may be chronic, seasonal, or temporary. Food insecurity results in catastrophic amounts of human suffering, the World Health Organisation (WHO), estimates that approximately 60 percent of all childhood deaths in the developing world are associated with chronic hunger and malnutrition. In developing countries, persistent malnutrition leaves children weak, vulnerable, and less able to fight such common childhood illnesses as diarrhoea, acute respiratory infections, malaria, and measles. The United Nations (UN) estimates that about 805 million people, approximately one in eight, are undernourished as of 2014. The majority of these people live in developing countries, where more than 14 percent of the people cannot meet these dietary energy requirements. Progress has been made in Southern Asia, Northern Africa and most countries of Eastern and South-eastern Asia and Latin America. Feeding this growing global population in the years to come will require producing more food and distributing it in a manner that reaches more people (Cargil, 2014).

The root cause of food insecurity in developing countries is the inability to access food due to poverty. While the rest of the world has made significant progress towards poverty alleviation, Africa, in particular, Sub-Saharan Africa continues to lag. Projections show that there will be an increase in this tendency unless preventive measures are taken. Food security on the continent has worsened with the increase in the effects of climate change. There are estimates that by the middle of the 21st century, climate change would reduce maize production in West Africa. This would be gravely affected by variance in the weather for years to come. Climate change has significant implications for agriculture and food security, creating new risks and challenges and exacerbating existing vulnerabilities from local to global levels. Rural livelihood systems and poor or marginalized groups that mainly depend on agriculture, forestry, fishery sectors, are the most vulnerable and strongly affected by climate change. Climate change and food insecurity are twin challenges which need to be addressed together, especially for any country serious about attaining food security.

Nigeria is a country with the largest human population in Africa and popularly referred to as the giant of Africa. Nigeria's growing population points out the outstanding and unavoidable results of a continuous increase in the human population. This includes depletion of resources, human congestion, weather modification, high unemployment rate, environmental degradation and lots more Oramah (2006). Population growth in 1750 was fewer than 800 million people on earth, whereas now we are over 7.5 billion, and by the year 2050, we would be at a projected 9.8 billion persons on earth. At the moment, Nigeria's

growth rate is projected at 2.56%, and this calls for urgent proactive measures to be carried out to combat the effects of a rapidly growing population.

Fig. 1: The estimated total population of Nigeria in the near future (Globalize Interactive World Map. 2005)

Source: Orameh (2006)

Worldwide, more than a billion farmers and their families face a significant challenge of climate change because the agriculture sector is the most vulnerable sector for climate change. Thus, their lives and livelihoods are directly affected by climate change, so there is an urgent need to implement many solutions to overcome this problem. This paper aims to discuss this and proffer solutions. Despite the attention paid to agricultural development and food security over the past decades, there are still about 800 million undernourished and 1 billion malnourished people worldwide. Simultaneously, more than 1.4 billion adults are overweight, and one-third of all food produced is wasted. Before 2050, the global food population is expected to increase to about 9.8 billion people. At the same time, global food consumption trends are drastically changing.

2.0 Impact of climate change on agriculture

Climate change can disrupt food availability, reduce food access, affect food quality and affect food security at a global, regional, and local level. Many advanced technologies, such as improved crop varieties, pest control methods, genetically modified organisms, and irrigation systems are widely adopted for crop improvement. By the year 1880, the earth's temperature increased to about 1.5˚Celsius. It is expected that throughout the 21st century, the earth, would experience warming above global levels. There would be seasonal temperature variation. Due to rainfall variability, changes in droughts and floods' frequency and severity could pose challenges for farmers and ranchers and will ultimately threaten global food security. Meanwhile, the rise in sea level and warming of seawater is likely to cause many fishes' habitat ranges to shift, which could disrupt ecosystems. Overall, climate change would adversely affect crops, animals and marine life. Along with the effects of climate change on agriculture, other evolving factors that affect agricultural production, such as changes in farming practices and technology, need to be addressed.

Climate change affects agriculture in many ways, directly impacting food production, poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa due to low levels of adaptation and mitigation (IPCC, 2015). Therefore, longer-term adaptation becomes necessary, especially over Nigeria, where agriculture is majorly rain-fed. Experience and studies have shown that, in general, local knowledge of climate risk is substantial and the attributable to anthropogenic influences such as the burning of fossil fuels, cutting down forest trees and developing land for farms, cities, and roads release greenhouse gases into the atmosphere and cause a shift in natural climate cycle. Higher Carbon dioxide CO□ levels can affect crop yields. The elevated CO□ levels can increase plant growth, particularly in plants with the photosynthetic mechanism. Increased CO□ level also reduces the quality of produce by reducing protein, nitrogen and minerals content in most plant species, including pest pressures and reductions in the efficacy of pesticides; thus more pesticides will be required in future which also threatened human health. Reduced grain and forage quality can reduce the ability of pasture and rangeland to support grazing livestock. Climate change also affects weeds, pests and fungi infestation due to an increase in host susceptibility.

The ranges and distribution of weeds and pests are likely to increase with climate change. This could cause new problems for farmers' crop previously unexposed to these species. Both historical and future estimated impacts of climate change on cereal crop yields in different locations indicate that the yield loss can be up to -35% for rice, -20% for wheat, -50% for sorghum, -60% for maize and -13% for barley depending on the location, future climate scenarios and projected year.

Heat stress also affects animals, both directly and indirectly. Over time, heat stress can increase vulnerability to disease, and reduce fertility and milk production. Climate change also affects rainfall pattern and distribution; due to this, many areas face a problem of drought stress which may threaten pasture and feed supplies. Drought reduces both the quantity and quality of forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from increased sunshine and reduced precipitation. Changes in crop production due to drought could also become a problem for animals that rely on grain for most of its nutrient and sustainability. Climate change may increase the prevalence of parasites and diseases that affect the livestock.

Fisheries and aquaculture, which provide at least 50% of animal protein to millions of people in low-income countries, are already under multiple stresses, including overfishing, habitat loss and water pollution. Changes in temperature and seasons can also affect the reproduction and migration of fishes and other aquatic animals. Forest provide employment and livelihood for more than 100 million people of the world's rural poor. Forests are home to more than 80% of the world's earth biodiversity and provide forests to produce goods and services and affect the people who depend on them directly or indirectly. On the other hand, temperate forest regional communities will be benefiting from elevated CO□ and temperature. Due to changes in occurrence, distribution, and frequency of precipitation, there would most likely be alterations in natural biodiversity and adversely affect crop growth, productivity, and crop yield. India and China, the most densely populated countries of the world, would need to keep pace with the growing population and sustain world food security, they would require at least 4-5% annual growth rate in agriculture. India supports about 17% of human and 11% of the world's livestock population just on 4.2% of water resources and 2.8% of the land. As per recent estimates, India will need to produce about 281 million tonnes (mt) food grains, 53.7 mt oilseeds, 22 mt pulses, 127 mt vegetables and 86 mt fruits by 2020–2021. In India, the average food consumption is 550 g per capita per day, whereas in China and the USA are 980 g and 2850 g per capita per day, respectively. To meet the demand for food from this increased population, every country's farmers need to produce 50% more grain by 2020. To enhance food production is under changing climatic conditions like aberrant weather, rising CO□ level, rising temperature and rising sea level, and we require the reorientation of agriculture from current practices to more sustainable and environmentally friendly practices.

3.0 Climate smart farming strategies

Many agricultural technologies and practices such as minimum tillage, different crop establishment methods, nutrient and irrigation management and residue management can improve crop yields: nutrient and water use efficiency and reduced greenhouse gas (GHG) emissions from agricultural activities. Similarly, improved seeds, rainwater harvesting, information and communication technologies (ICTs) based agro-advisories and crop/livestock insurances can also help farmers reduce the impact of climate change and variability. In general, climate-smart farming strategies options integrate innovative and traditional technologies, practices, and services relevant for a particular location and reduce the effect of climate change and provide the opportunities to stand such changing scenarios. Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial reduction in GHG mission over the next few decades can reduce climatic variability in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable agriculture.

I want to discuss different climate-smart farming strategies using natural or biological control methods to combat climate change and food insecurity in Nigeria. These methods are;

Rain-fed Agriculture

Combined effects of rainfall, temperature, humidity, and significantly, the variations of these within agro-ecological zones, significantly influence the types of indigenous and exotic plants that grow or can be introduced into the zone, coupled with the extreme impacts of climate change. About 90% of total agricultural output is produced by smallholder farmers who cultivate between 0.8 to 1.2 hectares in forest zones and 2 to 4 hectares in the savanna zones (Chude et al., 2011). Most crops would not attain their expected yield outputs mostly because of dry spell occurrence or dry seasons in Nigeria, resulting in low crop yields. To avert this from occurring, climate-smart farming strategies can be applied in the absence of either supplemental or full irrigation practice is contour farming with ridge-tying.

Strip cropping

According to Merriam-webster, strip cropping is defined as the growing of a cultivated crop (such as corn) in strips alternating with strips of a sod-forming crop (such as hay) arranged to follow an approximate contour of the land and minimize erosion. Strip cropping practice is not limited to sloping lands where its importance lies mainly in reducing slope length and soil carrying capacity of runoff, increasing infiltration rates of water and controlling erosion. According to Natural Water Retention Measures (NWRM), strip cropping is a method of farming used when a slope is too steep or too long, or otherwise when one does not have an alternative method of preventing soil erosion. It alternates strips of closely sown crops such as hay, wheat, or other small grains with strip or row crops such as corn, soybeans, cotton, or sugar.

According to Odunze (2019), in Nigeria's subhumid zone, farmers plant crops in strips to guard against crop failure, given the uncertain rainfall distribution pattern in the area. However, the practice is also of importance to conservation agriculture. For example, in practising strip cropping technique, two rows of cereal crops could be followed by four rows of legumes. These leguminous crops would help combat issues with soil erosion and help loosen the soil for optimum air and water movement through the soil pores. In the next planting cycle, the two rows of cereal crops would be interchanged and planted with legumes' four rows. Strip cropping practice helps in the control of weeds such as *Striga hermonthica.*

Fig 2: A contour ridged farming system used in Burkina Faso, West Africa in which sorghum or millet seeds are sown in planting basins containing a mixture of soil and fertilizer. The planting pits harvest rainwater.

Source: https://www.echocommunity.org/resources/66a8a3a9-ce11-4c60-b94f-d29de5fdfc53

Strip cropping

According to Merriam-webster, strip cropping is defined as the growing of a cultivated crop (such as corn) in strips alternating with strips of a sod-forming crop (such as hay) arranged to follow an approximate contour of the land and minimize erosion. Strip cropping practice is not limited to sloping lands where its importance lies mainly in reducing slope length and soil carrying capacity of runoff, increasing infiltration rates of water and controlling erosion. According to Natural Water Retention Measures (NWRM), strip cropping is a method of farming used when a slope is too steep or too long, or otherwise when one does not have an alternative method of preventing soil erosion. It alternates strips of closely sown crops such as hay, wheat, or other small grains with strip or row crops such as corn, soybeans, cotton, or sugar.

According to Odunze (2019), in Nigeria's subhumid zone, farmers plant crops in strips to guard against crop failure, given the uncertain rainfall distribution pattern in the area. However, the practice is also of importance to conservation agriculture. For example, in practising strip cropping technique, two rows of cereal crops could be followed by four rows of legumes. These leguminous crops would help combat issues with soil erosion and help loosen the soil for optimum air and water movement through the soil pores. In the next planting cycle, the two rows of cereal crops would be interchanged and planted with legumes' four rows. Strip cropping practice helps in the control of weeds such as *Striga hermonthica.*

Fig 3: Strip cropping combing cereal and legume

Source: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0184503

Mono cropping

Mono cropping is the agricultural practice of growing a single crop year after year on the same land, in the absence of rotation through other crops or growing multiple crops on the same land polyculture, corn, soybeans, and wheat are three common crops often grown using monocropping techniques. Mono cropping of cereals or legumes is also practised in the cub humid savannas of Nigeria.

Fig 4: Monocropping of maize

Source: Climate-smart agriculture technologies for profitable farming

4.0. Agricultural engineering techniques: how 5g can change the future of farming

According to Nell Lewis, Max Burnell and Angelica Pursley of CNN Business in 2019, 5G has the potential to disrupt a vast number of industries, including one of the world's oldest: farming. Next-generation 5G networks can be 100 times faster than 4G, making communication between devices and servers much quicker. 5G can also carry much more data than other networks. These data can be transmitted through remote sensors and drones, essential tools tested by farmers in developed worlds. 5G network also helps in automating farming processes. Drones that use 5G are helping to improve potato production in the Netherlands. In Japan, 5G sensors monitor the water temperature and salt concentration of oyster farms. In the United Kingdom, 5G rural first launched a smartphone application in March of 2019 called Me+Moo, which lets farmers track a connected cow and receive daily updates on the animal's health and behaviours.

Fig 5: Cows equipped with 5G connected collars and sensors that monitor their health and habits

Source: https://edition.cnn.com/2019/04/01/business/5g-farming/index.html

The cows wear 5G connected collars that send data to the application on everything they are eating to how they are sleeping. Farmers can see the information instantly and pass it on to veterinarians or nutritionists.

Given the massive variety in niche equipment needed to run a modern-day farm successfully, it will come as no surprise that the technology available to the agricultural industry today is just as varied and has the benefit of being made bespoke to a specific requirement. This provides the much-needed precision farming equipment needs to optimize and streamline traditional operations while also providing feedback on equipment use and performance, maintenance and repair data, and environmental conditions. This enables farmers who adopt these technologies to increase their productivity and the speed at which they can operate, and most significantly, they adjust to the effects of climate change in combating food insecurity.

According to the United Nations Food and Agriculture Organisation (FAO), predictions to provide for the world's rapidly increasing population, the planet needs to grow 70% more food in 2050 than it is currently producing. To respond to the growing demand for food supply, farmers will need to try out new technologies to produce more from less land, with fewer hands. This is where automation comes into play in agriculture. In 2017, another 5G Rural First project became the first in the world to successfully plant, tend and harvest a crop without a single human stepping foot in the farm. Autonomous tractors that do not emit carbon sowed the seeds, drones with sensors monitored the crops, smaller machines took samples to access what fertilizers and pesticides to apply and where.

Hands-Free Hectare, another project, reported another successful harvest in 2018. It was now going even further by using 5G technology to increase precision and crop spraying efficiency.

In Australia, agriculture is one of the fastest-growing industry, making over $50 billion in exports every year. Australia landscapes are vast and varied, comprising a mix of terrain, land uses, drainage lines, and soil properties. This country has cooperated the use of 5G technology to meet the ever-growing need for food supply. Australia uses precision farming techniques. Australia agricultural future will largely be enabled by the implementation of 5G technologies which will provide farmers with real-time data on everything from water and power usage, livestock movements, maintenance alerts, market prices, and control a wide range of machinery from all over their property. The essence of referring to the progress achieved in agriculture in Australia is for African countries, especially Nigeria, to learn and adapted to meet the ever-growing population's demand. Agricultural engineering techniques can be applied to improve farming and agriculture in the following ways;

4.1. Water Management

Irrigation systems are one of the most common features of any farm or agricultural site. To optimize irrigation systems, farmers could access data collected from remote sensors and use it to analyze where their water resources should be directed, in what kind of volume and for how long, and all form their connected laptop, tablet or smartphone.

4.2. Fertigation

Fertigation is defined as the injection of fertilizers, soil amendments and other products typically needed by farmers into the soil. With Agricultural engineering fertigation solutions, farmers could remotely control how many fertilizers are injected and within what volumes. It would also enable them to monitor fertilizer concentrations and other environmental conditions, such as pH, in the soil using remote sensors and adjust to the required levels if necessary.

4.3. Livestock Safety and Maturity Monitoring

Anyone who has ever worked on a livestock farm will tell you that animals sometimes tend to wander off. With agricultural engineering technology-enabled sensors producing real-time livestock data such as GPS positioning, farmers will be able to keep track of even the most determined to travel animals. Even systems being developed provide real -time biomedical data on livestock such as body temperature, pulse, and even tissue resistivity.

4.4. Crop Communication

As the world becomes ever hungrier, farms will need to keep up with global crop requirements. To do so, smart farming Agricultural engineering solutions can be deployed to enhance production, minimize waste and costs and improve resource consumption. The ability to monitor the soil condition in which your latest crop is planted via your smartphone or tablet connected to a self-driven censored motor.

4.5. Aerial Crop Monitoring

Monitoring a vast field to expose soil variation, fugues, and irrigation is quite challenging and costly to achieve in a timely fashion. Thanks to cheap drones, equipped with sensors, inexpensive but powerful processors, and GPS and radio technologies, farm monitoring is now affordable and way more precise. Now farmers can use time series animations to keep an eye on developing their crop and soil variation issues leading to more efficient crop management.

5.0 Mitigation strategies

Mitigation practices help farmers and those in the agricultural sector reduce the emission of greenhouse gases from agriculture system because elevated greenhouse gases ultimately lead to climate change and contribute to food insecurity. Changes in farming practices that have included pre farming, farming, post farming processes, nutrient management, water management, waste management, and storage practices help reduce greenhouse gas emissions.

The table below illustrates the conservation practices,

Table 1: Agricultural practices and climate change mitigation for crops. Sources: http://soils.usda.gov/survey/global climate change.html

CONVERSATION PRACTICES	GHG OBJECTIVES	ADDITIONAL BENEFITS
Conservation tillage and traffic control	Capture carbon and reduce emission	Improve soil, water and air quality. Soil erosion, compaction and fuel use are also reduced.
Integrated and site-specific nutrient management	Capture carbon and reduce emission	Improve water and air quality and also saves time, labour and money
Crop diversification and crop rotation	Carbon sequestration	Improves soil and water quality and also reduces emission and water requirement and provides food security

ANIMALS

CONVERSATION PRACTICES	GHG OBJECTIVES	ADDITIONAL BENEFITS
Manure management	Reduces emission	Improves soil quality, crop yield, on-farm sources of biogas fuel and possibly electricity for large operations provides nutrients for crops.
Rangeland and pasture management through rotational grazing and improved forage	Sequestration, emission reduction	Reduces water requirement, helps it withstand drought, and increases long-term grassland productivity.
Feed management	Emission reduction	Reduces the quantity of nutrients, improves water quality. More efficient use of food

Table 2: Agricultural practices and climate change mitigation for animals
Sources: http://soils.usda.gov/survey/global□climate□change.html

greenhouse gas objectives, and benefits of several mitigation processes used in crops and animal production to reduce climate change.

6.0 NiMeT

NiMet produces the Seasonal Rainfall Prediction (SRP) as a climate-smart tool to reduce the negative impacts of climate change on crop production and provide a vital tool for informed decision-making for policy formulation and planning in agriculture, water resources and environmental management in Nigeria. The timely preparation and release of seasonal rainfall predictions enhance preparedness against predicted climate risks and hazards. The SRP assists decision-makers, disaster managers, and those in the agricultural sector to implement adaptation and mitigation strategies outlined previously.

Proper application of the SRP as a climate-smart agricultural tool reduces climate-related risks and enhances production, security, and revenue generation, thereby improving the nation's economy. When the SRP is effectively applied, it reduces the risk of crop failure and losses, increases agricultural productivity and food security, and helps adapt and mitigate the impacts of climate change in Nigeria.

7.0 Conclusion and Recommendation

In the year 2019, Ethiopia set a new world record for planting over 353 million trees seedlings in 12 hours to fight the effect of climate change. I would recommend that every country should take a clue from what Ethiopia has done.

Climate-smart strategies like choosing suitable crops, integrated farming system, site-specific nutrient management, residue management, intercropping with legume, conversation agriculture-based resources conservation technology, agroforestry and crop diversification can help minimize negative impacts to some extent and strengthen farmers by sustainably increasing productivity and income.

Agencies like the Nigeria Institute of Soil Science should liaise with NiMeT to attain precise and accurate weather forecasting for a different location to help make a contingent plan for different crop and cropping systems. Researches on farming, clear water, nutrient and pesticide application using improved farming technologies, are to be encouraged to meet the world's growing population.

References

Adamu James Ugbah, Paul A, and Olaniyan Olumide (2019). Seasonal Rainfall Prediction (SRP): A Tool for Combating Climate Change and Food Insecurity.

Cargill, 2014: Food Security – The Challenges

Eze, U.F, Ikeogu, C., Iwuh, C.F. and Nwakama C.I. (2012). Review of potential applications of GIS and welfare forecasting to challenge climate hazards in developing countries: Nigeria as a case study. International Journal of Development Digest, Mid-year special edition, 15(1), 60-77.

http://nwrm.eu/measure/strip-cropping-along-contours

http://www.cargill.com/wcm/groups/public/@ccom/documents/document/na3059573.pdf

https://scialert.net/abstract/?doi=jas.2006.1332.1337

https://www.merriam-webster.com/dictionary/strip%20cropping

IPCC, (2015) Climate change 2014: synthesis report In: Core writing team, Pachauri, R.K, Meyer, L.A. (Eds.), Contribution of working groups I, II, AND III to the fifth assessment report of the intergovernmental panel on climate change. IPCC, Geneva, Switzerland, 151 pp.

Nell Lewis, Max Burnell, Angelica Pursley (2019): How 5G will change farming's future. CCN business; https://edition.cnn.com/2019/04/01/business/5g-farming/index.html

Okebukola, P. and Akpan, BB (2009). Recent developments in climate change.

Omotosho, J.A and NM Kerandi 2008. Seasonal Rainfall Prediction in Kenya Using Empirical Methods. Journal Kenya Meteorol. Soc.

Oramah Ikenna Theodore (2006): The Effects of population growth in Nigeria.

Otaha Imo Jacob, Ph.D (2013): Food insecurity in Nigeria: the way forward.

Oxford Dictionary of Science (2005). Oxford paperback reference. United States: Oxford University.

Odunze A. C (2019): Climate-smart agricultural technologies for profitable farming.

Chude V O and Odunze A.C (2011). Priorities for sustainable soil management in Nigeria.