CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES

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PUPLISHED BY:

Society for Agriculture, Environmental Resources & Management (SAEREM)

SAEREM BOOK CHAPTERS First published July 2026-- ISBN 978-978-60709-1-7 @ SAEREM World

First published August 2026

SAEREM World , Nigeria

CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT --- ISBN 978-978-60709-1-7

Typeset in Times New Roman

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Printed at: SAEREM World

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** necessary in policy making process that will stimulate increase in food production and environmental sustainability. **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management : *Global Issues & Local Perspectives*** is organized in two parts. Part One deals with The Concept of **Climate Smart Agribusiness Financing (CSAF)**, Part Two is concerned with The Concept of **Forestry and Waste Management**

Eteyen Nyong; August 2026

Chapter Six

Influence of Climate Change Adaptation Strategies and Information Communication Technology (ICTS) Utilization by Soybean Farmers in North East Nigeria

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1.0 Introduction

Recent advances in information and communication technology (ICTs) have expanded the range of options available for delivery agricultural innovation information to rural farmers. The growing availability of digital communication tools has changed how agricultural knowledge is shared, making it possible for farmers to access information more quickly and interact with experts regardless of geographical location. Internet based platforms, mobile applications, and other digital communication channels has strengthened communication between farmers and extension agents supporting more informed decision making in agricultural production at all level (Suvedi *et al.,* 2023). One area where ICTs can have a big influence on people is the delivery of agricultural extension services, which mostly depend on information sharing between farmers and other sector participants. Around the world, traditional civilizations as we know them are evolving into knowledge-based society, doing away with the concept of "illiterate rural communities," Antiquated methods of offering crucial services to the public are no longer able to produce the intended outcomes, (Meera, Jhamtani, and Rao, 2021).

Coping entails facing and handling obligations, issues, or challenges, particularly in a composed and sufficient manner. It also entails struggling and handling unfairly harsh situations or achieving some degree of success (Simpson, 2014). The term "coping" describes the mental and physical strategies used to address certain external and/or internal demands that a person perceives as burdensome or beyond their capacity. While strategy is the art and science of organizing resources for the most effective and efficient use, it is also a technique or plan adopted to bring about a desired feature, such as the accomplishment of a goal or a solution to a problem (Oxford Dictionary, 2014). Coping techniques are defined as responses or actions taken to control, lessen, or endure the demands imposed by stress (Weiten *et al.* 2011). Hence, a coping strategy is an intentional attempt to resolve a personal or social issue in order to reduce, eliminate, or tolerate stress or conflict (Lazarus 1993). Coping mechanisms can differ between people and between situations. This is to say that the ability of people to break out of poverty or adopt a coping mechanism is often associated with the peculiarities of the conditions within their communities. Coping techniques relate to immediate responses to shocks, such climate change, as opposed to adaptation, which is a long-term response to stressors. Households often rotate crop fields annually, plant crops at the appropriate time based on rainfall intensity, mix crop species, choose crop

varieties based on adaptation, and utilize water collection systems to deal with rainfall unpredictability (Alemayehu and Bewket, 2017).

2.0 Statement Problem

Nigeria's climate has changed in many ways, and the government has paid little or no attention to these changes. Its inhabitants' lives are becoming more challenging, as seen by the rising temperatures, shifting rainfall patterns, rising ocean levels, catastrophic flooding, land degradation, an increase in the frequency of extreme weather events, compromised clean water supplies, and a decline in biodiversity. All economic sectors are feeling the effects of environmental degradation, but the agricultural sector is severely affected because crops and animal production farmers has no other sources of income apart from agriculture (Elisha *et al.*, 2017; Ebele and Emodi, 2016; Olaniyi *et al.*, 2019). If the government and all stakeholders do not take any action to reduce the impacts of climate change, North East of Nigeria may not be able to engaged in meaningful agricultural activities (Nzeh, Uke, Attamah, Nzeh, and Agu, 2016). Agriculture provides a living for more than 70% of Nigeria's rural population and a small percentage of its urban dwellers. Because Nigerian agriculture is mostly rain-fed and prone to erratic rainfall variation, farmers find it difficult to organize their operations in a way that will both limit the consequences of climate change and produce a high yield. Issues linked to climate change, such as higher temperatures, less precipitation, droughts, desertification, less acreage, and lower agricultural product yields, would have an influence on rural farmers' life styles (Ogbuabor and Egwuchukwu, 2017).

In Nigeria, the government is not able to supply farmers and community members with the knowledge, information, and proper learning methods they require for growth and development. Amidst all of this, extensionists are debating how best to use information and communication technologies (ICTs) to raise the standard of living and enhance rural livelihoods of farmers. Around the world, new agricultural technologies are putting pressure on traditional methods of supplying farmers with basic services, and ancient civilizations are being transformed into knowledge-based society (Abiodun, Mauzonsu, Albert, 2022; Lightfoot, 2020). Nonetheless, Nigeria and other African nations' agricultural progress has been hampered by the low percentage of ICT adoption.

Considering these challenges, there is need to examine the influence of climate change adaptation strategies and information communication technology (ICTS) utilization by soybean farmers in north east Nigeria. It is important to examine Adaptation and Coping Strategies by Farmers in Nigeria, ICTs Impact and Monitory of Climate Change, Role of Weather Information in Farm Management, and

Sources of Information on Climate Change by Soybean Farmers. Addressing this gap will contribute to adoption of coping strategies and utilization of ICT by rural farmers in North East Nigeria.

3.0. Concept of Adaptation and Coping Strategies

The production of food crops is currently facing serious threats from climate change. Nonetheless, farmers' adaptation strategies to mitigate the effects of climate change largely determine how much of these effects are felt. Nigerian agriculture is already under a lot of strain from the country's expanding population, which puts further strain on the limited, frequently damaged soil and water supplies. This strain is increased by the effects of climate change. The two main strategies for addressing climate change are adaptation and mitigation. An adjustment made to a physical, ecological, or human system in response to vulnerability is known as adaptation to climate change (Umar, 2019).

A farmer's ability to adapt helps them meet their goals for food, income, and livelihood security when faced with shifting socioeconomic and climatic conditions, including erratic short-term fluctuations in local and large-scale markets. The detrimental effects of climate change are mitigated by adaptation. In order to fulfil and continue satisfying Nigerians' increasing food demands, agricultural productivity and methods must be modified to adapt to climate change. Research indicates that Nigerian farming practices and agricultural technologies have been adapting to the consequences of climate change. Farmers, particularly those that grow food crops, can lessen the possible harm by adapting strategically to these changes (Otitoju, *et al*., 2016).

crop diversification, mixed cropping, the use of various crop kinds, dates for planting and harvesting, and drought-resistant cultivars are coping strategies adopted by so many farmers in Nigeria. Strategies for adapting to climate change in Southeastern Nigeria include mulching, agro-forestry/afforestation, multiple/intercropping, and harvesting and purchasing water for irrigation. Southwest Nigerian farmers are being helped by extension officers to adapt to climate change through reported tree planting, timely crop planting, avoiding bush burning, small-scale irrigation, mulching, avoiding felling trees, and monitoring weather conditions prior to planting crops (Adewoyin, *et al.* 2022).

Real-world repercussions might arise from our comprehension—or lack thereof—especially for the poorest people, families, and communities on the issue of climate change. Treating the two terms interchangeably can encourage—or worse the outcome of our action and environment, even support—actions or approaches that was effective in the past, could prove devastating in the context of our shifting climate. Some might even result in maladaptation, as it is frequently termed. Traditional coping strategies that are prevalent throughout most of semi-arid Africa countries include selling off productive

assets like animals and/or increasing incomes through the production of artisanal charcoal may not be the best coping strategies in the face of this current climate change (Taylor *et al.*, 2010).

To deal with rainfall unpredictability, farmers frequently practice crop rotation on the farm annually, plant crops at the appropriate time based on rainfall intensity, combine crop species, and use crop that are adaptive to the changing climate (Sime and Anne, 2019). They also frequently employ water harvesting techniques. Other approaches to addressing farmers difficulties resulting from climate change susceptibility include non-agricultural firms, livestock sales, food lending, food borrowing, and remittances. Risks can vary in their impact based on the difficulties they provide (Food and Strategy, 2017). Coping with climate change is often difficult in underdeveloped countries because socioeconomic, geographical, and meteorological variables influence adaptability (Omerkhil *et al.*, 2020). Vulnerability assessments must take into account and address a number of important issues. These problems include the insufficiency of current assessments in terms of supporting decision-making, the ambiguity surrounding the operationalization of the vulnerability, the lack of standardization in vulnerability measures, and the inadequate consideration given to indigenous knowledge and experience (Onyeneke *et al.*, 2020).

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4.0. Characteristic Differences between Coping and Adaptation

Coping strategies is a Short-term and immediate while adaptation practices and results are sustained. Coping strategies oriented towards survival security while adaptation is oriented towards longer-term

livelihood. Coping strategies is not continuous while adaptation is a continuous process. Coping strategies is motivated by crisis; reactive while adaptation Involves planning. Coping strategies often degrades the resource base while adaptation uses resources efficiently and sustainably. Coping strategies is prompted by a lack of alternatives, adaptation focused on finding alternatives; Combines old and new strategies and knowledge (Taylor *et al.*, 2010).

5.0 Adaptation and Coping Strategies by Farmers in Nigeria

It is commonly acknowledged that adaptation is an essential part of any policy response to climate change because it enables farmers to meet their goals for food, income, and livelihood security in the face of shifting climate circumstances. Research indicates that in the absence of adaptation, climate change typically has a negative impact on the agricultural industry; however, via adaptation, vulnerability can be significantly mitigated (Shrestha, *et, al.* 2022).

Farmers use adaptation as a strategy to improve their capacity to deal with an uncertain future. Therefore, adapting to climate change will involve putting effective measures into practice to decrease the negative effects of climate change by making the required adjustments so as to not feel the effects too strongly. Developing nations, like Nigeria, generally view developed nations as having less vulnerability and superior adaptation techniques because these areas are better equipped to recognize the opportunities presented by cold weather events and, as a result, take deliberate action to boost agricultural output. The UNFCCC is leading the international community in careful discussions about how to combat the problems of climate change. Therefore, it is imperative that the international community incorporate procedures that will help developing countries transfer knowledge, technology, and financial resources so they can adapt at all levels and in all sectors into their future decisions (Gabriel, *et, al.*, 2023).

Given the wide diversity of temperatures and environmental conditions in which agriculture is carried out, the nation must provide a variety of adaptation alternatives to suit the unique requirements of its many ecological areas. Numerous adaptation strategies have been tested in various agricultural contexts. While the impacts of the remaining ones are still being felt, several have produced encouraging results. Adaptation and coping strategies carried out by crop production farmers with a lot of cropping options are also available. These include:

5.0.1 Crop Diversification: Crop diversification is a strategy used by African farmers to increase agricultural sector resilience, according to a recent study (Mango *et al.* 2018), some farmers may not find this to be advantageous. Nonetheless, adaptation is already regarded as a crucial and essential component of any future system addressing climate change, regardless of how is practiced. Crop

diversification, the adoption of early-maturing and drought-tolerant crop types, and the planting of cover crops are a few of the known methods being used to mitigate the variability and impacts of climate change. According to studies, the government and other non-governmental organizations in Nigeria are helping farmers to better adapt to the effects of climate change by providing them with relevant information and other resources. Agricultural extension services can also provide pertinent weather-related information and skill development that can raise productivity. Though the techniques for adaption are limited by the current irregularity of extension services in Nigeria (Akintonde and Shuaib, 2016).

5.0.2 Early Planting of Crops: Early crop planting, a situation in which the farmer changes the date of planting crops to enable the crop benefit from a fair quantity of rain before it stops. The current year's rainy season was marred by a slight change in the climate in some parts of Nigeria. As a result, the north east and many other parts in the country did not receive rain during the months of July and August, which are typically farmers' period of farming activities. As a result, some farmers who took advantage of the early planting window planted specific cereals (like maize) in May or June during the first significant rainfall, which helped the farmers survive the drought brought on by the lack of rain. As such, majority of the crops that would typically be planted later in July did not survive, farmers lost their resources—cash, inputs, time, and energy—and the rains stopped in July and August (Robert, 2019).

5.0.3 Improved Variety of Crop: Another adaptation method used to deal with the effects of climate change is increased variety. Improved varieties with excellent resistance to pests and diseases, low water requirements, rapid maturation, and numerous other attributes are currently planted by farmers. It was discovered that Nigerian cereal producers were fond of this method. Based on the maturity group of soybeans, the improved varieties resulting from the breeding programmes were divided into three groups: early (91-100 days), medium (100-110 days), and late (>110 days) maturing soybean varieties (Tefera *et al*., 2019). Majority of the farmers in the north east of Nigeria planted the early maturity soybean which enable them to overcome the effect of climate change. However, the drawback is that the improved seeds are more costly. On the other side, farmers can save money by using the current growing season's seeds to make new ones for the following growing season. Again, if there are extended dry period and no irrigation infrastructure, this strategy might not succeed.

5.0.4 Crop Rotation: One method farmer employs to mitigate the effects of climate change is crop rotation. Nigerian and other Africa countries, farmers do not limit themselves to planting a single crop. They alternate between grains and/or legumes according to the season. In one season, a farmer may cultivate corn and other tuber crops, like cassava, and in another, just corn and cowpea. Given their

knowledge of past patterns of climate variation and the local meteorological indicators, farmers may sometimes forecast the characteristics of the upcoming planting season, however such forecasts may not always come to pass. For example, if temperatures are high this year and there have been too few precipitations, farmers may look forward to a favorable climate in the upcoming growing season. A farmer can forecast which crops will yield more in a situation like this if there is a lot of precipitation and less susceptibility to the weather. Farmers with suitable soils rushed to plant soybeans when the rains returned towards the end of August and the beginning of September of last year. This crop requires less rainfall and typically germinates in 12 weeks, so whatever rain falls during the remaining portion of the season should be sufficient to see the crop through to November harvest. Other times, farmers would depend on weather forecasts from the appropriate government organizations to ascertain the characteristics of the upcoming growing season and make necessary preparations for the crops that would do better in such conditions. To choose which crops to rotate with each other in upcoming seasons, one can also use this information to ascertain which crops give a comparative advantage over others. These computations assist farmers in making more informed decisions and better planning, both of which can result in lessening the effects of climate change (Akintonde and Shuaib 2016).

5.0.5 Irrigation and Drainage System: In Nigeria, farmers typically take into account irrigation and drainage practices when planting crops. This is to ensure that plants have access to water during times of scarcity, as observed in northern Nigeria, and to lessen the effects of flooding in the event that it becomes necessary, particularly in the coastal southern region of the country. This may lessen crop loss during periods of both abnormally high and insufficient rainfall, such as the two months of break already mentioned during Nigeria's current rainy season. The collection of secondary data, along with observations and experiences from past and present planting seasons, demonstrated that farmers in northern Nigeria had been depending on direct interventions, such as building dike systems to prevent flooding, relocating farmers from areas that had been severely eroded, choosing new crops, building dams to increase irrigation, and rotating crops, to mitigate the effects of climate change. Farmers were able to guarantee a sufficient crop output by using techniques like these.

5.0.6 Cultivation of More Agricultural Lands: Cultivating more agricultural land is another adaptation option used by crop farmers in many parts of the country. This led to the observation that farmers were proactive in increasing their production by cultivating wide areas of land rather than waiting until harvest time to discover significant crop losses and/or damages. In order to enhance their livelihood and raise revenue, several farmers have expanded their farms by cultivating additional land. First of all, the government owns all of the land in the nation, and anyone wishing to take possession

must obtain permission from the owner through a process known as "registration of title," which carries additional fees. Nonetheless, farmers have typically farmed land without the owner's consent, and they are constantly prepared to relocate to new areas of land once the legitimate owners show up to claim the land. When such situations occur, farmers have occasionally reported suffering enormous losses, but they would rather take the chance because it has practically become the standard for them. Usually, only large-scale commercial farmers are able to legitimately purchase the land. Farmers may be raising their yields by cultivating larger areas of land, but doing so indirectly increases the amount of land used for agricultural purposes, which raises their risks and exposes them to the effects of climate change (Federal Ministry of Environment 2015; Gabriel, *et al.*, 2023).

Another strategy employed by the crop farmers in the region of interest is livelihood diversification. Some farmers have made the decision to switch to another source of income because they believe they can no longer manage the effects of climate change. In an attempt to adapt, some crop farmers have tried diversifying into nonfarming activities, and they are trying to discourage young people from getting involved in agriculture because they are more interested in white-collar employment. In order to support their family, several farmers have regrettably chosen to forgo farming in favor of artisan employment. Incorporating revenue from non-farming and other farming activities into a diversified livelihood plan, enhancing the efficacy of weed, disease, and pest management techniques by expanding the application of integrated pest and pathogen management, creating and utilizing species and varieties resistant to pests and diseases, preserving or enhancing quarantine capacities, and monitoring programs are coping strategy adopted by farmers in Nigeria

Additional traditional methods include managing low-lying areas, building store dikes, restoring lands with green manure, controlling tall grasses to fix soil nutrients washed away by runoff, and safeguarding river banks and low-lying areas. Most of the time, these adaption techniques aren't applied separately. When necessary, farmers might combine two solutions to get the desired outcome. The truth is that climate change is still a factor in agricultural practices, and it may not be possible to prevent it in the near future. The most practical course of action for farmers to take in reducing the risk of climate change is to build up adaption methods to deal with the changing climate (Robert, *et al*., 2019).

6.0 Other General Adaptation and Coping Strategies

Adaptation and coping capacity are the ability to deal with the consequences of changing climates, to mitigate potential changes, to take advantage of opportunities, or to adapt to them. It is dependent upon

possessing sufficient information, resources, income, and resources. (Madu, 2016). The following are some adaptations and coping strategies:

6.0.1 Acquisition of Skills, Information and Awareness: To effectively integrate adaptation to climate change in all aspects of national life, Nigerians need to understand what climate change is, how it is affecting them, and how they may adapt. They also need to have access to this knowledge. People, communities, and the country as a whole must be equipped with specialized skills in order to address the challenges posed by climate change and begin the adaptation process. The dissemination of knowledge and information must be available to a broad range of individuals, particularly the most vulnerable (Anabaraonye, *et al.*, 2019).

It is believed that the general populace in Nigeria has a poor awareness of climate change-related issues. Research indicates that the Nigerian media has not given adequate attention to climate change issues (Ajaero and Anorue, 2018). The amount of information that is easily accessible influences people's awareness of issues related to climate change. The development and modification of coping or adaptation strategies may also aid farmers by giving them access to forecasting, early warning, and specialized weather data (Otitoju and Enete, 2016).

6.0.2 Agricultural extension services: Farmers must have access to innovations and adaptable technology in the face of climate change, because it will help farmers' agricultural activities yield more profit, increase productivity, and resource-efficient. The more the farmers engage with agricultural extension agents and services the more they have access to information on climate change and adaptation strategies. Farmers sure ways of increasing agricultural productivity and they standard of living is to access extension agents and services on a regular basis. Farmers in Nigeria are suffering from poor agricultural production because extension agents are inadequate. Nigeria is in dear need of extension experts that can help create awareness on issues relating to farmers needs and adaptation strategies in this current food insecurity and effect of climate change. Although the extension agents will need regular training to meet up with the changing world and technology (Solomon and Edet, 2018; Otitoju and Enete, 2016).

6.0.3 Education and school curricula: Education has not yet been recognized and embraced by Nigeria as a successful counter-strategy against climate change. Nigerian children and young people are still not receiving enough education on these issues, and as a result, they lack the skills needed to handle climate change-related emergencies. It is imperative that university curricula and courses in Nigeria address and integrate climate change. The nation's educational program is beset by issues with infrastructure and

inadequate teacher preparation. Appropriate tools and teacher preparation should be provided to enable the young people acquire the needed skills and knowledge to navigate through the challenges of climate change and engage in agricultural production profitably. Interactive blogs, innovation, and technology as a coping strategy should be introduced regularly to farmers and young people in this way both the farmers and the young people will be happy to farm and practice agriculture as a major occupation. (Duru and Emetumah, 2016; Amanchukwu *et al.,* 2015).

6.0.4 Indigenous knowledge: The value of indigenous knowledge in ecologically friendly development and environmental management is becoming more widely acknowledged. Many agricultural adaption strategies heavily rely on indigenous knowledge. Indigenous knowledge needs to be conserved in order to prevent its gradual loss over time. Indigenous knowledge should be incorporated into agricultural extension and training programs, as well as policy suggestions to address the difficulties posed by climate change (Nkechi *et al.,* 2016).

6.0.5 Institutional capacity: The government of Nigeria and its several agencies have not gone far enough in developing and constructing institutions that are related to the needs of its citizen and farmers in particular. Enhancing institutional competency is crucial for all institutional entities that are engaged in climate change adaptation in Nigeria. For example, there is a need to strengthen and empower the Special Climate Change Unit of the Federal Ministry of Environment to perform better. In order to help smallholder farmers adapt to a changing environment the institutions need to put study findings into practice, new organizations are also needed, such as Public-Private Partnerships (Avanlade *et al.,* 2017).

7.0 Concept of Information and Communications Technology (ICT)

The continents of African abundant natural resources and agricultural potential, has not help many African countries like Nigeria from deep neck exporters of food crops and other consumer goods. With natural resources that is sufficient to meet the needs of the continent, Africa still imports food crops valued at over US$25 billion per year. Africa's high rate of poverty and over-reliance on imports of products and services are caused by the leaders and stakeholders who refused to engage in value addition, agricultural commodity processing, and postharvest management of the various crops produced in Africa (Moyo, Bah, and Verdier, 2015). However, a substantial portion of the continent's population still lives in sparsely populated cities and rural areas, where agriculture is their primary source of income. A little over two thirds of Nigeria's workforce worked in agricultural sector, which generated nearly three quarters of the country's total domestic revenue. The majority of Nigerians rely

on agriculture for their primary source of income, hence raising living standards of the populace, depends on the sector's expansion and advancement in the agricultural sector. Encouraging growth can be achieved by effective use of information and communication technology (ICT), as ICTs are widely used in many nations where growth and an improved level of living standard of the populace are evident (World Bank, 2018).

The agricultural value chain has become much more productive and efficient in American and European nations that have effectively used ICT. For example, this developed nation uses traceability technologies like radio frequency identification (RFID) and block chain to track and trace food from farms to stores, promoting efficiency and transparency throughout the whole food supply chain. In most of the advanced countries of the world ICT is used in most food-related incident that can be harmful to humans or animals and this has help them to be able to tracked back food incidents to its original source. ICTs, which are necessary to successfully raise citizens' standards of living, are still not widely adopted in Africa (Food and Agriculture Organization, 2017). As of 2019, more than 33 million smallholder farmers had access to digital apps; if the current trend of ICT usage continues, this number is expected to rise to more than 200 million by 2030. Using cutting-edge ICTs like block chains, artificial intelligence, cloud computing, Internet of Things (IoT), and big data analytics, along with traditional ICTs like computers, radios, TVs, and mobile phones, which are the current trends that is solving global economic and agricultural issues all over the world, food insufficient will be the thing of the past. ICTs have the potential to facilitate agricultural sustainability transitions by boosting output, traceability, and transparency for the good of humanity. Even if ICTs have certain drawbacks, they can also help with the move to more sustainable agriculture (El and Allahyari, 2018). Currently, a lot of countries use satellite technology and GIS to improve agricultural productivity. Big data analytics can also be used to forecast climate changes in an area, which will help farmers work more productively, influence decisions made in real time, and update their business procedures for the contemporary day (Wolfert, Verdouw, and Bogaardt, 2017; Ahoa *et al.*, 2020; Kassahun *et al.*, 2020).

The term "precision agriculture" refers to the application of a number of technologies, such as mobile computing, enhanced information processing, GPS, GIS, software for detailed data on agricultural productivity, and mobile devices. ICT has been widely adopted by developing nations, such as Nigeria, because of its many advantages. ICT's rapid progress over the past ten years and its impact on every aspect of human endeavor demonstrate that it is the best thing that has ever happened to the globe (Koksal and Tekinerdogan, 2019; Verdouw *et al.* 2019). The collection of hardware and software known as information and communication technologies facilitates the sharing, storing, and processing of

pertinent information both within and between a particular population. Examples of this technology include computers, software, and digital and analogue libraries. The term "information and communication technologies" (ICTs) refers to any form of remote communication used in print and electronic media. ICTs can help fight climate change, its effects, and environmental preservation (Academy for Educational Development and Win Rock International, 2022). An information and communication technology (ICT) is any electronic device that collects, processes, stores, and transmits data in a way that is clear to both the sender and the recipient. It combines communication technology (CT), which encourages the flow of knowledge, with information technology (IT), which serves as the basis for knowledge. While the latter is concerned with knowledge interaction, exchange, and linkage as well as the channel—such as networking—through which knowledge is sent, the former is focused on the processing and packaging of knowledge.

In Nigeria, the government is not able to supply farmers and community members with the knowledge, information, and proper learning methods they require for growth and development. Amidst all of this, extensionists are debating how best to use information and communication technologies (ICTs) to raise the standard of living and enhance rural livelihoods of farmers. Around the world, new agricultural technologies are putting pressure on traditional methods of supplying farmers with basic services, and ancient civilizations are being transformed into knowledge-based society (Abiodun, Mauzonsu, Albert, 2022; Lightfoot, 2020). Nonetheless, Nigeria and other African nations' agricultural progress has been hampered by the low percentage of ICT adoption. The outdated Training and Visit distribution mechanism, which is no longer relevant or functional, is still used by Nigeria's national extension agency. Historically, mobile, movie theatre, video, television, radio, and phone introduction have all been used to support this service. Even at the headquarters ADP, most employees do not actually own a working Andro phone, as a result, despite the introduction and expansion of the global mobile communication system, the use of various ICTs, such as telephones, in extension delivery remains very limited (Othman, Alam, Melaiye, Shelleh and Rikwentishe, 2020).

8.0 ICTs Impact and Monitory of Climate Change

ICTs undoubtedly contribute to climate change, as evidenced by the events of the last few years, not only through their causes but also through their impacts, but also by their involvement in environmental monitoring, mitigation, and adaptation. By promoting and supporting the development of more energy-efficient equipment, encouraging environmentally friendly design, and lowering the carbon footprint within its own sector, ICTs have the potential to greatly reduce the effects of climate change on the environment. When implemented properly, ICTs have the potential to significantly reduce GHG

emissions. New paths to pursue include the promotion of Next Generation Networks (NGNs), which can reduce power consumption by as much as 40%, and the development of a standardized method for calculating carbon footprint (Kuhlmann, 2022).

Utilizing ICTs to improve human activities has become a smart idea. Examples of these include radio and telecommunication technologies, weather and climate change monitoring systems, and more. Predicting, identifying, and mitigating the effects of typhoons, thunderstorms, earthquakes, tsunamis, and other man-made catastrophes can be greatly aided by ICT. The Global Observing System (GOS), for example, is one of the three integrated core system components that comprise the World Weather Watch (WWW). It assists in providing observations of the earth's surface and atmosphere from space as well as from all over the world. Generally speaking, this technology serves as a relay for remote sensing instruments that are mounted on satellites, airplanes, radiosondes, and marine and terrestrial meteorological radars. Using radio and telecommunication technology, the Global Telecommunication System (GTS) enables real-time communication and the sharing of critical data between national and international meteorological centers. The Global Data Processing System (GDPS) processes a vast amount of meteorological observational data to provide meteorological products such as forecasts for agricultural and economic growth, warnings, and analyses (El and Allahyari, 2018).

9.0. ICTs in Forecasting and Broadcasting Weather Information

The use of science to predict the atmospheric conditions at a given place and time is known as weather forecasting. Quantitative information about the current condition of a specific atmosphere is obtained and relayed to the target stations responsible for weather forecasting, making weather forecasts possible. The best prediction model still needs human input because a solution must be found. His prediction must be based on his awareness of model bias, teleconnections, pattern recognition skills, and model performance data. Using ensembles and model consensus aids in minimizing error and identifying the most likely result. Natural phenomena such as the unpredictable behavior of a location's atmosphere, the massive processing power needed to perform the calculations that characterize a location's atmosphere, measurement error related to initial conditions, and a lack of knowledge about atmospheric processes all contribute to forecasts losing accuracy and becoming more inaccurate. One of the many applications for weather forecasts is weather alerts, which are crucial forecasts since they support, improve agricultural output, and safeguard lives and property (Gelb and Offer, 2022).

10.0. Role of Weather Information in Farm Management

Along with native information dissemination organizations, mobile phones, radio, television, print media, and other ICTs platforms are all actively used in agriculture production. All of this information is useful to farmers when choosing crops, figuring out when to plant and harvest, setting up irrigation, reducing the effects of bad weather like frost, low temperatures, and heavy rains, applying fertilizer, scheduling the use of pesticides and fungicides, and tending to livestock (Menini and Carel, 2019). Specifically, the ability to obtain access to national government policies—known as natural capital—financial means of support open doors to interactions with lending institutions like microcredit; human capital in the process of education and certification that results in the creation of new capabilities; physical capital aids in infrastructure development; and forming relationships outside of one's immediate circle is a crucial component of social capital building.

11.0. Using ICT to Address Ecological Problems

The ability to conduct remote and online learning with mobile and web-enabled devices makes ICTs indispensable to the education sector. Infrastructure and transportation requirements in the educational services sector may decrease with the use of technologies for online and remote learning. By promoting e-democracy, wide-ranging economic opportunities, microfinance, community purchasing, and mobile phones and tablets with ICTs, the nation of Nigeria can see rapid economic growth. Adoption of ICT will greatly improve aspects of the health sector such as lowering infant and maternal mortality as well as combating the spread of malaria, HIV/AIDS, and other illnesses. Examples of these programmes include e-health, m-health, telecommunications, and others that support learning, interaction, and propagation of public health services. One way to reduce carbon emissions into the environment is to hold fewer physical meetings by using tele- and video-conferencing. Examples of these types of meetings are political gatherings and educational conferences that require attendees to travel from all over the Federation to a designated site. Smart meters can also be used to improve traffic monitoring, energy generation, and consumption efficiency (Wu and Raghupathi, 2023).

Nigeria's security status is a major cause for concern, along with other issues that are multifaceted in nature and scale and pose a threat to the lives and property of its citizens. It's time to acknowledge that incorporating new technologies into tried-and-true strategies to tackle vulnerability is necessary. Information sharing has been hampered by the bureaucratic, paper-based approach used to handle Nigeria's crime and security issues. To end the unstable condition, the nation has to use ICT more extensively. ICT, or automated identification systems of information (AFIS), can be applied in a variety of ways to either partially or totally eradicate crime in particular regions of the nation. For example, in the educational sector, a fingerprint authentication system can be used for JAMB assessment

authorization; in the political sector, an AFIS can be used for electoral operations. The usage of geographic data systems, web-based banking, mobile banking, and the International System for Mobile Device Communication are more examples (Wolfert, Ge, Verdouw and Bogaardt, 2017).

12.0. Advantages of ICTs to the Community's Ecosystem

Nigeria has embraced technology, especially when it comes to environmental monitoring and data collection. Technologies that improve environmental sustainability include communications hubs, wireless sensor networks, satellite images, and geographic information systems (GIS). Any nation that wishes to raise the standard of life for its citizens and boost its economy must understand that gathering useful information and making decisions that are relevant to the work at hand require the use of the right resources—tools, knowledge, and skills. Gathering and analyzing data is essential when using ICT to solve issues like flooding, pollution, poor sanitation, and land and water scarcity that impede economic development and the enhancement of people's quality of life. By evaluating topographical changes on formerly inhabited territory and looking at changes throughout time using retrograde satellite images, climate change forecasts predict rising sea levels. These components provide projections for the future expansion of a city as well as information into the growth and development of the city. When developing and evaluating programs, policymakers and the business community can effectively and affordably disseminate information about biodiversity to the end user (Kassahun, *et al.,* 2020). For example, the Combined Biological Diversity Examination Tool (CBDAT), which brings together globally renowned organizations like the United Nations Ecological Programmed, Wildlife Worldwide, and Preservation International and businesses like BP, Microsoft, the Bank of America, and Rio Tinto, makes a biodiversity database available to companies looking to incorporate eco-friendly practices into their projects. CBDAT could be used to assess the environmental impact of completed projects. Project planners can adjust their plans and take ecologically sensitive features into account when they have timely access to this information. It will be simpler for decision-makers and other interested parties to discover important data about the environment and endangered species from a single, reliable source.

The application of communication networks and detectors to optimize water use in a given region is a novel approach that can improve people's quality of life. Precision farming technologies use computers to collect data from remote sensors, like humidity and temperature sensors. This data is processed using a computer programme to determine the exact amount of water required to generate the highest possible crop output. This is an essential step for farmers who generally provide their farmland with regular

irrigation in order to achieve economic success. In order to effectively warn the public of impending disasters like heat stroke or tsunamis, advise them on what to do in the event of an emergency or disease, and explain the amenities that are available should they become ill or need assistance, national danger and catastrophe prevention programs should integrate ICT into every aspect of their operations. Preparation and adaptation mechanisms by the government and other stakeholders should be focused on the poor and disadvantaged people in the communities in order to protect and generate sustainable development that is impervious to storms. For already impoverished populations, climate change poses serious issues due to predicted temperature changes and sea level rises (Abdulkadir, Maryam, Muhammed, 2017).

13.0. Challenges to the use of ICT in Environmental Sustainability

The full utilization of ICT for agricultural sustainability faces hindrances, difficulties, and limitations that can be broadly categorized into these three areas:

1) Access, Availability, and Connectivity: It is a common misconception that science and technology are inherently gender, cultural, and linguistically neutral. But when it comes to application and use, it is clear that the design and implementation of technology typically mirror dominant—and even detrimental—paradigmas of society. For example, most manuals, Internet pages, and operating systems are written in only one of the four "world" languages (English, Chinese, German, and Japanese), rendering them incomprehensible to most people on the planet. Out of the approximately 1300 websites, only 3.22% were made in an African language. For the environmental sector to successfully and widely employ ICT, there must be greater material accessibility for the impoverished and those residing in remote areas. For bandwidth-intensive communication applications like video and flash technologies to remain viable options, countries need to modernize their ICT infrastructure. These communication infrastructures are not only costly to establish initially, but they also often sustain intentional and inadvertent damage, raising the cost of maintenance and repairs. Compared to rich countries, developing countries face greater risks to their phone, fiber optic, and energy networks, which could result in higher costs.

2) Information Gathering and Sharing: Among the primary functions of ICT are data collection, analysis, and dissemination facilitation. Once these tasks are completed, decision-makers have access to up-to-date and trustworthy data from the onset of their initiatives and programs related to agriculture. A more centralized approach should be taken by national governments, international organizations, and the commercial sector to address issues related to data collection and sharing. Nevertheless, there are already a number of factors that prevent information collecting and sharing as well as ICT from being

fully utilized for environmental sustainability projects. Additionally, because a large portion of the data is collected in the field and is not easily accessible to other practitioners, information needed for decision taken will also be incomplete as such recommendations for agricultural growth and development will be hamper.

3) Cost of ICT as a Barrier: One of the ICTs that could have the biggest impact on improving environmental sustainability is precision agriculture, but the high cost of the hardware, software, and infrastructure that comprise an ICT system severely restricts its widespread adoption. But as opportunities to use ICTs grow, especially in developing and impoverished nations, the world cannot wait for costs to come down because international financing and multistakeholder cooperation are expected to invest in ICT to force the cost downward and that is why they are crucial in this scenario.

Another obstacle to fundraising is the lengthy expenses that are often associated with ICT. Many of these projects need continuous funding, frequently because of the ongoing maintenance, repairs, and educational initiatives that go along with them. Because these projects need large financial commitments over months or even years, investors and donors are typically less eager to support them. The demand on the limited money available for such endeavors has increased due to the recent financial crisis and economic depression. On the other hand, long-term ecologically sustainable practices are becoming more and more important in the development process, as many prominent development economists have noted, and as such, they require more attention and support. Like all other countries, developing countries have budgetary limits and, in contrast to affluent nations worldwide, must priorities opportunity costs have based on these constraints. Not only is it harder for developing nations like Nigeria to draw in investments in order to reduce their budget deficits, but they also incur higher costs in the process. Therefore, the high cost of capital in least developed countries continues to impede the full use of ICT for development.

14.0 Sources of Information on Climate Change by Soybean Farmers

The soybean

1. Sources of Information through the Extension Agents
2. Radio as Sources of Information
3. Television as a Source of Information
4. Android Phones as Sources of Information
5. Farmers Association/Society as Sources of Information
6. Internet/Email as Source of Information
7. Personal Experience as Source of Information

8. WhatsApp Messages as Sources of Information
9. Agricultural Newsletters as a Source of Information
10. Face-Book Group as a Source of Information
11. Fellow Farmers and Relatives as Source of Information

15.0 Conclusion

The production of food crops is currently facing serious threats from climate change. Nonetheless, farmers' adaptation strategies to mitigate the effects of climate change largely determine how much of these effects are felt. Nigerian agriculture is already under a lot of strain from the country's expanding population, which puts further strain on the limited, frequently damaged soil and water supplies. To deal with rainfall unpredictability, farmers frequently practice crop rotation on the farm annually, plant crops at the appropriate time based on rainfall intensity, combine crop species, and use crop that are adaptive to the changing climate (Sime and Anne, 2019). They also frequently employ water harvesting techniques. Other approaches to addressing farmers difficulties resulting from climate change susceptibility include non-agricultural firms, livestock sales, food lending, food borrowing, and remittances.

Along with native information dissemination organizations, mobile phones, radio, television, print media, and other ICTs platforms are all actively used in agriculture production. All of this information is useful to farmers when choosing crops, figuring out when to plant and harvest, setting up irrigation, reducing the effects of bad weather like frost, low temperatures, and heavy rains, applying fertilizer, scheduling the use of pesticides and fungicides, and tending to livestock (Menini and Carel, 2019). ICTs undoubtedly contribute to climate change, as evidenced by the events of the last few years, not only through their causes but also through their impacts, but also by their involvement in environmental monitoring, mitigation, and adaptation. By promoting and supporting the development of more energy-efficient equipment, encouraging environmentally friendly design, and lowering the carbon footprint within its own sector, ICTs have the potential to greatly reduce the effects of climate change on the environment.

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