Influence of Digital Communication Agricultural Extension Services on Food Crops Production in Oyo State, Nigeria

Morufu Adewale SHITTU
LCU/PG/001266

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Certification

This is to certify that Morufu Adewale SHITTU with the matriculation number LCU/PG/001266 carried out this research work titled: Influence of Digital Communication Agricultural Extension Services on Food Crops Production in Oyo State in the Department of Mass Communication and Media Technology, Faculty of Communication and Information Science, Lead City University, Ibadan, Nigeria for the award of Doctor of Philosophy Degree (PhD)in Mass Communication and Media Technology, Faculty of Communication and Information Science, Lead City University, Ibadan, Nigeria and that this work has not been previously submitted.

Professor Taye Babaleye — **Date**
Supervisor

Dr.Yemi Oginni — **Date**
Head of Department

Dedication

This thesis is dedicated to the Almighty Allah.

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Abstract

Digital communication has the potential to revolutionise the entire agricultural sector, however, this potential has not been adequately taped by farmers to boost their productivity. This study investigated the Influence of digital communication agricultural extension services on food crop production in Oyo State, Nigeria. Diffusion of Innovation Theory, Unified Theory of Acceptance and Use of Technology, and Technology Determinism Theory guided the study. Descriptive survey research design was adopted. The sample size was 408 out of 5,250 registered food crop farmers in Oyo State. Google form titled Influence of Digital Communication Agricultural Extension Services Questionnaire (IDCAESQ) was used for data collection and administered through an online form. Descriptive statistics was used to analyse the research questions while Analysis of Variance (ANOVA) was used to test the hypotheses at a 0. 05 alpha level of significance. Findings revealed that cassava (40.2%), maize (27.7%), and yam (14.7%) were the three most cultivated food crops. Accessibility to digital communication extension services was poor ($\bar{x}$= 1.76±0.76); knowledge of digital communication agricultural extension services was good ($\bar{x}$= 2.39±0.68); utilisation of digital communication agricultural extension services was high ($\bar{x}$= 2.85±0.92); and constraints to utilisation of digital communication extension services were very severe ($\bar{x}$= 2.52±0.72). Accessibility of digital agricultural extension services ($F_{2, 405}$ = 30.962; P= 0.000), knowledge of digital agricultural extension services ($F_{2,405}$= 4.941; P= 0.008). Therefore, the study concluded that digital communication agricultural extension services significantly influenced food crop production in the study area. It was recommended that target-specific digital communication training that promotes capacity building be embarked upon through a community-based approach to improve the current knowledge of digital extension services among farmers. Furthermore, the government should embark on the provision of cheap, affordable, and efficient internet facilities that would enhance easy access to up-to-date agricultural innovations and essential extension services.

Keywords: Digital communication Agricultural Extension, Food Crop Production, Digital Agricultural Knowledge, Digitalisation, Community Based Approach.

Word Count: 297

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Chapter One

Introduction

1.1 Background to the Study

Over the past decades, Nigeria's domestic food production has consistently lagged behind the national food demand and this increasing pattern of annual food shortfall is a pointer to the fact that the nation may be on the threshold of food insecurity[1].The major agricultural agency of government in Nigeria notes abysmal deficit in domestic food crops production which failed to support the growing population's need for food, hence, the nation resorted to the importation of staple foods such as rice and wheat worth three to five billion dollars annually (Federal Ministry of Agriculture and Rural Development). The recurrent food shortage has been attributed to a number of factors like climate change, population growth, and failure of research scientists to improve crop yield, leading to increased input losses to the producers and marketers of food crops. Adding to these challenges is the structural problems such as poor agricultural policies, under-investment in modern agricultural practices, middlemen dominance in the supply chain of staple foods, digital divides, ineffective agricultural extension services, and poor communication systems[2,3,4].

Communication is the process of transferring information from sources to the recipient with the objective of forming the same meaning by both parties, and influencing behavioural modification[5,6].Communication is successful when information transmitted get to intended audience, and meaning is derived from semantics (dictionary meaning of words) and pragmatics (the way the words were deployed) by these intentional actors in the ongoing social interactions; that is, the recipients should be able to reconstruct the message as accurately as possible[7].Effective communication has been advocated as the fundamental tool

unique in creation and promotion of awareness of essential innovations in agricultural sector with the capability of birthing highly competitive industries with demonstrable sustainability both in management and productivity irrespective of geopolitical location[8,9,10]. Therefore, communication has been treated as a feature of social interaction adaptive to the senders and recipients with special focus on aspects of interactions that are communicative by design[7].

Communication is continuum and dynamic, with constantly changing processes geared towards adaptation to ever-changing societal interaction needs[6]. In recent decades, the need to reach a wider audience with appropriate information in record time necessitated the transition from analogue to digital communication system. The current unprecedented globalisation with mobility of people, products and services in an increasingly connected market and society require efficient, cost-effective, and timely dissemination of information; and this call for digitalisation of communication processes[8].

Digital communication refers to the transmission of information using digital signals over various communication channels such as the internet, computer networks, or wireless systems. It encompasses the encoding, transmission, and decoding of data in digital form, allowing for efficient and reliable communication between individuals, organisations, and devices[8,11]. It involves the exchange of data in the form of discrete signals represented by binary digits (0s and 1s), and this relies on digital devices like computers, smart phones to encode, transmit, and decode information. Digital communication has become ubiquitous in modern society, enabling instant messaging, email, social media interactions, and online transactions[12,13].

The evolving technological landscape has made digital communication an indispensable means of information exchange within organisations across all industries, and the agricultural sector is not left out. The creativity in this field has enhanced the knowledge and skills to tackle societal challenges, boost productivity, and ultimately achieved sustainability[11].

Interestingly, digital communication in agriculture have been deployed for continuous collection of various data from farmlands, machinery, weather variables, crops, animals, and other agricultural units, and are currently used to perform a wide range of tasks to make optimal decisions that can improve agricultural production[9,14,15]. The innovations and modern agricultural practices which are products of research are usually communicated to farmers, key actors in the agro-allied industries, and other key players of the agricultural sectors. Therefore, agricultural extension is the information conduit between research institutes and farmers and among farmers[16,17].

Agricultural extension is defined as the entire set of organizations that support and facilitate rural farmers who engage in food production by solving their problems through their activities of dissemination of information, teaching them skills and technologies to improve their productivity. It is a scheduled service involved in the transfer of research-based knowledge to the rural farmers with the intent of improving productivity. It also includes the components of technology transfer, comprehensive rural development goals, management skills, and non-formal education[18,19]. Nigeria probably has the most elaborate extension system in Sub-Saharan Africa with agricultural research systems that comprise of twenty-two commodity-based research institutes and two national extension institutes, over forty-five faculties of agriculture in conventional Federal, State and Private Universities, three Universities of Agriculture, and several Colleges of Agriculture as well as Polytechnics. It also includes three international agricultural research centres viz: International Institute of Tropical Agriculture (IITA), a sub-station of International Crop Research Institute for the Semi- Arid Tropics (ICRISAT) and a substation of the International Livestock Research Institute (ILRI) which collectively or individually serve as the fountain for agricultural innovations to both the public and private agricultural extension service providers [18,19,20].

Effective and cohesive extension services are some of the major components of agricultural development that empower farmers' analytical power and adaptation to the ever-changing production environments, markets, and technological conditions for increased productivity and profitability. Extension is concerned primarily with not just the adoption of relevant technologies, but the building of foundational knowledge and skills, promotion of localised evaluation and adaptation, and facilitation of farmers' experimentation and decision making[1,2,21]. The established methods of extension services, such as the Training-and-Visit or Farmer Field School, On Farm Adaptive Research systems, have not always achieved their desired outcomes in terms of technology adoption or livelihood improvements due to imperfect information flows between the stakeholders of a complex knowledge system which include farmers, input dealers, micro credit providers, food processors, marketers, extension agents, and researchers[22,23].

Extension service systems in Nigeria have been bedevilled by unidirectional; conveyance of technical information from researchers to the farmers without communicating farmers' knowledge to researchers; lack of essential facilities and equipment for extension agents and poor training of extension agents with consequent lop-sidedness and inefficient information dissemination to target farmers. Nevertheless, in the past, the establishment of Research-Extension-Farmer-Input Linkage System (REFILS), adapted from the training and visit (T&V) system had at one time facilitated communication processes among diverse stakeholders in the agricultural sector[19,24,25]. In spite of the advantages, the purpose which was to improve the translation of knowledge into agricultural productivity was not achieved due to the dynamics of constant evolution of communication channels between farmers and extension agents, the recent being the advent of digitalisation of communication systems[24].

Geographic accessibility was especially challenging under the Training and Visit systems where large demonstration plots were established to showcase effective and efficient farming

practices. Another point is the finite number of demonstration plots inherently limited to serve farmers farther from the demonstration plots' locations. This was further aggravated by shortage of manpower. It is noteworthy that regardless of the adopted strategy credibility, a short-staffed office will have limited interaction capacity within its intended target area, and this is obvious in the average extensionist-to-farmer ratio which is estimated to be as low as 1:3000 across Nigeria as against the recommended 1:500. Most Nigerian agricultural extension staff are spread too thinly to adequately serve their intended geographical areas using current strategies[2,25,26].

Recently, traditional extension delivery methods have metamorphosed to digitization of extension services which include the deployment of mobile phone-based platforms, internet connectivity, mobile applications, and customised smartphones to disseminate agricultural knowledge, innovations and practices to farmers in real time[27]. The traditional extension services are limited by lack of personnel, expertise, up-to-date information regarding marketing access, and adequate information storage; therefore, digitalisation of agricultural extension services can be crucial in overcoming these limitations through utilisation of various information and communication technology tools like Agri-based Apps, decision support systems, databases, cloud computing, artificial intelligence, robotics, among others[28]. The advent of digital technology has redefined the field of agricultural extension services as both farmers' and researchers' routine has been affected from both the economic and environmental perspectives[29].

Digitalisation, with respect to agriculture, is the socio-technical processes surrounding the use of varieties of digital technologies with the resultant impact on the social, economic and institutional contexts; spanning beyond singularity of business or entity, linking on- and-off farm data and managements tasks, which are enhanced by context and situation awareness, and triggered by real-time events[30,3132]. Therefore, digitalisation of agricultural extension can

be described as the adoption and utilisation of digital technologies, innovations, and data to transform business models and practices across agricultural value chain that address bottlenecks in agricultural productivity such as pre-planting activities, post-planting activities, postharvest handling, market access, finance, and supply chain management among others, so as to achieve greater income for smallholder farmers, improve food and nutrition security, build climate resilience farming systems, and expand inclusion of youth and women in modern agricultural practices [33,34,3536].

It has been argued that digitalisation reinforced current agricultural extension systems which were deemed unsustainable socially, economically, and ecologically, and favour the incumbent's key players which are the farmers, extension agents and researchers[37,38,39]. Thus, digitalisation could be viewed in the light of reinforcement with modern technology of the existing extension processes and systems in order to strengthen the intensity of linkages between and among components of the system, and the interaction and/or linkage process involves in communication and feedbacks among the actors- researchers, extensionists, input suppliers, marketers and others within the client system. The result would be evident in enhanced quality and efficient agricultural productivity, improved local participation and human resources development[40,41].

Agriculture remains the largest sector in Nigeria contributing an average of 24% to the nation's GDP over the past seven years (2013 – 2019)[42]. Agricultural production is broadly divided into four sectors in Nigeria- crop production, fisheries, livestock and forestry. Crop production remains the largest economic segment and it accounts for about 87.6% of the sector's total output. This is followed by livestock, fishing and forestry at 8.1%, 3.2% and 1.1% respectively[42].

Food crop production of the agricultural sector remains critical for the sustainability of livelihoods and creation of employment opportunities. Research have shown there are more

than 570 million smallholder farms worldwide and food production accounts for 28% of the entire global workforce[43,44]. In order to achieve the United Nation's Sustainable Development Goal of a 'world with zero hunger' target by 2030, more productive, efficient, sustainable, inclusive, transparent and resilient food systems is required[35]. Digital and technological innovations have caused several rapid transformations in the agricultural sector through innovative technologies like block-chain, internet of things, artificial intelligence, and immerse reality. In the food sub-sector, the spread of mobile technologies, remote-sensing services and distributed computing are already improving smallholders' access to information, inputs, market, finance and training. Digital technologies are creating new opportunities to integrate smallholders in a digitally-driven food crop production systems[45].

Digital agricultural extension has the potential to deliver economic benefits through increased agricultural food crop productivity, cost efficiency and market opportunities, social and cultural benefits through increased communication and inclusivity and environmental benefits through optimized resource use as well as adaptation to climate change[46]. The widespread access to mobile telephones has created new possibilities to support these information flow. In contrast to traditional mass media (such as radio, television, posters), mobile phones allow farmers to actively engage in more sophisticated information exchange through a two-way communication. Therefore, it is expected that more intensive use of modern ICT can help to improve the performance of agricultural extension[47,48]. Examples of new digital extension services include SMS-based market information services, call centres for technical farm advice, facilitation of farmer-to-farmer knowledge sharing via participatory video, or decision support systems implemented as smartphone apps[49,50,51].

Studies have shown that digital extension could mitigate information barriers by providing personalised advisory services on the types of crops to grow per season, the appropriate types and quantities of input to use, and the best timing for the different agricultural operations. It

could also provide farmers with new links to input markets by giving transparent information on market prices, reputed brands and their suppliers; increase farmers' bargaining power by providing more options for the purchase of inputs from different vendors[45,52]. Digital extension agents could provide varieties of advisory information services to the smallholder farmers, from pre-harvest to post-harvest stages activities; assisting farmers to understand and adopt agricultural best practices on crop selection, input management, land selection and preparation, harvesting, transportation, processing, packaging, and marketing of the agricultural produce. This could be communicated with the aid of digital tools like radio and television shows, mobile applications, digital video disks (DVDs), interactive voice response (IVR) technology, on such digital media platforms like WhatsApp, Facebook and Instagram among others, to promote and improve agricultural yields and encourage e-commerce participation value chains among farmers[35,53].

The global food crop production is geared towards the realisation of global food security which entails the provision of sufficient, safe and nutritive food to all people; and frames under food availability, food affordability, food accessibility, food utilisation and food stability[54]. These dimensions build the overall framework of the definition established by the Food and Agriculture Organization of the United Nations (FAO): "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritive food which meets their dietary needs and food preferences for an active and healthy life"[55]. Consequently, various international organisations and individual countries have embarked on aggressive food security crusades to remedy the situation in order to make food affordable to all, as availability and affordability of food is essential for the survival of humanity. In fact, the total wellbeing of human society significantly hinges on availability and affordability of nutritious foods[56,57].

The current global population growth and the soaring demand for food is placing unprecedented pressure on natural resources and food production. At the same time, food production, processing, and domestic and industrial wastes are putting unsustainable pressure on environmental resources. A critical challenge is to produce more food with the same or fewer resources[58,59]. Food production have experienced significant and considerable improvement in the past decades with consequent reduction in malnutrition rate across many nations[60]. However, in the last two years, there were substantial regional differentials that was evident especially among the developing nations of Asia and Africa[61,62]. According to the Global Hunger Index (GHI), sub-Saharan Africa (SSA) and South Asia (SA) have the highest 2017 GHI scores, at 29.4 and 30.9, respectively, which is closer to the alarming category (35.0-49.9)[61].

Despite the fact that most developing countries have abundant fertile arable lands as well as a conducive environment well suitable for food crop productions, they still rank lowest in the area of providing adequate nutritive food to their teeming population. Research has shown that between 720 and 811 million people are facing hunger globally and more than ninety percent of the hungry people in the world live in developing countries with a substantial proportion of uncultivated arable land[63]. Africa alone has around 60 million hectares of uncultivated arable land which constitute about 60 percent of the global total[57,64]. Estimation from the Food and Agriculture Organisation (FAO) has revealed that the number of hungry people on the African continent has risen by 47.9 million since 2014 and now stands at 250.3 million which represents about one-fifth of the population. Of these number, 15.6 million were found in Northern Africa and 234.7 million in sub-Saharan Africa[63,64]. Hence, the world is at a critical juncture to overcome the challenges of unending hunger, endemic food insecurity and all forms of malnutrition, as well as addressing the fragility of food systems with regards to the achievement of Sustainable Development Goal (SDG)[2]: “End hunger,

achieve food security and improved nutrition and promote sustainable agriculture" by 2030[63,64].

Globally, agricultural system is reported to have benefited from the application of innovative technologies leading to continuous improvement in the effectiveness and efficiency of food crop production. However, Africa, particularly the sub-Sahara African (SSA) nations have been significantly left behind in the upward trend of food self-sufficiency, due to a number of factors that constrain access to these innovative technologies with its characteristic low productivity[28,66,67]. The low agricultural productivity in the sub-Saharan African countries is evident in huge yield gaps between landraces, local varieties, which are predominantly cultivated by farmers and their improved varieties counterpart[68,69].

In order to reverse the low food crop productivity and unlock the food production potential in sub-Saharan African among farmers who are mostly smallholders, adoption of appropriate agricultural technologies is essential. The development and introduction of efficient and effective systems for agricultural technology transfer is crucial to accessing appropriate agricultural technologies including inputs like good quality seeds and planting materials[69], and the optimum involvement of the major actors along agricultural value chain depends largely on information sharing on all activities, from production through processing to marketing and consumption decisions[70].

The role of digital communication extension in agricultural development cannot be overemphasised, as it is the vanguard in the delivery of adequate information to farmers for increased food productivity. Globally, agricultural extension service delivery is concerned with the dissemination of research outcomes and improved agricultural practices to farmers. The efficiency with which these information and practices are conveyed to farmers to a large extent determines the level of agricultural productivity[29,71,72]. Low food crop productivity has been associated with inadequate farmer-extension service linkage, as efficient and effective

extension delivery service play a key role in transmission of innovative agricultural technologies and information as well as linkage between farmers and other actors in the economy[73].

The traditional extension services relied majorly on Training and Visit system which was grossly inefficient owing to the problems of geographical accessibility, shortage of trained extension agents, and poor funding among others[28,74]. Yet advisory services remain the major conduit for linkage and transference of necessary information, innovations, and technologies that will enables all actors in agricultural value-chain realise their full potentials by aligning scientific advances to the local agro-ecological and socioeconomic characteristics of the targeted areas which can be achieved with adoption and adaption of digital extension[69,70,75].

Digital communication agricultural extension and service systems are undoubtedly critical elements of technology transfer in agricultural systems and are vital determinant of agricultural productivity and competitiveness that could lead to increased food security and improved rural livelihoods[70]. In recent times, digital communication agricultural extension is a major conduit for pro-poor economic growth through provision of critical support services, which can enable rural communities to confront new challenges of transforming into global food and agricultural systems occasioned by the rise of supermarkets and the growing importance of standards, labels, and food safety[76,77].

Interestingly, studies have shown that digital communication agricultural extension could mitigate the differentials between potential and actual yields on cultivated lands by accelerating information transfer (bridge technology gap), assist farmers become better farm managers (bridge management gap), and enable research scientists establish tailored technologies to suit agro-ecological and resource circumstances of farmers. It could also play the crucial role of bridging communication gaps among farmers, agro-processors, researchers, traders, financial institutions and policymakers; the smallholder farmers being the focal point

in the bid to promote food security through increased food crop productivity[73,78,79]; and create vantage point to smallholder farmers for improved productivity and competitiveness, and enable rural farmers confront new challenges of transforming into global food and agricultural systems occasioned by the rise in supermarkets and the growing importance of standards, labels, and food safety[6,7,76,79,80].

1.2 Statement of the Problem

Extension communication services is critical to the systematic growth of agricultural sector and any factor that impedes its effective delivery will significantly impact the achievement of sustainable food crop production. However, it is regrettable that this vanguard of communication is hampered by myriads of constraints which may have resulted to the low impact and ineffectiveness that is currently observed in the sector. Inadequate funding and late disbursement of funds has been highlighted as one of the major constraints bedevilling the sector and this may be one of the major constraints hindering timely execution of agricultural extension service delivery in Nigeria[81,82,83]. Another factor that may play considerable role is the absence of proper legislation to guide the various agencies and institutions that render agricultural extension services across the country, and it is possible that lack of the basic principles and philosophies that guide agricultural extension delivery systems, may lead to outputs that abysmally fall short of expectations[81,84]. In addition, inadequate knowledge and poor technical know-how among farmers and agricultural extension communication agents may be another significant factor bedevilling the sector, as several studies have shown that many farmers and public extension agents do not have adequate basic information and communication technology (ICT) skills; thus, this may adversely affect the rate of utilisation of these facilities[85,86,87,88]. Furthermore, there have been increased rates of insecurity, farmer-herder clashes, and lack or poor digital communication infrastructure, especially among the rural dwellers and this may adversely affect both

accessibility and utilisation of digital communication extension services. Absence or dearth of agriculture extension officers is equally a major problems hindering dissemination of information to food crops farmer in the state.

Digital communication has the potential to revolutionize agricultural sector by harnessing the power of modern technology to reach farmers more effectively, disseminate timely information, facilitate interactive engagement, accelerate knowledge acquisition that ultimately improve food production and farmers' livelihood[35,36,89,90,91]. Majority of these studies were conducted in developed countries hence may not cover the peculiarities that may abound locally. Furthermore, the data available to the researcher revealed there is information dearth on the influence of digital communication agricultural extension services on food crop production especially in the Southwest Nigeria. It is on this note the researcher sought to investigate the influence of digital communication agricultural extension services on food crop production in Oyo State. the study also sought to examine the role of digital transfer of information on improved production of cassava, yam, maize, cowpea, rice, and vegetables.

1.3 Aim and Objectives of the Study

The aim of the study is to investigate the influence of digital communication agricultural extension services on food crop production in Oyo State, Nigeria. The specific objectives were to;

i. identify the major food crops facilitated by digital communication agricultural extension services in Oyo State;
ii. identify the extent of accessibility to digital communication agricultural extension services to food crop farmers in Oyo State;
iii. assess the extent of knowledge of digital communication agricultural extension services among food crop farmers in Oyo State;

iv. determine the extent of utilisation of digital communication agricultural extension services among food crop farmers in Oyo State;

v. ascertain the constraints to utilisation of digital communication agricultural extension services among food crop farmers in Oyo State;

vi. determine the influence of accessibility of digital communication agricultural extension services on food crops production in Oyo State;

vii. assess the influence of knowledge of digital communication agricultural extension services on food crops production in Oyo State; and

viii. evaluate the influence of utilisation of digital communication agricultural extension services on food crops production in Oyo State.

1.4 Research Questions

The following research questions will guide this study;

1. What are the major food crops facilitated by digital communication agricultural extension services in Oyo State?
2. What is the level of accessibility to digital communication agricultural extension services to food crop farmers in Oyo State?
3. What is the extent of knowledge of digital communication agricultural extension services among food crop farmers in Oyo State?
4. What is the extent of utilisation of digital communication agricultural extension services among food crops farmers in Oyo State?
5. What are the constraints to utilisation of digital communication agricultural extension services among food crops farmers in Oyo State?
6. What is the influence of accessibility of digital communication agricultural extension services on food crops production in Oyo State?

7. What is the influence of knowledge of digital communication agricultural extension services on food crops production in Oyo State?
8. What is the influence of utilisation of digital communication agricultural extension services on food crops production in Oyo State?

1.5 Hypotheses of the Study

The following null hypotheses were tested for the study;

$H_0$1: Accessibility to digital communication agricultural extension services has no significant influence on food crops production in Oyo State.

$H_0$2: Knowledge of digital communication agricultural extension services has no significant influence on food crops production in Oyo State.

$H_0$3: Utilisation of digital communication agricultural extension services has no significant influence on food crops production in Oyo State.

$H_0$4: Constraints to utilisation of digital communication agricultural extension services has no significant influence on food crops production in Oyo State.

1.6 Scope of the Study

The study is on digital communication agricultural extension services and food crops' production in Oyo State. The study is focused on all literate farmers in Oyo State that use digital communication extension services for the production of food crops and are registered members of All Farmers' Association of Oyo State. The major food crops focused in the study are yam, cassava, maize, cowpea, rice, and vegetables.

1.7 Significance of the Study

Digital extension is the crucial channel that bridges the communication gaps between farmers, agro-processors, research scientists, traders, financial institutions and policymakers. Thus, the study would help bridge the knowledge gap on the influence of digital extension on food crops production in Oyo State and serve as reference for further studies.

Extension agents could utilise the information from this study to design and execute extension service system that would efficiently diffuse valuable information on current agricultural practices to the clientele in record time; and such information could include disease outbreak and management strategies, prices of agricultural inputs and notable vendors, current market prices for agricultural produce and the available off-takers, among others. In addition, the current insecurity and farmers-herders' clashes have made digital agricultural extension a veritable for dissemination of modern agriculture information to areas had to reach due to insecurity.

The study would be significant to farmers as it would encourage the use of digital communication extension platforms to access relevant and timely information to enable farmers adequately plan production processes and make informed management decisions that would increase productivity and improve their wellbeing.

The findings from the study may be of significance to tech-savvy youths as it would reveal digitisation has made agriculture less laborious, lucrative, and interestingly easy to practice with little or no direct contact with farmland, thereby encouraging them to use their digital knowledge and skills to earn a decent living and making millions from agriculture, instead of engaging in cyber fraud.

The result from the study would also be of significance to policymakers as it could serve as bedrock for a well-planned and efficient digital extension programme that would facilitate the

dissemination of innovative technologies on food crops production from research scientists, and the adoption and adaptation by farmers.

The study would also contribute to the wealth of knowledge for consultation by the University students and scholars.

1.8. Limitation of the study

There was a delay in the responses from the farmers as the research had to provide incentives for them to fill out the questionnaire.

1.9 Operational Definition of Terms

Agricultural Innovations: The process whereby individuals or organisations develop new ideas, products or methods of improving agricultural productivity.

Digitalisation: This is the use of digital technologies to change business models, provide new avenue for revenue, and value-producing opportunities.

Digital Agriculture: This refers to agricultural practices that involve data collection, storage, analysis, and dissemination information in the form of electronic data to farmers along agricultural value chain.

Digital Communication: This is the electronic transmission of data, information, message using digital platforms such as email, Facebook, WhatsApp, Twitter, Telegram, Instagram, radio, television, et cetera.

Digital Extension: The process of using various platforms of the electronic media to transfer technologies to rural farmers. It also involves delivery of advisory services with the use of context-specific text messages to interactive voice responses (IVR), and smartphone applications that link farmers to multimedia advisory contents, farm inputs, and buyers.

Agricultural Extension Communication Services: This involves the use of modern technologies and innovations to offer technical advisory services like market prices of agricultural input, current prices of farm produce, modern farm practices, information on weather, and disease control, to farmers.

Digital Platforms: These include but not limited to mobile phone applications of the new media like WhatsApp, Facebook, Instagram, Telegram, global positioning system, e-wallet, among others.

Digital Technologies: These are electronic tools, systems, devices, and resources that generate, process, transmit or store data.

Food Crops: These include but not limited to staple crops cultivated for direct consumption like cassava, rice, yam, maize, beans, etc.

Improved Agricultural Productivity: This involve the enhancement of productivity through efficient utilisation of input resources to increase in yield, reduction in crop losses, and increasing the total factor productivity (TFP) -the efficiency with which agricultural inputs are converted to outputs.

Training and Visit Extension: This involve planned scheduled fortnight visits to farmers and training of extension agents and subject matter specialists with the aim of transferring appropriate information and technologies to farmers in the rural areas develop new ideas.

DCAES: This an acronym of Digital Communication Agriculutral Extension Services.

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Chapter Two

Review of Related Literature

This chapter reviews relevant literature related to influence of digital extension on food crops production in Oyo State. The chapter is reviewed under the following sub-headings:

2.1 Conceptual Review

2.1.1 Concept of Communication

2.1.2 Elements of Communication

2.1.3 Types of Communication

2.1.4 Forms of Communication

2.1.5 Concept of Agricultural Extension

2.1.6 Approaches to Extension Service Delivery

2.1.7 Agricultural Extension in Nigeria

2.1.8 Agricultural Extension and Modern Agriculture in Nigeria

2.1.9 The Concept of Digitalisation

2.1.10 Digital Agricultural Extension

2.1.11 Digital Communication Agricultural Extension

2.1.12 Importance of digital communication in modern agriculture

2.1.13 The Role of Digital Communication in Agricultural Extension

2.1.14 Tools and Technologies for Digital Communication in Agricultural Extension

2.1.15 Challenges and Barriers in Implementing Digital Communication in Agricultural Extension

2.1 Conceptual Review

2.1.1 Concept of Communication

Communication as the cornerstone of human social interaction, encompasses the exchange of information, ideas, and emotions through verbal, nonverbal, and written channels. It serves as the lifeblood of all relationships; facilitating understanding, cooperation, and connection across diverse contexts. From intimate conversations to global discourse, communication shapes our perceptions, influences decision-making, and drives societal progress[1,2]. Its significance lies in its ability to bridge differences, resolve conflicts, foster collaboration, and

ultimately enriching the fabric of society[3]. Studies have shown that effective communication is indispensable in navigating the complexities of personal, professional, and societal realms. In personal relationships, it aids in cultivating empathy, trust, and intimacy, thus, fostering harmonious connections. In the workplace, it enhances teamwork, productivity, and innovativeness which drives organizational success. Moreover, effective communication is pivotal in public discourse, enabling informed decision-making, democratic participation, and social change. Whether in interpersonal dialogues, business negotiations, or political debates, the ability to articulate thoughts clearly and empathetically is paramount for achieving mutual understanding and shared objectives[4,5,6,7].

The reasons for communication among people are diverse and dynamic, reflecting the complexity of human nature and context of interrelations. At its core, communication seeks to inform, educate, persuade, entertain, and build relationships. Studies have shown that through information dissemination, communication often influence attitude changes, inspire actions, and/or foster connections, thus, serving as a catalyst for individual growth, organizational effectiveness, and societal advancement. Hence, proper articulation of messages would promote active listening, nurturing meaningful dialogues, empower individuals with appropriate knowledge, bridge cultural divides, and cultivate a more inclusive and cohesive society[7,8].

Communication is not a one-way transmission but rather a dynamic exchange influenced by factors such as sender and receiver characteristics, message content, channels of communication, and contextual factors. The sender encodes a message, which is then transmitted through a chosen channel, decoded by the receiver, and potentially subject to feedback. Noise, both external and internal, can disrupt this process, impacting the clarity and effectiveness of communication. Also, other factors like cultural differences, power dynamics,

and emotional states of the actors (sender and recipient) can shape how messages are interpreted and understood[8,9,10,11].

2.1.2 Elements of Communication

The process of communication is a complex interplay of several elements that serve as linchpin for social interaction, shaping how information is exchange and meanings are inferred between individuals and/or groups. The dynamic process of effective communication involves key elements that collectively contributes to the seamless transmission and reception of messages. Starting with a sender who encodes ideas or thoughts into message, the communication journey encompasses the choice of channels, the decoding process undertaken by receivers, and the crucial feedbacks that close the loop. The presence of noise (internal or external) can influence the fidelity of the communication process[12,13,14]. The elements of communication process include the following;

i. **Sender:** The sender initiator the communication process by encoding ideas, thought or information into message. The sender not only consider the content but also the audience knowledge, perspective, and cultural background while tailoring the message for optimum reception.

ii. **Message:** This is the core content, and it encompasses emotions, ideas, information, or thoughts that (must be) drafted with precision to ensure clarity and understanding. The message can be verbal, nonverbal, or written. In verbal communication, verbal inflections and emphasis contribute to the message nuances; while in written communication, attention to tones and grammars are crucial.

iii. **Encoding:** This involves the translation of idea, emotions, or thought into format suitable for transmission. Effective encoding demands clarity to minimise the risk of misinterpretation by the receiver.

iv. **Channel:** Channel is the medium through which message is conveyed or transmitted to the receiver. Verbal channels such as face-to-face or telephone conversations offer immediacy, while written channels such as email or SMS allow for documentation and reflection.

v. **Receiver:** This is the intended audience of the message. The receiver understanding is influenced by their perception, attitude, opinion, level of education, communication skills, and other personal characteristics.

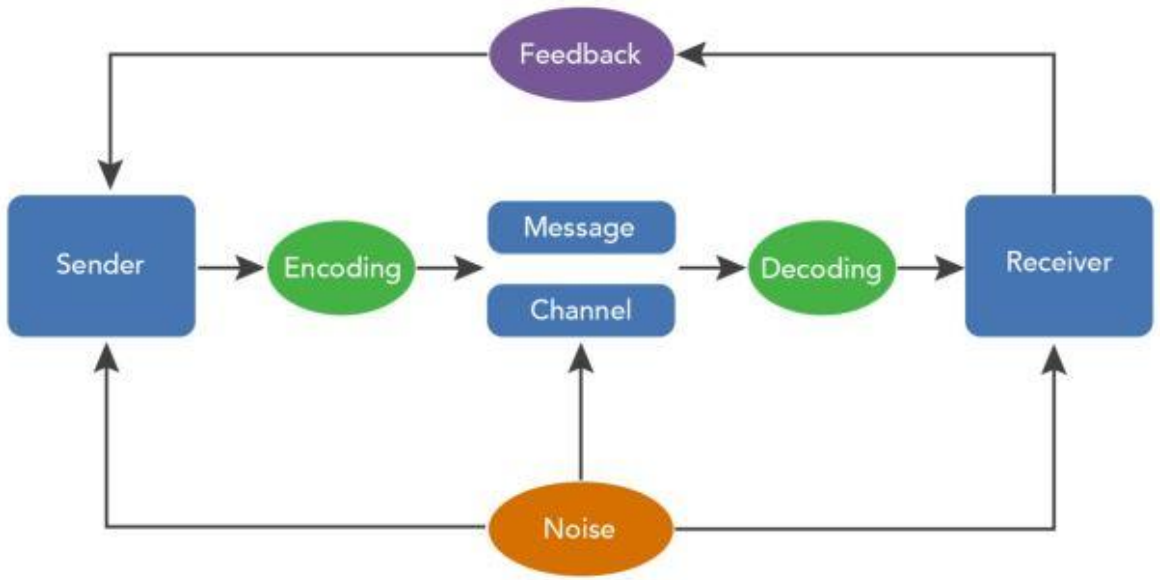
vi. **Decoding:** Decoding is the process by which the receiver interprets the encoded message. It involves extracting meaning from words, symbols, and nonverbal cues, and successful decoding occurs when the receiver's interpretation aligns with the sender's intended message, bridging the gap between expression and understanding.

vii. **Feedback:** This is the response provided by recipient of the message to the sender to analyse the efficacy of the message communication process. Feedback can take various forms, including verbal acknowledgment, nonverbal cues, or explicit responses. Effective feedback facilitates a dynamic exchange, allowing the sender to gauge the impact of their message and make adjustments for clearer communication.

viii. **Noise:** This refers to any interference, either internal or external, that may disrupt the communication process. External noise includes environmental distractions, while internal noise involves psychological barriers or emotional states that hinder accurate message reception. Thus, any element that distracts the communicators or disrupt the communication process at any stage can be refer to as noise.

ix. **Context:** The background on which communication is initiated, transmitted, and interpreted; and this influenced by cultural factors, social dynamics, and situational variables.

Effective communication transcends the mere transmission of information; it involves active listening, thoughtful expression, and a keen awareness of the nuances that colour our interactions. The intricacies of language, coupled with the subtleties of nonverbal communication, create a rich landscape where meaning is conveyed and shaped by the context and the participants involved[13,15].



Source: [14]
Figure 2.1: Communication Process

Communication plays a pivotal role in shaping perceptions, attitudes, and behaviours by influencing how individuals interpret information, form opinions, and make decisions. Through language, symbols, and narratives, communication constructs realities and influences how individuals perceive themselves, others, and the world around them. It shapes attitudes by framing issues, promoting certain values, and challenging existing beliefs. Moreover, communication serves as a catalyst for behavioural change, motivating individuals to adopt new habits, engage in social causes, or shift their perspectives. Whether through persuasive messages in advertising, educational campaigns, or interpersonal relations, communication has the power to sharpened societal norms, drive social change, foster empathy and understanding among diverse groups, and ultimately shapes the very fabric of society[4,9].

2.1.3 Types of Communication

Communication can be conveniently grouped into four different types, viz; verbal, non-verbal, visual, and digital communications[11,14].

1. **Verbal Communication:** Verbal communication refers to the transmission of information, thoughts, ideas, and feelings through spoken words. It involves the use of language, whether written or spoken, to convey messages between individuals or groups. Verbal communication encompasses various forms, including face-to-face conversations, phone calls, presentations, speeches, lectures, interviews, and discussions. Verbal communication is a fundamental aspect of human interaction, serving as the primary means through which people express their thoughts, emotions, needs, and desires[1]. It facilitates socialisation, collaboration, problem-solving, negotiation, and the exchange of knowledge and information across various contexts, from personal relationships to professional environments. In verbal communication, the sender (the person initiating the communication) articulates their thoughts using words, while the receiver (the person or audience receiving the message) listens and interprets the information conveyed. Effective verbal communication involves not only expressing ideas clearly and concisely but also engaging in active listening to understand the perspectives and responses of others[14]. Verbal communication can take the following forms;

❖ **Spoken Communication:** This is the most direct and immediate form of verbal communication, involving the exchange of information through spoken words. It encompasses vocalised conversations, speeches, presentations, and interviews. Spoken communication allows for real-time interaction, enabling individuals to express thoughts, convey emotions, and engage in dialogue with others. It relies on

verbal cues such as tone of voice, intonation, and emphasis to convey meaning and context.

- **Written Communication:** This involves the transmission of messages through written symbols, such as letters, emails, memos, reports, and texts. It offers the advantage of permanence and precision, allowing individuals to carefully craft their message and convey complex information in a structured format. Written communication is essential for documentation, record-keeping, and formal correspondence. It enables individuals to communicate across distances and time zones, facilitating asynchronous communication and collaboration[16].

2. **Non-verbal Communication:** Non-verbal communication is the transmission of information and messages through non-verbal cues rather than spoken or written words. It involves the use of gestures, facial expressions, body language, posture, eye contact, touch, and even the tone and pitch of one's voice to convey meaning and emotions. It can also play a crucial role in situations where verbal communication is not possible or where there may be language barriers[11]. Overall, understanding non-verbal cues is essential for effective communication and building strong interpersonal connections. Non-verbal communication often works in conjunction with verbal communication to enhance understanding and convey additional layers of meaning. Non-verbal cues include the following;

- **Body Language**: This is powerful non-verbal cue that convey meaning through physical movements and postures. It plays a significant role in interpersonal relations, influencing how messages are interpreted and understood. Body language includes a wide range of behaviours such as the use of posture, stance, and movement of the body to communicate messages. For instance, standing upright and leaning forward might indicate interest or engagement, while crossed arms can signal defiance, defensiveness or disagreement.

- **Gestures:** This involves physical demonstrations like hand movements, arm movements, and other bodily actions that convey meaning or emphasize verbal communication. For example, waving to say hello, nodding to indicate agreement, or pointing to indicate direction.
- **Facial Expressions:** These are expressive changes in facial muscles that convey wealth of information about a person's emotions, intentions, and attitudes. From a subtle twitch of the lips to a broad grin or furrowed brow, facial expressions provide valuable insights into an individual's inner state. The human face is incredibly expressive and capable of conveying a wide range of emotions such as happiness, sadness, anger, fear, surprise, and disgust. Facial expressions often cut across cultures, making them a veritable form of non-verbal communication. Smiles, frowns, raised eyebrows, and narrowed eyes can convey a spectrum of emotions, from joy and excitement to anger and frustration.
- **Eye Contact:** Eye contact is a key aspect of non-verbal communication, serving as a means of establishing connection, conveying interest, and regulating conversation. It involves the mutual gaze between individuals, where one person looks directly into the eyes of another; which could signal attentiveness, confidence, sincerity, and receptiveness that foster trust and engagement in interpersonal interactions. It can also facilitate social bonding and rapport-building, fostering a deeper level of socialisation, connection and mutual understanding. The connection fostered is particularly important in interpersonal relationships, business negotiations, and public speaking engagements, where trust and credibility are paramount.
- Personal space and proximity (Proxemics): This refers to the study of spatial relationships and the use of physical distance to communicate messages. It explores how individuals perceive, use, and interpret personal space in social interactions, and how it influences their comfort level, communication dynamics, and interpersonal

relationships. It involves the concept of personal space, which varies across cultures and individuals. Proxemics influences social dynamics, intimacy levels, and power dynamics in interpersonal interactions[1]. It varies in size and shape depending on cultural norms, social context, and individual preferences. Personal space can be divided into several zones, including intimate space, personal space, social space, and public space, each with its own rules and expectations. Intimate space is the zone closest to the body, and typically reserved for close friends, family members, and romantic partners; personal space extends beyond intimate space and is used in interactions with acquaintances, colleagues, and casual acquaintances; social space encompasses larger distances suitable for formal interactions such as business meetings or public gatherings; and public space refers to the vast distances found in public settings, such as parks, streets, or auditoriums[1].

3. **Visual Communication:** Visual communication is the transmission of information and ideas through visual elements such as images, graphics, charts, diagrams, symbols, and videos. Unlike verbal communication, which relies on spoken or written words, visual communication uses visual stimuli to convey messages, concepts, and data. It is an essential tool in the fields of advertising, marketing, graphic design, education, journalism, and data visualization[11]. It can be used to inform, persuade, entertain, or inspire audiences, making it a very effective means of communication in both digital and print media. Components of visual communication include the following;

- **Infographics:** The are visual representations of data, information, or concepts designed to convey complex ideas quickly and clearly. They combine text, graphics, and imagery in a visually appealing format, making it easier for viewers to understand and retain information. Infographics are widely used in various fields such as agriculture, marketing, education, journalism, and business to present key findings, statistics, or processes in a concise and engaging manner. By compressing large

amounts of data into easily digestible visuals, infographics help viewers grasp key insights and trends at a glance. This makes them particularly useful for presenting research findings, survey results, or statistical analysis in a format that is accessible, understandable, and appealing. The incorporating icons, illustrations, and diagrams, infographics can bring concepts to life and enhance understanding. Their eye-catching design and informative content make them valuable assets for content marketing, helping organizations attract and engage their target audience effectively[14].

- **Charts and Graphs:** These visual tools used to represent numerical data and trends graphically, such as bar charts, line graphs, pie charts, and scatter plots, among others. They provide a visual summary of numerical data, making it easier for viewers to interpret trends, patterns, and relationships, are commonly used in fields such as business, science, economics, education, and agriculture to illustrate data-driven insights and support decision-making.
- **Videos and Images:** These are visual tools capable of evoking emotions, capturing attention, provoking thought, and inspire action, making them highly effective for conveying messages and influencing perceptions. Through the combination of visuals, audio, and motion, videos bring stories to life and create immersive experiences for viewers. Images such as photographs, illustrations, and graphics, also play a crucial role in visual communication. Images can be used to enhance presentations, illustrate concepts, or evoke a desired mood or atmosphere.

4. **Digital Communication:** Digital communication refers to the exchange of information, data, or messages using electronic devices and digital technologies. It encompasses various forms of communication conducted through digital platforms, networks, and mediums, such as the internet, email, social media, instant messaging, video conferencing, and mobile communication devices. Digital communication allows individuals, organizations, and communities to connect, interact, collaborate,

and share information across geographical distances quickly and efficiently. It has transformed the way people communicate, enabling real-time communication, multimedia content sharing, and global connectivity. Digital communication also encompasses the transmission of digital signals and data packets over electronic networks, including wired and wireless technologies, to facilitate voice, text, video, and multimedia communication[13,17,18]. Forms of digital communication include;

- Electronic mail (Email): This is one of the widely used forms of digital communication for exchanging messages electronically. It offers a convenient and efficient way for individuals and organizations to communicate with one another, regardless of geographic location or time zone. Email allows users to send text-based messages, documents, and multimedia files to one or more recipients over the internet. One of the key benefits of email is its asynchronous nature, which means that users can send and receive messages at their convenience. This flexibility enables individuals to communicate across different time zones and schedules, making email an essential tool for conducting business, coordinating projects, and maintaining personal connections. Email also provides a record of correspondence, allowing users to track conversations, reference previous messages, and store important information for future reference. This archival feature is particularly valuable for business communication, legal documentation, and project management[13].
- Social media: Social media platforms have transformed the landscape of digital communication, enabling users to connect, share, and engage with others in real-time. From Facebook and Twitter to Instagram, TikTok and LinkedIn, social media has become an integral part of everyday life, shaping how we communicate, consume information, and interact with the world around us. Among the numerous benefits of social media is its ability to facilitate connections and build communities. Users can connect with friends, family, colleagues, and like-minded individuals from around the

globe, fostering relationships and expanding their social networks. Social media platforms provide a space for users to share updates, photos, videos, and thoughts, allowing them to stay connected and engaged with others. It also serves as a powerful tool for communication and information dissemination. Users can share news articles, blog posts, videos, and other content with their followers, sparking conversations, debates, and discussions on various topics. Social media platforms also enable users to participate in online communities, join groups, and follow pages dedicated to their interests or hobbies[17,19].

- Instant Messaging: (IM) platforms enable users to exchange text-based messages in real-time, facilitating quick and convenient communication with individuals or groups. From WhatsApp and Facebook Messenger to Slack and Microsoft Teams, instant messaging has become an essential tool for personal and professional communication in today's digital age. Unlike email, which may have a delay in delivery and response, instant messaging allows users to communicate in real-time, making it ideal for quick conversations, urgent requests, or informal exchanges. This speed and efficiency enhance productivity and collaboration in both personal and professional settings. Users can create group chats, share multimedia files, and use emojis, stickers, and GIFs to express themselves and add personality to their messages. In addition, instant messaging apps often offer features such as voice calls, video calls, and screen sharing, allowing users to communicate in multiple formats and mediums[20].

2.1.4 Forms of Communication

Communication occurs within various contexts, each characterized by unique dynamics, purposes, and channels. In order to effectively communicate and navigate diverse interactions in personal, professional, and societal settings, proper contextual understanding of communication is essential[2].

1. **Interpersonal Communication:** This refers to the exchange of messages between individuals in face-to-face or mediated settings. It encompasses verbal and nonverbal interactions, including conversations, gestures, and expressions. Interpersonal communication plays a vital role in building relationships, resolving conflicts, and fostering connections. Effective interpersonal communication involves active listening, empathy, and mutual understanding, enabling individuals to express themselves authentically and connect with others on a deeper level. Whether in personal relationships, friendships, or professional collaborations, interpersonal communication shapes our interactions and influences our perceptions of people and situations[2].
2. **Organisational Communication:** Organisational communication encompasses the exchange of information, ideas, and feedback within formal structures such as businesses, government agencies, and non-profit organizations. It involves various channels, including meetings, emails, memos, and reports, to facilitate coordination, collaboration, and decision-making. Organisational communication plays a crucial role in conveying goals, policies, and expectations to employees, promoting transparency, and fostering a positive organizational culture. Efficient deployment of organizational communication enhances productivity, employee engagement, and organizational performance, contributing to overall success and sustainability[22,23,24].
3. **Intercultural Communication:** Intercultural communication involves interactions between individuals or groups from different cultural backgrounds. It requires awareness, sensitivity, and adaptability to navigate cultural differences in communication styles, norms, and values. Intercultural communication plays a critical role in fostering proper understanding of cultural diversity of our modern society. By bridging cultural divides and promoting intercultural competence, individuals can build trust, resolve conflicts, and collaborate across cultural boundaries effectively[25,26].

4. **Mass Communication:** Mass communication involves the dissemination of messages to large, heterogeneous audiences through mass media channels such as television, radio, newspapers, and the internet. It encompasses various forms of media content, including news, entertainment, advertising, and public relations. Mass communication sharpens public opinion, influences social norms, and facilitates cultural exchange on a global scale. Mass media platforms such as radio, television, mobile phone, et cetera, serve as powerful tools for information dissemination, advocacy, and social mobilization, shaping public discourse and driving social change[27,28].
5. **Digital Communication:** These encompasses the exchange of messages through digital platforms and technologies, including email, social media, instant messaging, and video conferencing. It enables individuals to connect and communicate in real-time, transcending geographical barriers and time zones. Digital communication has transformed how we interact, work, and socialise, offering new opportunities for collaboration, creativity, and engagement. However, it also presents challenges such as information overload, privacy concerns, and digital divide disparities. Effective digital communication requires digital literacy, cybersecurity awareness, and ethical considerations to ensure responsible and meaningful interactions in the digital age[29,30,31].

2.1.5 Concept of Agricultural Extension

Globally, agriculture has metamorphosed from production driven to market driven with high demand for innovative information and technologies that create vantage to farmers, vendors of agricultural inputs, product processors, off-takers, research scientists, and other major actors in agriculture value-chain; and agricultural extension and advisory board has since inception been saddled with the responsibility of information dissemination among the major players in the sector[32,33]. Agricultural extension has a venerable, albeit largely unrecorded,

history. It is a significant social innovation, an important force in agricultural change, which has been created and recreated, adapted and developed over centuries.

Its evolution extends over nearly four thousand years, although its modernity is largely a product of the past two centuries. Today, the organizations and personnel that engage in agricultural extension encompass a diverse range of socially sanctioned and legitimate activities which seek to enlarge and improve the abilities of farm people to adopt more appropriate and often new practices and to adjust to changing conditions and societal needs[34,35,36]. The goals of extension include the transfer of knowledge from reputable sources such as subject matter specialists and research scientists to farmers, playing advisory role to farmers by providing assistance during decision making process, and educating farmers to clarify and prioritise their goals by setting realisable targets that stimulate desirable agricultural growth thereby empowering farmers to maximise their potentials[37,38,39].

The recent sustained exponential population growth and constant shrinkage of land-based resources due to population pressure, declining agricultural productivity due to natural resource degradation exacerbated by global warming, and high competitiveness of agricultural produce in the international markets, have made agricultural transformation expedient to boost food production in order to address the emerging challenges of food insecurity, hunger, and malnutrition as well as the improvement of economic and livelihoods of farm families[32,39]. Agricultural extension along with innovative research and timely dissemination of information and technologies remains crucial for global agricultural productivity and sustainable food systems[40].

Optimal contribution by the major actors along agricultural value chain depends largely on efficient information sharing on all agricultural activities, ranging from production to processing, transportation, storage, marketing, and consumption choices[41]. It is therefore

apparent that intensive agricultural systems aimed at improving agricultural productivity is in dire need of timely innovative information, a fundamental requirement, necessary for the adoption and adaption of cost effective, high yielding, economically viable, and sustainable agricultural production and marketing innovations and technologies by farmers[32,42,43,44].

Globalisation and modernisation have pressured agricultural extension to undergo several transitional reforms in order to meet with current realities that extend beyond the transfer of innovative ideas, new technologies and increased productivity, to include the need to;

i. view agriculture as business geared towards rural development that provides both on-farm and non-farm employments, business development and agripreneural services appropriate to scale, as well as resources and capacities to facilitate the creation of producer organisations within each farm;
ii. assist farmers to have better understanding of market and its attendant requirements, linking farmers to both local and international market to promote their competitiveness;
iii. mitigate farmers' vulnerability and promote production techniques adaptable to microclimate that enhance their livelihood resilience;
iv. provide timely and seasonal information regarding inputs and outputs market services that expose farmers to a variety of alternatives and choices of input vendors;
v. promote capacity building of extension agents through regular training to keep abreast with current realities, thereby strengthening the innovative processes that enhance the linkages between farmers and other key actors of the agriculture value chain;
vi. support institutional and organisational cohesion to enhance social capital and collective bargaining of farmers through vantage competitiveness; and

vii. undertake the facilitation, brokering and coaching of different actors to improve market access, deal with endemic but changing patterns of risks and ensure the protection of environmental resources.

The myriads of challenges that barrage agricultural sector requires adequate and timely information to overcome Agricultural extension and advisory services were established to ensure adequate flow of information pertaining to production, processing, storage, marketing, consumption, weather and other related knowledge to farmers[42,45]. Agricultural extension is therefore, the information conduit between research institutes and farmers and among farmers as well[46]. Hence, extension service can be described as an out-of-school educational programme designed to help farmers solve their day-to-day challenges, for the improvement of their overall wellbeing[47].

A broader description of extension is given as the "systems that facilitate access of farmers, their organisations and other markets actors to knowledge, information and technologies; expedite their interaction with other partners in the research, education, agribusiness, and other relevant institutions; and assist stakeholders develop their own technical, organizational and management skills and practices that improve agricultural productivity and profitability"[32]. The definition implicated extension as the tool for promoting capacity building in good agricultural practices, creating linkages among the major value chain actors (farmers, inputs vendors, processors, and marketers); stimulating the adoption and adaption of innovations and technologies; improving economic and livelihoods of farmers; and facilitating agricultural and rural development programmes[48].

Since agricultural productivity is highly information sensitive and access to information a pre-requisite and valuable resource for agricultural development, extension services therefore, facilitate the dissemination of up-to-date agricultural research findings to farmers, creating

platforms for leverage through analytical capacities, managerial and communication skills improvement for optimal productivity[32,48]. Farmers therefore need appropriate information to explore opportunities in real time, raise awareness about potential negative impacts of disease and weather conditions, and sustained productivity and profitability of their farms. These have birthed the need for research and innovation strategies that promote the development of resilient and farmer-driven extension systems that improve efficiency; extension systems that is pluralistic and market driven[49,50,51].

Agricultural extension has been the major undertakings of the government, with Ministries of Agriculture having a de facto monopoly over the provision of extension and advisory services to farmers[46]. Sadly, though, many governments have decimated their budgetary allocations toward agriculture, making the delivery of extension services to farmers more difficult[48]. The uneven access to agricultural extension services by smallholder farmers due to limited public extension support is, therefore, one of the key factors hampering their potential to commercialisation. In addition, inadequate access to extension services and appropriate agricultural information has further worsen farmers' ability to address challenges and optimize the path to efficient productivity[52,53].

2.1.6 Approaches to Extension Service Delivery

Historically, agricultural extension services have assisted both rural and urban population to improve farming methods and techniques, increase production efficiency and income, and improve standards of living through a wide range of educational procedures and programmes[54]. It plays an important role in the advancement of innovations and development in rural areas[49]. Agricultural extension serves as the motivating force for enhanced agricultural productivity in many developing countries, and the efficacy of any extension system in fostering capacity building, technological adoption, and ultimate improvement in

agricultural output depends on key factors such as the extension delivery approaches, the governance, capacity, and management structures of extension system. Also, included are the underlying contextual factors such as the policy environment, market accessibility, characteristics of beneficiaries and the prevailing weather conditions[49,55].

Extension approaches refers to the procedure through which knowledge and skills are disseminated and/or shared with farmers[56]. These approaches include but not limited to individual farm visits approach, training and visit approach, farmer field schools' approach, farmer to farmer approach, participatory extension approach, commodity approach, transfer of technology approach, farmer-based extension organisations, information and communication technology approach, among others[57,58,59,60].

1. **Individual Farm Visit Approach:** The individual farm visit was designed to identify and analyse the major problems affecting an individual farmer and to proffer advice on the best possible actions, and this has been considered critical for effective extension service delivery and development[49]. Extension agents might as well visit an individual farmer to learn about innovative farm practices or research conducted by a particular farmer, relate with other members of the farm household that might have different perceptions of problems that require different potential solutions, encourage participation of other members of the family in acquisition and dissemination innovative technologies, skills and information[49,61,62]. The approach is especially effective when the extension agent is required to provide on-the-spot advice during emergencies such as diagnosis of crop, fish, or animal disease outbreaks at the farm of a particular farmer[49]. Although individual farm visit approach is very effective in the establishment of extension-farmer rapport, trust and confidence building, it is rather capital intensive that required careful and extensive planning before execution; it is also not effective in reaching out to larger number of farmers as it was specifically designed for one-on-one contact. In addition,

extension agent risks arousing resentment among the farmers if a single farmer is frequently visited[60,63,64].

2. **Training and Visit (T&V) Approach:** This was the evolution of extension services. The T&V system was a donor-driven approach which concentrated on knowledge and information transmission through a top-bottom, one-size-fit-all, single line of command approach[60]. Regular fortnight training of extension workers and consistent biweekly farm visits was adopted on the premise that methodological information to enhanced productivity was deficient among farmers hence the need to equip farmers with contemporary practical, cost effective, high-yielding skills, technologies, and market information[65,66]. The subject matter specialists usually train extension workers on modern yet comparatively cost-effective, easy to practice innovations; the extension workers thus advanced the acquired knowledge to farmers and/or farmers' group. Thus, among the advantages of T&V approach were frequent farm tours, constant training of extension workers, and a touch of competence and professionalism by extension workers[49]. However, it was limited by its top-down nature, rigidity, and financial unsustainability due to high-cost implication of continuous training and management of large number of personnel involved[59,66,67].
3. **Farmer-to-Farmer Extension Approach:** This is a complementary approach that involves farmers sharing knowledge of agricultural innovations and technologies within their communities, and provision of training to farmers by farmers[68]. The knowledge and information delivery are usually from farmers to farmers through lead farmers and/or farmer instructors which are mostly nominated and named principal, model, master, or lead farmer based on their agricultural proficiency and productivity, and at times they are called "farmer promoters" or "farmer trainers" a designation for their advocacy and training prowess and/or achievement[69]. Farmer-to-farmer extension approach is built on the premise that farmers disseminate innovations more efficiently and effectively amongst

their peers compared to a visiting extension agent. The spread of the innovations is usually at no/or minimal costs, the degree of trust and confidence among farmers are high, and there are apparent greater chance of sustainability of adopted innovations and technologies among farmers[68,70,71]. Among the drawbacks of farmer-to-farmer approach is conflicts of interest where extension agents view farmer-trainers as rival or substitute instead of complement their services; poor farmer-trainer performance due to lack and/or inadequate coaching and technical backstopping costs of training farmer-trainer could result to discontinuance following project termination[72].

4. **Farmer Field Schools Approach:** The approach was developed by FAO as alternative to the top-down extension method of Green Revolution which failed to work in situations where more complex and counter-intuitive problems such as pesticide-induced pest outbreak existed[73]. Farmer Field School (FFS) is a participatory approach that involved teaching, scientific research and development, and diffusion of innovations based on adult-learning pragmatic principles[68]. In this approach, a group of 20-25 farmers meet weekly in a local field setting under the guidance of a trained facilitator to observe and compare two plots, one of which is the local conventional method while the other is the experimental plot, and determine which could be considered "best practices" [73,74]. The adopted learning-by-doing approach promotes farm-based experimentations, group organisation, and decision-making thereby increasing the likelihood that farmers will eventually adopt and adapt the improved practices[49]. Farmers with exceptional performance during the season are trained to assume the role of Farmer-trainers and offered accredited support like teaching material to serve as facilitator the next farming season. Although the approach was found effective and efficient in dissemination of innovative best practices, the costs implication on training the facilitators and infrastructure procurement, as well as time investments could drastically affect farmers' commitment[75].

5. **Participatory Extension Approach:** This involves participatory learning process in which farmers' residents in the community or village collectively engage in identification, prioritising, and analysing problems, as well as making action plans to address the problems, implementing and monitoring activities through members of village organising committees[76]. The approach assumed that farmers have much indigenous knowledge regarding food production from years of experience, but their productivity could be much improved by participatory learning and knowledge sharing[58,60]. There have been a lot of developments in the use of participatory approach, some of these focused more on problem diagnosis, others are more oriented towards community empowerment, while some concentrated on facilitating farmer-led research and extension. In all the adopted methods, the design always involves professionals in different fields listening to-, learning from-, and guide farmers through process of problem solving[61,77]. Some of the methods deployed in participatory approach include;

   i. **Rapid Rural Appraisal (RRA):** An efficient method for extracting information and data from rural communities and individuals for use by outsiders. It involves systematic but semi-structured activities by multidisciplinary team designed to obtain information and formulate hypotheses about rural life through the use of interviews, cross-checking available written information/data, direct observations, walks, focus group interviews among others. RRA has the advantage of being comparatively quick, and very useful for familiarization and perhaps ground proofing/confirmation of more detailed analyses. However, it lacks precision and its value is heavily dependent on judgment of outsiders, individuals or groups[78].

   ii. **Participatory Rural Appraisal (PRA):** It is similar to RRA except that the design enables the community to community participates in the information gathering and interpretation processes. It has been described as "a family of approaches and methods that enables rural people to present, share, and analyse their knowledge of

life and conditions to plan and act"[79]. The community is fully involved in providing information, identifying and analysing problems, priorities, developing solutions, implement and evaluate impacts of the solutions. The method assists communities identify the needed skills for controlling their own developmental activities for their profits using indigenous resources and knowledge. The information is always elicited by the locals and used by the locals, and the applications include natural resource management, agricultural development programmes, poverty and social programmes, health, and food security. The key tenets of a PRA are participation, teamwork, flexibility, and triangulation to ensure that information is valid and reliable[80].

iii. **Participatory Needs Assessments (PNA):** Farm households and communities are involved and must be fully involved in the assessment of the prevailing needs and constraints, and the accuracy in identifying their needs, plan, and secure commitment necessary for implementation depends on total inclusivity of the community residents. Following a process of participation of all interest groups, both formal and informal organizations would lead to definition of priorities and provision basic information from which community action plans can be prepared.

iv. **Participatory Monitoring and Evaluation (PME):** This is process by which the community continually monitors the status of action plan implementation, periodically conducting a participatory evaluation exercise to determine the impact of the actions implemented. This helps the community to assess the performance, share results and experiences with others, learn from achievement and mistakes, and develop capacity for better performance in future. In PME, the communities define the performance indicators for judging the success or failure of the actions, the lessons learnt and the overall project impact.

v. **Participatory Learning and Action (PLA):** Participatory Learning and Action is participatory development process in which facilitators, change agents and extension

staff engage rural communities. This process starts with the collection, exchange and analysis of local data, and continues through a long distance and intense learning phase and eventually ends with the proactive community member taking action to further their own development. The method is presumed to create greater sense of individualised and collective ownership through active participation, empowerment of farmer through new skills and knowledge acquisition, and enhancement of self-decision-making capabilities which are important for sustainable rural development.

In participatory extension approaches, extension workers offer practical information and technical know-how that is convenient in resolving the recognized problems as identified by farmers, and prioritised based on their hierarchy of needs. Farmers' involvement in the identification of their needs and constraints necessitates actual sense of possession and responsibility, which eventually motivates the farmers to form community extension organization geared towards harnessing local resources for community-based solutions. It therefore demands that extension workers should possess good analytical, pedagogical, and facilitation of skills to assist farmers in the implementation of the action plans[60].

6. **Commodity-Based Approach:** The approach focuses on a single crop or an aspect of farming, and it generally addresses everything from extension and research to input supply, marketing and prices to increase production in the selected crop[81]. The production scheme is vertically combined from the contribution source to the knowledge acceptance and selling of the harvest[59]. Farmers produce a particular amount and value of a crop, livestock, or livestock products, and trade with the firm to which they are affiliated. In response, the firm delivers inputs, credit and information amenities, excellent supervision, and marketing facilities. For sustainability, enhanced and mutual flow of information between administration, extension workers, and farmers must be established which serve as a lifeline for creating profitable association that would be valuable and beneficial to all

stakeholders[60,61]. Commodity-based extension is sometimes referred to as contracted farming and its benefits comprise great earnings from specialised crops or livestock, improved farmers' revenue, enhanced practical and decision-making abilities, and reduced fears and worries due to the availability of standby off-takers. It also offers small and intermediate farmers the opportunity to ambitious and lucrative markets to farm resources (inputs and outputs of all kinds), skills, and professional guidance[60,82]. However, the planning is often controlled by the commodity organizations whose interests might not match farmers'. In addition, the approach typically does not provide support to other aspects of farming outside their scope[81].

7. **Cost-Sharing Approach:** The approach was introduced in a bid to stabilize the source(s) of financing agricultural technology transfer for improved and expanded extension activities and geared toward a more flexible and pluralistic, demand-driven strategy where all the stakeholders partake in the overall extension activities. Cost-sharing extension is believed to foster private cooperative initiatives, and encourage co-operative ventures by farmers, enhance the co-ordination of public-private extension services and increase private sector participation in extension and/or full privatisation of the public extension systems[83]. Proponents of the approach assumed that cost-sharing with local people (who do not have the means to pay the full cost) will promote a programme that is more likely to meet local situations and make extension agents more accountable to local farmers. Its purpose is to provide advice and information to facilitate farmers' self-improvement[83,84].
8. **Transfer of Technology Approach (TOT):** The approach depends greatly on direct perception of knowledge transmissions, such as the transfer of modern innovations and information produced by experts, scientists, and other specialists, and conveyed to farmers by agricultural extension workers to enhance productivity through a top-down information dissemination mechanism[85]. The approach was considered on the supposition

that farmers are void of practical understanding for growing yield, therefore the answer was to offer them up-to-date practical innovative information. TOT was later developed to include response schemes with farmers and scientists allowing extension workers deliver responses and feedbacks to the investigative teams on the requirements of the farmers ensuring the resolutions of particular issues and challenges as demanded by[49,82]. Transfer of technology still remains popular among the smallholder farmers in developing countries[85,86,87].

9. **Farmer-Based Extension Organisations:** This is a demand-driven extension system that is directed, operated, and financed by farmers themselves, and generally operated under different management structures and with different sources of financial support[80]. The extension approach is majorly practiced among large-scale, commercial farmers with better leadership and organisational structure, better technical skills, as well as strong economic powers. It is dominant in developed nations where farmers with organised associations institute and run extension agendas in agriculture to attend to the desires of the participating farmers, and the members of these associations, and not the government, control the functioning of the extension scheme. However, participants may pay part of the cost of extension programmes and the government sources provides the matching support[80,85]. The success in this approach requires a high level of trust and confidence among the farmers since group members are the ones involved in its management.

2.1.7 Agricultural Extension in Nigeria

In Nigeria, agriculture is the largest livelihood portfolio among rural dwellers, contributing an average of 24% to national Gross Domestic Products (GDP) over the past decades and employs about 36% of the nation's population, a feat which ranked the sector as the largest employer of labour in the country[88]. The role of agricultural extension in developing nations cannot be overemphasized as farmers depend on extension services for technical advice and

timely information. Agricultural extension has been the vanguard in the delivery of adequate information to farmers for increased productivity, and the efficiency with which these knowledge and practices are conveyed to farmers to a large extent determines the level of agricultural productivity[89,90].

The history of agricultural extension in Nigeria is interconnected with the general development of agriculture, and the reason is that extension is concerned with all aspects of agricultural productivity[91]. During the pre-colonial era by the British, conscious efforts were made in selection, introduction and teaching of practices involved in the production of good varieties of crops and breeds of animals. Farmers selected the best seeds for multiplication, from which the seedlings are being transplanted to their farms. Similarly, farmers introduce to their farms improved seeds and animals from their neighbouring communities and trans-Saharan traders from neighbouring countries[92]. The farmers themselves experimented upon and projected their production methodologies without the assistance of formally designated extension agents.

Traditional farming practice was largely through apprenticeship. Families have taught succeeding generation crop production, animal husbandry, and soil management through observation and participation by learners. Neighbours and friends shared new knowledge of improved farm practices[91]. During the colonial era by the British, some agricultural development initiatives were undertaken with the purpose of increasing production. The first step was to establish the Department of Botanical Research in 1893 with its headquarters at Olokomeji in the former western Nigeria and its responsibilities included conducting research in both agriculture and forestry[91,93].

In 1905, the British Cotton Growers Association acquired 10.35 square kilometres of land at the site now called Moor Plantation, Ibadan for growing cotton to feed the British textile

mills. In 1910, Moor Plantation, Ibadan became the headquarters of the Department of Agriculture in Southern Nigeria, while the Department of Agriculture was established in the North in 1912. In 1921, a unified Department of Agriculture was formed in Nigeria, after the amalgamation of the North and the South. The major policy of the central Department of Agriculture was to increase production of export crops for the British market, which was ready to absorb it for its industrial growth. Extension activities were therefore directed towards increasing efficiency in crop production and marketing. Regulations were made to set and enforce standards in export crops production[91,94,95].

The colonial government also established some agricultural development schemes to upgrade the skills of farmers and to produce agricultural commodities such as the establishment of Kware irrigation scheme in 1926 which was situated 25.74 kilometres north of Sokoto town. Its purposes were to increase rice yields and provide experimental data on production under severe drought during dry season and flooding during the rains. The scheme started with 1000 acres or 405 hectares involving 800 farmers with farms situated along the riverbanks. The colonial period also witnessed the establishment of the Niger Agricultural project in 1949 with the aim of producing groundnut as export and guinea-corn for local consumption. It was also to relieve world food shortage, demonstrate better farming techniques and increase productivity of Nigeria's agriculture. The project was sited near Mokwa at an area, which is suitable for mechanized food crop production[91,96,97].

The post-colonial agricultural extension in Nigeria can be categorized into two major groups: (1) government-organised agricultural programmes; and (2) extension programmes organized and sponsored by private agencies; the first group constitutes the more extensive of the two. Government organised agricultural extension include the National Accelerated Food Production Project (NAFPP) which was introduced in 1972, Agricultural Development Projects, ADP (alongside the ADPs, faculties of agriculture in some Nigerian universities as

well as the three universities of agriculture also offer some extension services, especially to their immediate host communities) (1975), the Accelerated Development Area Project, ADAP (1982), and Multi-State Agricultural Development Projects, MSADP (1986). Other programmes were the Operation Feed the Nation Programme, OFN (1976), the River Basin Development Authority, RBDA (1973), the Green Revolution Programme, GRP (1980), the Directorate of Food, Roads and Rural Infrastructure, DFRRI (1986), the National Directorate of Employment, NDE (1986), the Nigeria Agricultural Insurance Scheme, NAIS (1987) and the National Fadama Development Project, NFDP (1992). In recent years, the Poverty Alleviation Programme, PAP (2000), and National Economic Empowerment and Development Strategy, NEEDS[45,98,99,100].

Specifically, the National Special Programme for Food Security, NSPFS was launched in March 2003. Some private agencies have embarked on agricultural extension services largely towards a specific clientele system of their choice. Some of the agencies are; the Nigerian Tobacco Company (NTC) (now British American Tobacco Nigeria [BATN]), oil companies such as Shell Petroleum Development Company, and religious organizations such as the Catholic and the Anglican churches. Some Non-governmental organizations (NGOs) such as the Leventis Foundation also operate some extension services. Many international organisations have been involved in agricultural extension, agricultural and rural developments in Nigeria for decades. Notable among these are the World Bank, International Fund for Agricultural Development, IFAD, United States Agency for International Development, USAID, Technical Centre for Agricultural and Rural Cooperation ACPECCTA, and Food and Agriculture Organisation, (FAO) of the United Nations. Some NGOs also provide extension services as part of their mandate. Most NGOs adopt precision targeting of the most vulnerable poor and have been active all over Nigeria[101,102,103,104,105,106]. Private processing and marketing companies are also a vital part of the extension matrix in Nigeria.

In their heydays, the Nigerian textile companies and the Nigerian Tobacco Company had very robust out-grower programmes that they supported farmers with credit, inputs, and advisory services[91].

2.1.8 Agricultural Extension and Modern Agriculture in Nigeria

The Agricultural Transformation Agenda (ATA), a five-year strategy initiated in 2011 to revitalise the Nation's agriculture, was essentially a modernisation of agricultural extension service delivery systems with the goals to bolster agricultural productivity, reduce food import dependency, and fully liberalise government administered inputs supply thereby transform Nigeria's agriculture from mere traditional practice to business enterprise[107,108]. The value-chain approach adopted promises to lift agricultural activities beyond primary production to embrace significant investment in storage, processing, services and marketing[101,109].

Coming during a period of serious national economic stress, there was a shift of emphasis from public services to favour public-private partnership, and free-market operations. The policy claims to be sensitive to the needs of the most vulnerable farmers as structures were set in place for to capture their peculiar needs[107]. For instance, the Growth Enhancement Support Scheme is designed to deliver subsidized farm inputs including fertilizers, seeds and other inputs the resource poor farmers. The strategy to achieve this was the e-wallet system, a restructured Federal fertiliser subsidy under the Growth Enhancement Support Scheme (GESS) that coordinated fertiliser procurement with private companies selling subsidised inputs directly to farmers resulting to an estimated 12 to 14 million farmers benefiting from fertiliser subsidies over five years[107,110]. The consequent increase in average fertilizer usage and farm revenues generated demonstrated that timely and adequate inputs provision

(including adequate funding and staffing) can be tightly linked with agricultural extension success[108,111].

Another key component of ATA was the Nigeria Incentive-based Risk-sharing System for Agricultural Lending. This strategy was designed to make agricultural credit more accessible to all players in the agricultural value chain and attractive to the lenders by considerably reducing the risk associated with lending for agricultural production. The ATA was sustained and gave rise to the Agricultural Promotion Policy in 2016. Agricultural Promotion Policy of 2016 was produced based on the review of the Agricultural Transformation Agenda (ATA). The review noted that ATA did not sufficiently address the critical challenges of agricultural extension. APP identified the main challenge of extension as the absence of coordination of extension activities at the federal level, since agricultural extension function has been vested in the states[91,92,101,111].

Functions of agricultural extension can be provided in three major ways. The first is the public sector or supply-driven extension where the government takes full responsibility. Second is the NGO extension, which provides philanthropic outreach to a limited number of clienteles by donor agencies and other private NGOs. The third extension approach is the private or demand-driven extension where manufacturers, marketing firms, and other commercial players provide extension functions. In many developing countries the private sector-led extension model (both non-profit and for profit) is expanding because of shrinking government funding for extension. The consensus, however, is that the resource-poor farmers are too poor to participate in the private sector led extension and must be supported by public funding[91,112].

2.1.9 The Concept of Digitalisation

Digitalisation is the use of digital technologies to transform information (or business models) into digital format to enhance value addition and revenue accruement opportunities. It involves the process of moving from analogue to digital computation and transmission for ease of operationalisation. The result digitalisation is evinced in the representation of an image, object, document, sound, or signal obtained through generation of series of numbers that describes a discreet set called digital images[82,83]. Expounding the concept further, Gupta[84]averred that digitalisation refers to improving and/or enabling processes by leveraging on digital technologies and digitized data to promote business transformation. Thus, digitalisation improves an existing business process or processes, increases productivity, and promotes efficiency while reducing costs of production; this is done through the creation of new value-producing opportunities that transform the ways companies and business owners interact with their clients, and vice versa.

Although digitalisation has been in existence (in embryonic form) in the early nineteenth century, the advent of personal computer and internet in late twentieth century made it gained popularity and traction among citizens around the globe. Technological advancement has made possible the conversion of different forms of information such as audio, video, text, and images into digital forms with attributes that enhanced understanding. The process of digitalisation has clearly revolutionised modern commercial and communication systems with its profound effects felt on every facet of our modern societies[85,113,114]. The profound impacts of digitalisation in modern societies hinges on the ways in which many domains of our socio-cultural and socio-economic lives are structured around digital communication and the infrastructures associated with digitalisation[86].

Interestingly, digitalisation is increasingly pervading the nooks and crannies of our modern society via smart personal devices and hyper-connectivity brought about internet. This has created new phenomenon of urban "spamming" which exposes both urban dwellers and rural

to arrays of commercial advertisements and other forms of digital contents, and the implication is evinced in the perceived link between digitalisation and ecological, economic, and social sustainability which has serve as a guide to various stakeholders and policy-makers' decisions[86,115]. It is thus agreed that digitalisation is of critical importance not only to ecological sustainability, but the three main pillars of development, namely economic development, social inclusion, and environmental protection[86,116]. It is noteworthy that digitalisation has removed the necessity for colocation through interconnectivity capacity enhancement that extend economic activities beyond a fixed location, while simultaneously intensifying the variety and volume of activities at a given point in time[117]. The benefits of digitalisation are numerous, and among these benefits are;

i. It enhances the transformation towards a more robust and sustainable circular economy;
ii. It aids in the closure of material loops by providing accurate information on the availability, accessibility, location, and products condition for acquisition;
iii. It enables efficient product processing in companies, minimise wastage, promotes longer shelve life for products, and minimises the transaction costs;
iv. It helps in closing loops, bridging the material gaps, and narrowing the loop created by losses with increased resource allocation and technical efficiency;
v. It creates awareness of knowledge that lies beyond the traditional boundaries of information by bringing together collaborative groups in ways that contribute to both the development and delivery of additional values;
vi. It reduces cost of production/transaction by granting access to strategies that are cost-effective, while promoting dexterity and insight into future directions; and
vii. It promotes success based on enhanced agility and capability to adapt to clienteles, taking cognisance of their economic, social, cultural, and geographic differences.

The utilisation of digitalised technologies for virtualisation of processes, products and services by stakeholders have been highlighted to create major opportunities in the transformation of business models and the increased application of digitalisation in agricultural sector play a crucial role in enhancement of agricultural productivity, food security and sustainability, if its potentials are diligently harnessed[118,119,120].

2.1.10 Digital Agricultural Extension

Agricultural extension and advisory services are the critical conduits linking farmers and farmer-based organisations with other key stakeholders such as government agencies, private sectors, research institutes, and non-governmental organisations (NGOs) along agricultural value chain. The desire to overcome spatial constraints and efficiently disseminate current relevant information to a wider audience at relatively low costs has resulted in a paradigm shift in extension delivery system resulting in adoption of digital technologies with plethora redefinition of extension methods implemented through a variety of institutional arrangements involving state institutions, private agencies, farmers' organizations and farming communities[121].

Digitalisation can be defined as the use of digital technologies and data, as well as to the interconnection that results in new activities or changes to existing activities[122]. The current digital technologies include the following: mobile data networks (4G and 5G, for example); mobile payment and financial products; the Internet of things (IoT); block-chain; artificial intelligence (AI); and big data analytics and cloud computing[123]. Digitalisation of agricultural extension will therefore foster the ability of farmers to participate in and benefit from information and knowledge that can fuel adoption of innovative practices, problem solving and farm management skills, as well as enhance farmers' dynamic engagement in agricultural value chain with resultant increase in farm productivity and profitability. Digitalization of

agricultural will thus provide technical optimiation of agricultural production systems, value chains and food systems[124,125,126].

Digital agricultural extension (sometime referred to as ICT extension services) can be described as the design, development, and use of digital technologies and innovations in an increasing ubiquitous trend in the entire agricultural value-chain[127,128]. It encompasses a range of phenomenal technologies that include sensors, robotics, digital communication tools, block-chains, computational decision and analytical tools, system integration, ubiquitous connectivity, artificial intelligence, machine learning, internet of things, cloud-based technologies, among others; with demonstrable potentials to dramatically change the way knowledge is accessed, processed, communicated, and utilised thereby delivering a step change in farm management efficiency, productivity and sustainability at the farm level and across the value chain[129,130,131].

Digital extension is an extension system that enables extension workers reach out to farmers using a more efficient alternatives to the traditional extension system through platforms like SMS, Interactive Voice Response (IVR), downloadable applications, Unstructured Supplementary Service Data (USSD), and mobile web and services that would duplicate and disseminate different technologies to accommodate larger clientele given the wide array of mobile devices among the targeted audience with intent of enhancing farmers' productivity, profitability and global competitiveness[132]. Reiterating the potentials of digital agricultural extension, it has been posited that it will engender systems of higher productivity, that are safe, anticipatory and adaptable to the consequences of climate change, offer greater food security, profitability and sustainability among all cadre of farmers. For farmers, digital applications will provide decision-making capabilities that were previously not possible, potentially leading to radical changes in farm management[133].

In addition, digital agricultural extension is described as agricultural revolution that involves digitalising the entire agricultural production processes and its supply chain through remotely gathering, saving, reviewing, and exchanging of agricultural- and related data for optimum activities across the entire food production and supply chains using software and other innovative technological resources at the three main stages of decision-making (pre-farming, on-farm, and after-farming -supply value chain) based on available data to improve food production, processing, storage, distribution, and consumption[133]. Farmers can deploy digital extension services before, during and after farming through decision support systems that heavily rely on digital technologies to manage and control all aspects of food production, processing, and storage to improve production sustainability[133,134]. Accordingly, digitalisation of agricultural extension can, in;

i. The pre-farming stage helps farmers to plan, select seedlings and other agricultural inputs, choose a farming approach, and apply the appropriate technologies;
ii. The on-farm stage enables farmers to use the proper amount of farm inputs, fertilizer, and other resources to improve farming output sustainability by adopting appropriate digital technologies such as drip irrigation, hydroponics, and urban farming, that are now possible. The suppositions are premised on the fact that growth, stability, and performance are affected by a farm's topology, environmental factors, and morphology; and those agricultural soils exhibit spatial variability in properties, landscape features, crop stresses, and crop yield[135].
iii. The after-farming stage enables farmers identify and manage economic matrices using digital tools to analyse farm significant productivity through input-output rationalisation, and create an economy based on reconstruction, optimisation and resource-saving process, facilitated by digital technologies to achieve non-waste production and

consumption, sustainable economic growth, and socio-economic and environmental efficiency[136,137].

Since the major agricultural production activities takes place in the rural communities, digital agricultural extension can facilitate dissemination of new knowledge from researchers and research institutions to small-scale farmers in a rural area while receiving feedback from the same to improve productivity, efficiency, and farmers' outlook towards farming difficulties thereby serving as a political and organisational instrument for facilitating social and economic development[138]. The problems of inadequate extension personnel, technical and logistic problems, difficulties accessing remotely located farms can be remedied through the adoption of digital extension services to provide quality, timely, effective, and automated electronic extension support to all categories of farmers. Services that are timely, independent, and complimentary such as good agricultural practices (GAP), weather advisory services, connection to buyers/off-takers, and access to reliable Agricultural inputs (seeds, pesticides, and fertilizer), through USSD codes, SMS, calls, smart mobile phone apps, radio/TVs, videos, and the Internet can be effectively and efficiently rendered to farmers irrespective of their locations, farm size, socio-economic status and/or political affiliation[133].

2.1.11 Digital Communication Agricultural Extension

In today's dynamic agricultural landscape, digital communication stands as a transformative force in agricultural extension. By harnessing the power of technology, agricultural extension services can reach farmers more effectively, disseminate timely information, and facilitate interactive engagement. Digital communication has the potential to revolutionise agricultural extension, empowering farmers with access to knowledge, resources, and support necessary for sustainable farming practices and improved livelihoods[129,139,140].

Digital communication in agricultural extension refers to the use of digital technologies and platforms to facilitate the exchange of information, knowledge, and resources between agricultural extension services, farmers, agribusinesses, researchers, and other stakeholders in the agricultural sector. It encompasses various digital tools and channels, including but not limited to mobile applications, SMS platforms, social media, websites, radio, television, and interactive voice response systems. At its core, digital communication in agricultural extension aims to bridge the gap between information providers and recipients, leveraging on technology to overcome traditional barriers such as distance, time, and resource constraints. It enables timely and targeted dissemination of agricultural information, extension services, and advisory support to farmers, thereby empowering them to make informed decisions and improve their farming practices[129,140].

One key aspect of digital communication in agricultural extension is its ability to reach a wide and diverse audience, including smallholder farmers in remote rural areas who may have limited access to conventional extension services[45]. By leveraging mobile phones and other digital devices, extension agencies can deliver tailored content and interactive learning experiences directly to farmers' fingertips, regardless of their geographical location. Furthermore, digital communication facilitates two-way interaction and feedback mechanisms, allowing farmers to engage with extension agents, experts, and fellow farmers, share their experiences, ask questions, and seek clarification on agricultural issues. This interactive approach fosters a sense of community and collaboration, enabling knowledge sharing and peer learning among farmers[45,141].

Overall, digital communication in agricultural extension plays a crucial role in promoting sustainable agricultural development, enhancing productivity, resilience, and livelihoods in farming communities. It represents a paradigm shift in extension service delivery, harnessing

the power of technology to democratise access to agricultural information and empower farmers to thrive in an increasingly complex and interconnected world[142,143144].

2.1.12 Importance of Digital Communication in Modern Agriculture

Digital communication has become increasingly vital in modern agriculture due to its transformative impact on various aspects of the agricultural sector. Several studies have shown the importance stems from the following benefits:

i. **Timely and Targeted Information Dissemination:** Digital communication enables agricultural extension services to rapidly disseminate relevant information, including weather forecasts, market prices, pest and disease alerts, and best agricultural practices. This timely access to information empowers farmers to make informed decisions, adapt their farming practices, and mitigate risks.

ii. **Enhanced Farmer Education and Training:** Digital platforms offer interactive and engaging educational resources, such as videos, tutorials, and online courses, which can be accessed anytime and anywhere. These resources provide farmers with valuable knowledge and skills to improve their agricultural productivity, sustainability, and resilience to climate change.

iii. **Improved Extension Service Delivery:** Digital communication facilitates the delivery of extension services in a more cost-effective and efficient manner. Extension agents can use mobile applications, SMS platforms, and social media to reach a larger audience of farmers, provide personalized advisory support, and track the impact of their interventions in real-time.

iv. **Access to Market Information and Value-Added Services:** Digital platforms connect farmers to market information, buyers, and agribusinesses, enabling them to access better prices for their produce and engage in value-added activities such as

processing and marketing. E-commerce platforms and mobile payment systems further streamline transactions and financial inclusion in rural areas.

v. **Empowerment of Smallholder Farmers:** Digital communication levels the playing field for smallholder farmers, who often lack access to traditional extension services and market information. By leveraging mobile phones and other digital devices, smallholder farmers can access extension services, financial services, and market opportunities, improving their livelihoods and economic prospects.

vi. **Data-driven Decision Making:** Digital communication generates vast amounts of data on agricultural practices, market trends, and socio-economic indicators. By analysing this data using advanced analytics and artificial intelligence, stakeholders can gain valuable insights into emerging trends, identify areas for intervention, and optimize resource allocation for maximum impact.

Thus, digital communication is essential for modern agriculture as it enhances information dissemination, education, service delivery, market access, empowerment, and decision-making processes, ultimately contributing to sustainable agricultural development and food security[129,140,143,145,143].

2.1.13 The Role of Digital Communication in Agricultural Extension

The role of digital communication in agricultural extension is multifaceted and pivotal in driving positive change across the agricultural sector. It plays a crucial role in bridging the gap between agricultural experts, extension agents, and farmers, facilitating the exchange of information, knowledge, and resources[146,147148]. Some key aspects of its role include;

i. **Facilitating Information Dissemination:** Digital communication enables agricultural extension services to disseminate relevant information to farmers in a timely and targeted manner. This includes updates on weather forecasts, market prices, pest and

disease outbreaks, agronomic practices, and government policies. By providing access to accurate and up-to-date information, digital platforms empower farmers to make informed decisions and adapt their farming practices accordingly.

ii. **Enhancing Farmer Education and Training:** Digital communication offers various educational resources and training materials that farmers can access remotely. These resources may include videos, tutorials, webinars, and online courses covering a wide range of topics such as crop cultivation, livestock management, soil health, water conservation, and climate-smart agriculture. By improving farmers' knowledge and skills, digital platforms contribute to increased productivity, sustainability, and resilience in agriculture.

iii. **Improving Extension Service Delivery:** Digital communication enables extension agents to reach a larger audience of farmers more efficiently. Through mobile applications, SMS platforms, social media, and other digital channels, extension services can provide personalised advisory support, answer farmers' queries, and offer technical assistance. This facilitates better engagement between farmers and extension agents, leading to more effective extension service delivery and positive outcomes for agricultural development.

iv. **Enabling Farmer Feedback and Interaction:** Digital communication platforms facilitate two-way communication between farmers and extension services, allowing for feedback, discussions, and knowledge sharing. Farmers can provide input on their needs, challenges, and experiences, while extension services can gather data on farmer preferences, practices, and outcomes. This feedback loop helps improve the relevance and effectiveness of extension interventions, ensuring they address the real needs of farmers on the ground.

In essence, the role of digital communication in agricultural extension is instrumental in empowering farmers, enhancing their capacity, and driving sustainable agricultural development. When digital technologies are leveraged by stakeholders in the agricultural sector, extension service delivery would reach more farmers, deliver better-quality information and services, and foster greater collaboration and innovation in the agricultural sector[129,143].

2.1.14 Tools and Technologies for Digital Communication in Agricultural Extension

i. **Mobile Applications:** Mobile applications provide farmers with access to a wide range of information and services directly on their smartphones or tablets. They offer real-time interactive features on weather updates, market prices, pest and disease identification and personalised advisory services tailored to specific crop and region. Farmers can also use mobile apps to access training materials, connect with extension agents, and participate in online forums or webinars. Examples include Agrikore, Farm rowdy, Verdant, Agro Data, Hello Tractor, and Probity farm apps for farm management, real-time support, and pest detection among other services. Mobile applications empower farmers by putting valuable resources and expertise at their fingertips, regardless of their location or access to traditional extension services[71].

ii. **Short Message Service (SMS) Platforms:** SMS platforms are widely used for digital communication in agricultural extension, particularly in regions where smartphone penetration is low. These platforms enable extension services to send text messages containing timely and relevant information directly to farmers' mobile phones. Messages may include updates on weather forecasts, market prices, modern agricultural tips, and government programmes and policies. Farmers can also subscribe to receive personalized SMS alerts based on their crops and location. SMS platforms are cost-effective, scalable, and accessible even on basic mobile phones,

making them an effective tool for reaching a large audience of farmers, including those in remote and marginalized communities[31,149].

iii. **Social Media Platforms:** Social media platforms play a crucial role in digital communication in agricultural extension by providing a space for farmers, extension services, researchers, and agribusinesses to connect, share information, and engage in discussions. Platforms like Facebook, Twitter (X), Telegram, WhatsApp, Quora and Instagram allow extension services to disseminate educational content, promote events, and facilitate peer-to-peer learning among farmers. Farmers can join groups and communities related to agriculture, where they can ask questions, share experiences, and access resources shared by experts and fellow farmers. Social media platforms also offer interactive features such as live streaming, polls, and surveys, enabling real-time engagement and feedback. Specifically, social media enhances the reach, visibility, and effectiveness of agricultural extension efforts by leveraging the power of online networking and collaboration[129,150].

iv. **Web-based Platforms and Websites:** Web-based platforms and websites serve as centralised hubs for accessing a wide range of agricultural information, resources, and services. These platforms host educational materials, articles, videos, and interactive tools covering various aspects of agriculture, from crop production to marketing strategies. Agricultural extension services often maintain their websites where farmers can find information on upcoming events, training programs, advisory services, and government schemes. In addition, web-based platforms may feature discussion forums, chat support, and online communities where farmers can interact with extension agents, experts, and fellow farmers. By offering a user-friendly interface and accessible content, web-based platforms empower farmers to access valuable resources and support for improving their agricultural practices and livelihoods[71].

v. **Interactive Voice Response (IVR) Systems:** Interactive voice response (IVR) systems are automated telephone systems that enable farmers to access information and services using voice commands or keypad inputs. IVR systems provide farmers with pre-recorded messages on various topics such as crop cultivation, pest management, market prices, and weather forecasts. Farmers can navigate through menu options to select the information from their platform of interest or request a call back from an extension agent for personalized assistance. IVR systems are particularly useful in areas where literacy rates are low or access to smartphones and internet connectivity is limited. By leveraging basic mobile phones, IVR systems ensure that agricultural extension services reach a wide audience of farmers, including those in remote and underserved communities[151].

vi. **Radio and Television Programmes:** These are traditional yet effective tools for digital communication in agricultural extension, reaching millions of farmers in rural and urban areas. These programs cover a wide range of agricultural topics, including crop cultivation, livestock management, post-harvest handling, and market information. They feature interviews with experts, success stories from farmers, practical tips, and live call-in segments where farmers can ask questions and seek advice. Radio and television programmes such as *Agbelere* and *Farmers' Forum* by Diamond FM, *Food Today* by NTA Ibadan FM, and *Ere Agbe* by Amuludun FM, *are* accessible to farmers who may not have access to the internet or smartphones, making them inclusive communication channels for reaching diverse audiences. In addition, these programmes often incorporate entertainment elements such as music, drama, and storytelling to engage and educate listeners and viewers, making agricultural information more engaging and memorable[63].

vii. **Geographic Information Systems (GIS) and Remote Sensing:** GIS and Remote Sensing technologies play a crucial role in digital communication in agricultural

extension by providing valuable insights into land use, soil health, crop health, and environmental conditions. GIS platforms allow extension services to analyse spatial data and create interactive maps that visualize agricultural landscapes, identify areas of productivity and vulnerability, and plan interventions accordingly[71]. Remote sensing technologies, such as satellite imagery and drones, provide high-resolution data on crop growth, pest infestations, and natural disasters, enabling timely monitoring and response measures. Extension services can use GIS and remote sensing data to assess the impact of agricultural practices, predict crop yields, and recommend adaptive measures to farmers. When these technologies are adequately harnessed by stakeholders in the agricultural sectors for agricultural extension services delivery, it can improve decision-making, resource allocation, sustainable land management practices, and ultimately enhance agricultural productivity and resilience[7,71].

2.1.15 Challenges and Barriers in Implementing Digital Communication in Agricultural Extension

i. **Access to Technology and Digital Literacy:** One of the primary challenges in implementing digital communication in agricultural extension is the unequal access to technology and varying levels of digital literacy among farmers. Many farmers, especially those in rural and marginalized communities, may lack access to smartphones, computers, or reliable internet connectivity. In addition, several studies have shown great disparities in digital literacy levels among farmers, with some individuals having limited knowledge and skills in efficient use of digital tools[152]. Addressing this challenge requires investments in infrastructure, such as expanding internet coverage and providing affordable access to digital devices, as well as initiatives to improve digital literacy

through training programmes and user-friendly interfaces tailored to the needs of farmers[153].

ii. **Poor Rural Connectivity:** Connectivity issues, such as poor network coverage and slow internet speeds, pose significant barriers to digital communication among agrarian rural communities. Farmers may experience frequent disruptions in internet connectivity, hindering their ability to access online resources, participate in virtual training sessions, or engage in real-time communication with extension services. The poor connectivity is often exacerbated by inaccessible terrain inadequate infrastructure, and limited investment in rural telecommunications[152,154].

iii. **Language and Cultural Barriers:** Language and cultural diversity present challenges in effectively communicating agricultural information through digital platforms. Cultural factors such as beliefs, norms, and traditional practices may influence farmers' receptiveness to digital communication and adoption of new technologies. Extension agents should take into cognisance cultural sensitivities and preferences when designing digital interventions, incorporating local knowledge and engaging community leaders as trusted intermediaries to facilitate acceptance and adoption[155,156].

iv. **Sustainability and Maintenance of Digital Platforms:** The sustainability and maintenance of digital platforms for agricultural extension pose significant challenges, particularly in resource-constrained environments. Developing and maintaining digital platforms require ongoing investments in infrastructure, software development, content creation, and technical support. Without adequate funding and institutional support, digital platforms may become outdated, inaccessible, or unreliable over time, undermining their effectiveness in supporting agricultural extension efforts. In order to mitigate this barrier, sustainable funding models, public-private partnerships, and community-based approaches should be explored to ensure the long-term viability and impact of digital communication initiatives in agriculture[153,157]. Also, there should be

capacity building initiatives targeted at empowering local stakeholders, including extension agents, farmers, and technology providers, with the skills and resources necessary to manage and maintain digital platforms effectively, ensuring their continued relevance and usefulness in serving the needs of the agricultural community[140].

v. **Privacy and Data Security Concerns:** Privacy concerns can make hesitate to share personal information or engage in online transactions if they are unsure about safety of their personal information. Moreover, the collection and storage of sensitive agricultural data, such as farm location, production records, and financial information, raise privacy concerns about potential abuse or unauthorised access. To allay the fears of farmers, extension agents must adhere to strict data protection policies and security protocols to safeguard farmers' privacy and confidentiality. This may involve implementation of encryption policies, obtaining informed consent for data collection, and providing clear information about data usage and rights to farmers. Establishing trust and transparency in data handling practices is essential in the promotion of farmers' confidence and engagement in digital communication and data sharing in the agricultural sector[158].

2.1.16 Digital Communication Agricultural Extension and Current Realities

Nigeria has emerged among the top leaders in digitalisation in Africa and the adoption of innovative digital technologies have enabled smallholder, who constitute about 88% of the farming population in Nigeria farmers, access a range of opportunities to improve their productivity and enjoy several advantages such as reduction in travel times, cost reduction in business transactions; increased synergy through stronger farmer-to-farmer networks and interconnectivity; timely access to market and farming information; increased adaptability to situational changes; greater farm leverage with input vendors, off-takers; and transport/haulage providers[159,160,161]. However, in spite of the huge potentials, digital extension in Nigeria still grapples with challenges like inadequate access to capital, poor

quality infrastructure, low internet connectivity, unstable power supply, among others. The current realities of digital extension in Nigeria can be assessed as follow;

i. **Attitudes towards Agricultural Entrepreneurship:** The proliferation of entrepreneur in Nigeria has been associated with the desire to generate additional income, as well as high level of unemployment among the teeming graduates[162]. However, negative perception that agriculture cannot suffice as a primary career, due in part to lack of successful role model, and exacerbated high poverty rate that forced the youth to search for "safer" long-term and sustainable career options in sectors other than agriculture. Research have shown that many graduates prefer to work for big companies instead of start-ups due to lower pay scale[163,164].

ii. **Level of Research Synergy between University and Other Institution:** Poor synergy between universities (which conducts about two-third of agricultural research in Nigeria) and other key stakeholders such as government and the private sector have hampered the opportunities to translate research findings into innovative solutions that addressed farmers' needs; some institutions would rather collect fresh data when working on a project than consulting and/or utilising the existing database[159,165].

iii. **Presence of Technology Hub:** Assessment of network density in Nigeria revealed the country has excel in presence of technology hubs but falls short in cluster development. Although Nigeria is reported to have the second strongest technology hub in Sub-Saharan Africa, majority of the technology hubs are headquartered in Abuja and Lagos. Although a large proportion of digital agricultural technology hubs choose to have offices in these cities, many recognise the value generated by working near the smallholder farmers they serve. As such, they maintain core operations in rural areas. Other agricultural technology clusters in the country include Enugu, Ibadan, and Kaduna. These communities continue to cultivate ideas and host a moderate presence of DAT start-ups. Nonetheless, such

clusters receive significantly less support compared with clusters in Lagos and Abuja[166,167].

iv. **Equity Financing:** Inadequate supplies of seed-level capital have constrained the growth potential of digital agricultural extension technologies. According to[159], the main source of capital for many entrepreneurs is personal funds or funds from friends and family. Because Agribusiness start-ups are deemed high risk, investors prefer to wait and see if such businesses can gain market traction before investment commitment, and this often creates ineffectual situation in which agribusiness struggle to grow due of limited financial resources. Government and development partners can help bridge the funding gap in Nigeria by allocating more capital to Agribusiness start-ups either directly by providing them with loans or matching funds low-interest-rate, or through investment in technology hubs that specialises in identification in viable agribusiness with high-potential models[163,168].

v. **Financing for Agricultural Research:** An evaluation of the digital extension subsector's financial landscape revealed shortage of funding for agricultural extension research and development, and Agri-technology start-ups. Although Nigeria committed the second-largest financial investment in technology start-ups in Sub-Saharan Africa in 2018, the level of investment was still considered inadequate given the size of the country's GDP. The issue of low investment was particularly pronounced in the Agro-technology space[165,166].

vi. **Extent of Digital Skills among the Population and Graduate Skill Set:** A review of the human capital landscape for digital agricultural technology revealed severe gaps in digital literacy and basic ICT skills. Digital literacy is low across Nigeria, and the universities system exacerbated the situation by failing to adequately equip students with the skill sets demanded by the Agro-tech market. There are fundamental mismatches between what is taught and what is needed, an indication that the university systems are

failing to adapt to changing labour market needs. Graduates often enrolled in programmes at training hubs to gain the requisite market skills[48,159].

vii. **Labour Market for Digital Agricultural Technologies:** Too few graduates possess basic technology and business skills in Nigeria. The skill gap has forced digital agricultural technology operators to leverage foreign talents, putting them at a cost disadvantage. However, Nigerian universities are gradually investing in activities to develop the skills of their students in the field of digital agricultural productivity. In response to the technology hub growth trends, the university system can redesign agriculture-focused degree programmes to align with the Agro-tech space, and improved graduates' employability in the digital agricultural extension subsector[159]. However, collaboration with the private sector would increase universities' credibility and make their students more attractive to employers in the Agri-tech subsector.

viii. **Availability and Accessibility of Transportation:** Among the major constraints to agricultural extension delivery services are poor and inaccessible road networks connections in farming communities. Innovators and other key players in agricultural value chain like input vendors find it extremely difficult to deliver inputs to farmers and farmers struggle to access or link markets and off-takers with their farm produce. The disruption in road connectivity hampered smallholder farmers in rural areas from participating and benefiting from digitalisation of agriculture[161]. On the other hand, the poor road networks in rural areas that militate against traditional agricultural extension services in rural areas has opened tremendous opportunities for digital extension to thrive where farmers are connected through effective digital media.

ix. **Internet Access:** Lack of internet connectivity acts as a significant constraint for Digital Agricultural Technology (DAT) start-ups. The low use of fourth-generation (4G) connectivity[170] is partly due to its limited availability in Nigeria, particularly in last-mile rural areas. Mobile network providers have more incentives to launch 4G in high-traffic

urban areas, which tend to yield greater profits. Farm rural households are often excluded from innovative technologies until it has saturated the urban areas. Moreover, broadband in Nigeria is still relatively expensive and service delivery in the rural communities is of poor quality[37,169].

2.1.17 Concept of Mass Media

Mass media is a deceptively simple but complex term that encompasses numerous individuals and institutions with similar or divergent information scope, purpose, method and style of dissemination, and cultural context. It includes all forms of information disseminated to larger groups of people, either in the form of a handmade sign or news casted on an international news network[171]. Mass media has been defined as the modes of mass communication whereby information, opinion, advocacy, propaganda, advertisement, artwork, entertainment, and other forms of expressions are conveyed to a very large heterogenous audience. Generally included in the term "mass media" are the audio media such as radio, tapes, and audio recordings; the visual media such as pictures, album, banners, and prints like newspaper, bulletin, journals, periodicals, conference proceedings, among others; and audio-visual media such as television, film, video, playlets, demonstrations, and the new media such as telephone, internet (especially the World Wide Web) and internet-based social media such as WhatsApp, Twitter, Instagram, LinkedIn, Facebook, Telegram, E-bay, et cetera[104,105,172].

Mass media is also used collectively to refer to all types of public and private organisations that produce and/or disseminate particular forms of expressions through diverse modes that include newspaper and wire services, book publishing, journals and periodicals, radio and television networks, cinema and movie studios, among others. Mass media is a powerful communication tool that is critical in the dissemination of information through diverse medium. It serves as a conduit through which information can be obtained, exchanged, and

transmitted to the intended audience. The wider audience reached thus promotes economic growth in both urban and rural communities among the developed and developing countries[119].

2.1.18 Functions of Mass Media

i. **Knowledge Gap Bridge:** The mass media influences knowledge gaps due to factors including the extent to which the content is appealing, the degree to which information channels are accessible and desirable, and the amount of social conflict and diversity there is in a community. Mass media become very effective in knowledge gap bridging when specific issues are disseminated to specifically targeted audience who are known to constantly exposed to such media. It was observed that that media types and media contents are key determinants its efficiency and effectiveness in bridging the knowledge gap among their audience[106].

ii. **Agenda Setting:** People are influenced in how they think about issues due to the selective nature of what media groups choose for public consumption. It has been established that when risks are highlighted in the media, particularly in great detail, the extent of agenda setting is likely to be based on the degree to which a public sense of outrage and threat is provoked. Thus, when trying to set an agenda, framing can be invaluably useful to a mass media organisation. Framing involves "taking a leadership role in the organisation of public discourse about an issue". The media is influenced by the desire for balance in coverage, and the resulting pressures can come from groups with particular political action and advocacy positions. Hence, groups, institutions, and advocates compete to identify problems, to move them onto the public agenda, and to define the issues symbolically[106].

iii. **Cultivation of Perceptions:** The extent to which media exposure shapes audience perceptions over time is known as cultivation. Media like radio and television are

common example where they can be described as “homogenising agents”. The reason is prolonged exposure to broadcast programmes from these media, where they are available, can affect the audience perception to the point of accepting or adopting a lifestyle, an idea, innovation, policy, et cetera[106].

iv. **Advocacy Setting:** Mass media can be used for advocacies both for business and social concern. These advocacies can take the form of advertisement, marketing, public relations, propaganda, and political communication. Also included are public service announcement, emergency alerts, public enlightenment among others.

v. **Entertainment:** Mass media bring entertainment to their audience door-step traditionally through broadcasting performances of acting, TV shows, soap operas, music, sports, and along with light reading; and since the late twentieth century, through computer and video games.

2.1.19 Roles of Mass Media in Agriculture

Modern agriculture is increasingly becoming information dependent hence timely accessibility is integral for agricultural development. In order word, to successfully improve agricultural productivity, grow revenue, create more employment opportunity, promote food security, and ensure agricultural sector achieve its aim in furtherance to improving rural and even national development, the communication system adopted in the implementation of various agricultural programmes is crucial[104]. The mass media played a crucial role in shaping public opinions; stimulating deeper insight into human working. It is an invaluable channel through which agricultural information on current development, latest innovations or emergencies get across to farmers in the shortest possible time. To agriculture as an industry, the key values of communication that media provides are peer to peer networking, farmer-industry networking, consumer engagement, and crisis communication[173,174]. Hence, mass media, being source of information and entertainment, play a vital role in the transformation

of attitude, interest, and perception of farmers toward modern agricultural practices and productivity. The mass media carried out these functions through its agenda-setting for critical topics bordering on agricultural transformation, knowledge transfer, opinion forming, and behavioural changes. It creates avenues though which several stakeholders in the agribusiness value-chain are linked to exchange information essential for sustainable agricultural growth[104,175].

Mass media also play significant roles in awareness creation about new innovations and technologies that can boost production to farmers. The speed of spread and the larger audience reached within the shortest times frame makes mass media a veritable tool for information dissemination to farmers. Chief among the mass media is radio, which has been reported as the most utilised media by farmers and the farming communities, and this was followed by mobile phone, television, and pamphlets[175,176]. The mass media is an invaluable to in the hands of extension agencies and their agents. Extension agents often utilised these media to disseminate agricultural information and technologies to farmers to enhance agricultural production. Farmers on the other hand access mass media to acquire knowledge on how to effectively utilised the new innovations and technologies to improve production and profitability[104,107]. Mass media can conveniently be classified into print media, electronic media, and new age media.

i. **Newspaper:** Newspapers are regular publications that contain informative articles, editorial opinions, analytical articles, advertisements, special reports, pictures and comics. Newspapers can also provide continuous and prominent coverage on specific topics and they are important in driving the public to change attitudes, raise awareness, increase knowledge and skills, and learn about different topics, including agriculture. Hence, newspapers play a very important role in disseminating development information, including information agriculture production information. Although newspapers play an

essential role in disseminating important information to the public, in various nations, there are still concerns that newspapers will give priority to advertising, political, entertainment and criminal events, while neglecting development topics such as agriculture. Study has shown that newspapers place little emphasis on agriculture in Nigeria[177,178].

ii. **Magazines:** These are periodical publication containing a variety of articles, generally financed by advertising or purchase by readers. They are typically published weekly, biweekly, monthly, bimonthly or quarterly, with a date on the cover that is in advance of the date it is actually published. They are however in practice, a subset of periodicals, distinct from those periodicals produced by scientific, artistic, academic or special interest publishers which are subscription-only, more expensive, narrowly limited in circulation, and often have little or no advertising[177,178].

iii. **Radio:** A study on broadcasting agriculture information among growers in Nigeria, presented that radio provides farmers with information on fisheries, livestock and radio is a significant medium for communicating among farmers in Nigeria. In the study of[178], the efficiency of radio and agricultural programmes was undeniable. The results showed that most farmers like to participate in radio broadcasted agricultural programmes, which indicates that most farmers listen to radio programmes about plants and agricultural products. Furthermore, it was observed that some farm families like to listen to radio programmes that would improve their knowledge on livestock and animal husbandry. It was deduced that broadcasting is a multi-dimensional resource that provide effective information even to remote areas of developing countries; and the influence of broadcasting programmes has proven helpful in several farming communities. The usage of radio broadcasting among rural farmers is still very popular. Many farmers rely on newspapers and radio. These broadcast networks can transfer important information

between rural farmers and can improve the skills and knowledge of agricultural development[177,178].

Radio bridged the literacy barriers required in the print media such as journals, newspaper, bulletin, et cetera. In essence, radio does not require higher educational qualification or back-ground to be effective as the information are usually disseminated the local language or dialects. Even the pastoralists who live in low population densities and are often physically inaccessible can be mobilised with aid of radio broadcasting without necessarily interfering with their daily activities at home or in field. It has also been found that radio is a major source of information in educating farmers regarding new agricultural innovations and practices; and in the successful dissemination of agricultural information to a target group in the remote rural areas which improved their skills, knowledge and growers adopt such new technologies for improvement and enhance their agriculture production[110,179,180].

iv. **Television:** The advancement of agriculture in developing countries depends mainly on the usage of mass media that can connect people while bridging gaps created by distance among societies. Television as one of the mass media broadcasting technologies have played an essential role in improving the capacity-building of growers via dissemination of various information on agriculture. Moreover, television stations broadcast agricultural information among growers and provides important knowledge through dialogue with agricultural experts and other stakeholders among agribusiness value chain. It has been pointed out that by watching farming-related programmes on television, farmers can easily obtain better information. Television broadcasting disseminates information and skills to all patrons of society, and builds awareness, skills and information among farmers on the use of new technologies in agriculture. Such broadcasts attract attention of farmers who often rely on the mass media to get the latest news on agriculture, health, education, weather, and other relevant topics. These have

made the diffusion of scientific knowledge to a large farmers' audience, literate and illiterate alike, highly efficient, cost effective and within a very short time[179,180,181].

v. **Film and Cinema:** Film comprises a series of individual frames, but when these images are shown in rapid succession, an illusion of motion is created. Film has emerged as an important medium for entertainment, education, enlightenment, and inspiration to a wide audience of diverse background. Films are produced by recording objects and people with different types of cameras, or by creating them through the use of special effects or animation techniques. The films and motion pictures created are veritable tools in teaching farmers modern farm practices, demonstration of new innovations, and techniques that improves agricultural productivity[177,178].

vi. **Telephone:** The advent and introduction of smartphones into agricultural productivity has bridged the huge gap between farmers, farm-input producers and manufacturers, marketers (traders), and other key players in agricultural value chain, while simultaneously connecting farmers directly to customers, thus creating opportunities excellent pricing of their agricultural products. With the aid of smartphones, can inquire about price of inputs such as improved seeds, fertilisers, and herbicides from the comfort of their homes. Farmers can as well enquire about the current price of their farm products, reach a bargain with buyers or off-takers, make transactions through mobile applications, and complete any agribusiness deals in record time[111,182]. The use of smartphones in agriculture among farmers was further popularised by their participation in e-wallet programme and other agricultural supports programmes launched by government and Non-Governmental Organisations (NGOs)[106,183]. Thus, mobile phones have provided multi-dimensional benefits through farmers' linkages to extension experts, facilitation of interaction among key players in the agribusiness value chain, promotion of accessibility and timely information exchange among individuals within and outside agricultural sector[104].

vii. **Internet:** The advent and spread of internet have transformed the world into a global village as it has mitigated spatial gap to information exchange that was created by distance. Particularly handy are internet-enabled social media platforms such as Facebook, YouTube, and WhatsApp with 2.6 billion, 2 billion, and 1.6 billion active monthly users respectively, as of 2020. Others include twitter, e-Bay, Telegram, Instagram, et cetera[280]. Reports have shown that internet-based social media platforms are continuously evolving owing to the emergence of several smartphones. Prominent these social media for the dissemination of agricultural and extension information are YouTube videos which are excellent source of agricultural knowledge using audio-visual aids; Facebook and WhatsApp are notorious for profile and interest-group creation that are used in agricultural extension service delivery worldwide owing to their popularity; while LinkedIn and Telegram are known social media platform used in dissemination of agricultural innovations, techniques, and technologies among "elite farmers". Thus, internet and internet-based social media platforms are invaluable tools for knowledge delivery and sharing across different agriculture subsectors[176,112,184].

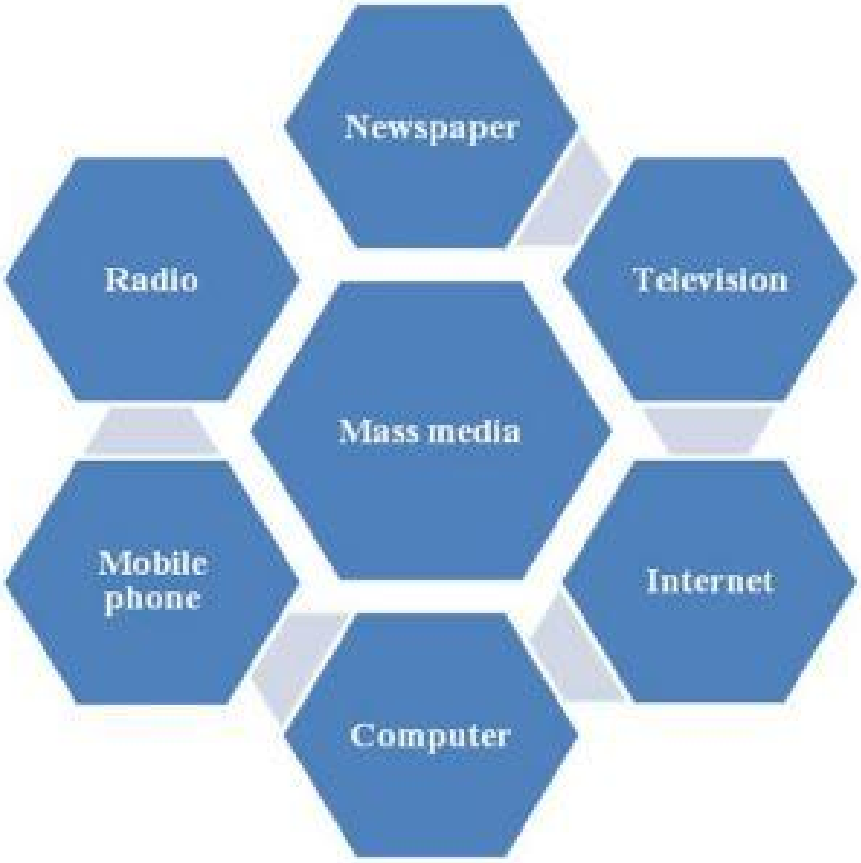


Figure 2.2: Mass Media Representation
Source: *https://doi.org/10.22192/ijarbs.2020.07.04.025*

2.1.20 Food Crops Production

Food is a basic necessity and source of energy for the sustenance, healthy, and productive life. All living organisms on this planet need food to stay alive and to carry out physiological functions and other essential life processes, and plants are the main sources of food on which both humans and animals depend[185]. With the rapidly growing population, demand for more food, loss of produced crops, and other problems affecting agricultural output are the major cause of food insecurity especially in the developing countries, a situation that necessitated the call for global synergy toward food crop production[32]. Crops production is the branch of agriculture that deals with the cultivation of crops for domestic and commercial purposes. Food crop production involves the cultivation of arable crops like cereals (rice, maize, millet,

wheat), pulses (beans and peas), tubers (yam, cassava, potato), oilseed crops (groundnut, sunflower, palm tree) among others for man and animal consumption[88,186].

Global food crop production has experienced significant increase with cereals representing about one-third of the total production, followed by sugar crops, vegetables, oil crops, roots and tubers[89]. The increase has been attributed to several factors such as increased use of pesticides, irrigation, fertilizers, high-yielding crops, and better farming practices[90].

In Nigeria, food crops production remains the largest segment of agricultural production and accounts for about 88% of agricultural outputs[60]. Evaluating the performance of food crop subsector in Nigeria, report shows that food crop production has steadily contributed more than 85% to the nation's Gross Domestic Products (GDP) in the past two decades, with cassava and yam in the forefront[91]. However, it has been posited that smallholder farmers remain the engine room for food crops production in Nigeria and they engage in the cultivation of diverse food crops prominent among which are maize, cassava, yam, beans, millet, groundnut, pepper, sorghum, and rice in that sequence[33].

2.1.21 Influence of Digital Extension on Food Crops Production

In the last decades, agriculture has undergone series of revolutions that have enhanced efficiency, increased yield and strengthened productivity and profitability of the sector[187]. The adoption and adaptation of innovative technologies in dissemination of information needed by farmers for a better performance has given further impetus to zero-hunger target of the United Nations (UN) Sustainable Development Goal (SDG). Digital extension delivery focuses on timely information provision and knowledge transfer that include social, economic, as well as technical, innovations to all major players in the agricultural sector, especially farmers. For instance, through precision agriculture, farmers have been equipped with adequate information and knowledge, effectively managed and control all aspects of food

production, processing, and storage to improve production sustainability[202]. Farmers' use of effective adaptation, resilience and mitigation approaches made available through digitally enhanced extension platforms to mitigate the vagaries of changing climate offer potential ecological, agronomic, economic and social co-benefits[188,189].

Digital extension has changed every aspect of the Agro-food value-chain; through the deployment of internet of things (IoT), cloud computing technologies, and management software and Apps, the management of agricultural resources throughout the system has become highly optimized, individualized, localised and pre-emptive, and the effects demonstrated in yield and productivity improvement in food production.[92]. The potentials of digital extension anchored on its real time functions through data driven internet hyper-connectivity that enabled the entire agricultural value chains to become traceable and coordinated at the most detailed levels whilst different fields, crop production activities can be accurately managed to their optimal prescriptions[133,190]. Digital agricultural extension has created systems that are highly predictive, anticipatory, strategic and adaptable to changes such as those caused by adverse climate, leading to greater efficiency in productivity, profitability and sustainability[93,94,191].In the context of the Sustainable Development Goals, digital agriculture has the potential to deliver economic benefits through increased agricultural productivity, cost efficiency and market opportunities, social and cultural benefits through increased communication and inclusivity and environmental benefits through optimized resource use as well as adaptation to climate change[45,125].

The various areas in crop production that have been influenced by digitalisation of agricultural extension delivery systems are enumerated as follows;

i. **Crop Production Diversity:** The use of digital Agro-tech platforms and advisory services by farmers has enabled them to diversify their production and cultivate different food crops with competitive nutritional and market values. Crop productivity was

observed to be positive among farmers that learnt to grow different food crops but negative for those that specialised on a particular lucrative crop. Crop diversification has been considered as an adaptation response to long-term climate change, as high reliance on rain-fed agriculture makes farmers more vulnerable to weather variability and therefore serve as an important driver of crop diversification[95,96.]

ii. **Input Use Intensity:** Farmers receive timely seasonal information and advisory services that specify the types, quantity and mode of application various agricultural inputs such as quality seeds, fertilizers, pesticides, herbicides, and other farm inputs. Optimum investment in quality agricultural inputs was positively associated with improved yield and productivity, while inadequate use and/or overuse as well as high inputs cost due to information asymmetry was negatively associated with crop yield. According to[192], crop yields will improve significantly by 70% with the introduction, dissemination, and adoption of precision agriculture technologies, with 18% yield increase due to precision fertilizer application, 13% increase due to precision planting, 4% increase due to precision spraying, and 10% increase due to precision irrigation.

iii. **Crop Productivity:** Improved access to information through digital extension services is expected to result in higher crop productivity as personalized advice on crop choices and input regimes will hardly lead to lower yields and revenues, unless the information provided is flawed. Digital extension services are usually specific and individualised considering the peculiarity and complexity of the edaphic factors, and economic competitiveness of the crops grown[97].

iv. **Crop Commercialisation:** This refers to the share total of crops sold by farmers per growing season. Access to market through e-commerce and other digital platforms and/or market forecasts creates vantage points for farmers with privilege of price comparison and healthy competitiveness. Digital marketplaces and e-platforms for agricultural products provide direct linkage between producers and consumers, shortened agro-food

value chains, expand producers' access to new markets (usually within national borders), reduce food loss, create new business opportunities for small agricultural producers and small- and medium-sized enterprises (SMEs), and improve price transparency[98,194].

The potential benefits of digitalizing the agro-food sector are convincing but it will require major transformations of farming systems, rural economies, communities and natural resource management. These pose a challenge and require a systematic and holistic approach to achieve the full potential benefits[38].

Digitalization of the agro-food system involves the risk that the potential benefits will be unequally distributed between rural and urban areas, gender, and youth population. Urban areas often have better developed 'digital ecosystems' (resources, skills, networks) compared with rural areas. Combined with global trends of urbanization and middle and rich classes settling in cities, there is potential for digitalization to exacerbate existing rural-urban disparities and populations to fall behind in the process of a digital transformation. FAO is committed to assist governments and partners' bridging such multidisciplinary digital divides to ensure that everyone benefits from the emerging digital society[38].

There are several conditions that will shape the digital transformation of agriculture in different contexts:

i. Basic conditions are the minimum conditions required to use technology and include: availability, connectivity, affordability, digital education and supportive policies and programmes (e-government) for digital strategies;
ii. Enabling conditions ('enablers') are factors that further facilitate the adoption of technologies: use of internet, mobile phones and social media, digital skills and support for agripreneural and innovation culture (talent development, sprint programmes including hackathons, incubators and accelerator programmes).

There are some basic conditions that must exist for the use of digital technologies and therefore for digital transformation of the agriculture and food sector. These include: infrastructure and connectivity (mobile subscriptions, network coverage, internet access, and electricity supply), affordability, educational attainment (literacy, ICT education) and institutional support. Access to digital technology can offer significant advantages to smallholder farmers and other rural business by providing links to suppliers and information and allowing users to tap into workforce talent, build strategic partnership, access support services such as training, finance and legal services and, critically, reach markets and customers. However, the introduction of digital technologies in rural areas can be a challenge. Around the world, rural populations are declining and education and employment opportunities are limited. There is often a lack of infrastructure, including basic IT infrastructure, particularly in very remote rural communities and those with large indigenous populations. The costs associated with IT infrastructure present a major challenge in rural areas where rates of poverty are often high, especially in developing countries and least-developed countries (LDCs)[38].

2.1.22 Oyo State Government and Agricultural Productivity

Agriculture remains the mainstay of many States in Nigeria and Oyo State is not an exemption. In Oyo State, agriculture is the currently the leading driver of the State's economy, contributing approximately 38% to the gross state product (GSP), and directly or indirectly employs as much as 70% of the State workforce. Thus, agricultural sector is the priority of the restoration, transformation and reposition agenda and economic development programmes of the State Government. The numerous potentials in the sector as demonstrated by wide range of both arable and cash crops produced across the four agricultural zones, and these include but not limited to cocoa (41,320 tonnes), oil palm (66,970 tonnes), cassava (2.92m tonnes), yam (2.5m tonnes), maize (431,140 tonnes) and rice (290 tonnes), oranges

(321,490 tonnes), banana (61,770 tonnes) and tomatoes (6210 tonnes), among others [267,268,269]. In order to boost productivity in the agricultural sector, the state government has commissioned and maintained rural feeder and farm settlement roads, established cottage industries in commodities clustered areas, established cassava processing and products packaging plants, established agricultural training centre for youths at farm mechanisation (through the Youth Employment in Agribusiness and Sustainable Agriculture project), and promotes farmers-market linkage through a varieties of approaches, among others [100,101,195].

2.2 Theoretical Framework

Theories can be described as a generalised statement of abstractions or ideas that assert, explain or predict relationships or connections between or among phenomena, and presented within the limits of critical bounding assumptions that the theories explicitly make; and the generalised statement is demonstrated by interrelated concepts, definitions, and propositions that explain or predict the events or situations by specifying relations among variables in order enables better understanding of the phenomenon and prompt appropriate acts[196].

The expounded concept of theory is presented as a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena[197]. The definition highlight three things: 1.) a theory is a set of propositions that consists of defined and interrelated constructs; 2.) a theory sets out the interrelations among a set of variables (constructs), and in so doing, presents a systematic view of the phenomena described by the variables, and 3.) a theory explains phenomena by specifying which variables are related to which variables and how they are related, thus enabling the researcher to predict from certain variables to certain other variables. Thus, a theory usually emerges from a long process of research that uses empirical data to make assertions based on deductive and inductive analysis of the data; and on the basis of clearly stated assumptions,

the observations from the research produce results that converge on findings about relationships, and these enable the researcher to formulate the core propositions from which the abstract theory is then generalised[196,198]. Recent definition expressed theory as "an explanation of a phenomenon or abstract generalization that systematically describes the relationship among given phenomena, for purposes of explaining, predicting and controlling such phenomena"[199]. According to the definition, the function of any theory in research is to identify the starting point of the research problem and to establish the vision to which the problem is directed.

This section therefore presents the theories and models that are considered relevant, and form the basis for some a-priori of the study. These theories include Diffusion OF Innovation Theory (DiT), Unified Theory of Acceptance and Use of Technology (UTAUT), and Technology Determinism Theory (TDT).

2.2.1 Diffusion of Innovation Theory (DIT)

The theory propounded by Rogers in 1962 and extended in 2003, explains how, over time, an innovation (an idea, product, or technology) gained momentum and diffuses (spread, circulate) through a specific population or social system. It creates a feedback mechanism to agricultural researchers and provide the basis for creating a coherent body of generalisation without which, the purpose of completed research would be lost[199,200]. IDT maintained that five factors influence the adoption of innovation among farmers, and these are:

i. **Relative Advantage:** the degree to which the innovation is perceived as better than the idea, product or technology it supersedes by a particular group of users in terms of economic advantage, improved yield, social prestige, or satisfaction;

ii. **Compatibility:** how consistent the innovation is with the values, experiences, and needs of the potential adopter (farmers). An innovation that is compatible with farmers' values,

norms, and practices will likely experience rapid adoption, while incompatible innovation is like to be rejected;

iii. **Complexity/Simplicity:** this refers to the degree of ease- or difficulty- to understand and/or use the innovation. Innovations that are simple to understand and easy to use are likely to be readily adopted by farmers than those that require the farmers to acquire new skills and understanding to operate;

iv. **Trialability:** the extent to which the innovation can be tested or experimented with before actual commitment for adoption is made. The ability to experiment with new technology increases their chances of adoption;

v. **Observability:** the extent to which the adopted innovation yielded expected outcomes. Visible results eliminate uncertainty and stimulate peer discussion of the innovation, this improved the rate of dissemination of the idea and subsequent increase in the rate of adoption among farmers[200,201].

The adoption of innovation involves critical decision-making processes in which a farmer passes through five different stages of adoption process namely knowledge, persuasion, decision (to adopt or reject), implementation of innovation, and confirmation of decision[200,202].

i. **Knowledge Stage:** At this stage, the farmer is exposed to existence of an innovation through different communication channels, and questions like "what", "how" and "why" about the innovation are often posed for awareness-knowledge purpose.

ii. **Persuasion Stage:** This occur when the farmer shows interest in the innovation and actively seek further relevant information for clarity.

iii. **Decision Stage:** The farmer takes the concept and weighs the advantages and disadvantages of using the new technology, form an attitude (positive or negative) toward the innovation, and decides to adopt or reject it.

iv. **Implementation Stage:** The farmer deploys (practice) the innovation to a varying degree depending on the situations. The implementation stage involves overt behaviour change as the new idea id eventually put to practice by farmers.

v. **Confirmation Stage:** This is the stage of authentication and endorsement marked by definite behavioural change toward the innovation which could be motivated in part by a state of internal disequilibrium (cognitive dissonance), an uncomfortable state of mind that the farmer seeks to reduce or eliminate. The farmer finalizes his/her decision to continue using the innovation, and seek supportive information that confirm his decision.

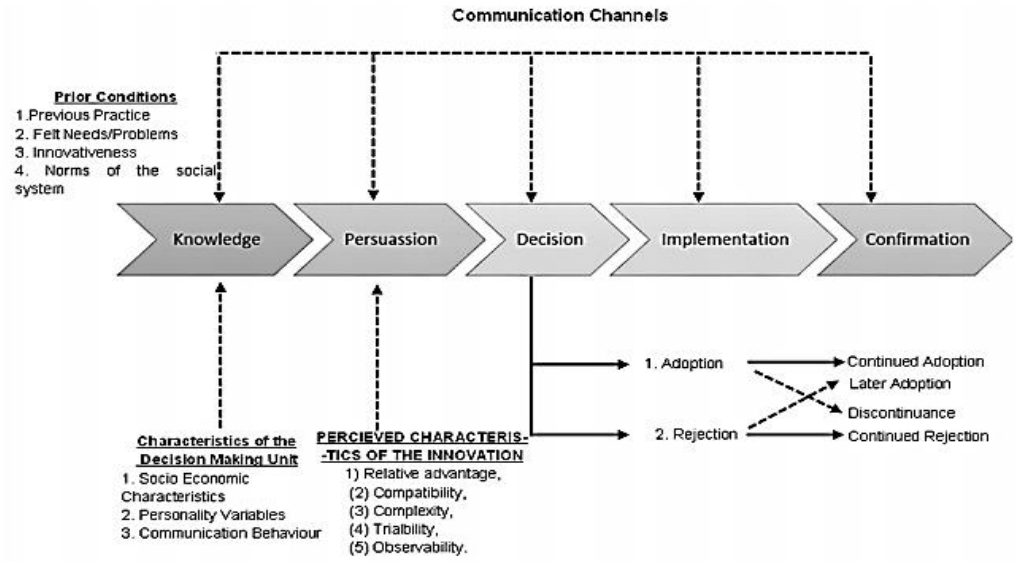


Fig 2.3: **Stages of Innovation-Decision Process: Diffusion of Innovation Theory**
Source*: sgbfamilylaw.com*

However, the process of diffusion has been observed to be more complex and fraught with difficulties, primarily because new techniques or technologies have to be embedded within local circumstances and contexts to function successfully[203]. Apart from the specific characteristics of the innovation as mentioned above, other factors like economic, social, cultural, ideological and psychological conditions all play a significant role in the diffusion process. Economically, the intrinsic economic benefit of an innovation could only be of importance if it adapted to the local or personal situations, and perceived as such by the farm

families; as most subsistence farm economies tend to focus more on security, stability and flexibility, with the aim of feeding the family and minimizing risk, rather than increasing output or profitability[204].

The social and political context involved revolve around decision-making roles in the adoption process. Here the ability to implement changes and to accept or share risks is crucial, and this is influenced by factors like land ownership (inheritance, outright purchase, or lease), farm size, personal wealth, social status, household structure (whether nuclear or extended) and its stage in the lifecycle (presence of children). The prevailing ideology such as willingness to challenge nature, existence of taboos and socio-cultural norms usually influence whether the maintenance of status quo or initiatives for change are pervasive. Conclusively, the psychological make-up of farmers influences their inclination and readiness to try new things. This inclination is shaped by personal characteristics like age, education, socio-economic status, ambition, competitive spirit, ability to mix widely, business acumen, among others[319]. Thus, farmers are classified into five categories of adopters[200];

i. **Innovators:** These are adventurous risk-taker individuals with the highest social status, financial liquidity, and closest interactive contact with both scientific sources and other innovators. Their risk tolerance allows them to adopt technologies that may ultimately succeed or fail, while their financial resources help absorb these likely failures[202,205].
ii. **Early Adopters:** These are opinion leaders who are the first within their group to adopt, and are willing to maintain their position by evaluating innovations for others. They have higher social status, financial liquidity, advanced education and are socially forward. However, they are more discreet in adoption choices than innovators, and this help them maintain central communication position[202].
iii. **Early Majority:** These include individuals who are more watchful and mooted to adopt an innovation. Although, they usually rely on information provided by early adopters to

use a new technology or an innovation, they are highly pragmatic and comfortable with moderately progressive ideas, hence, won't act without solid proofs of benefits.

iv. **Late Majority:** They are individual that are very sceptical and cautious about innovations at first, but who eventually succumb to peer pressure. These group include individual with below-average social status, little financial liquidity, less opinionated, and limited contact with early and late majority[202,206].

v. **Laggards:** They are the last to adopt any innovation. Those in this category typically have an aversion to change-agents, and tend to focus on "traditions", maintaining the status-quo. They are individual with lowest social status, lowest financial liquidity, oldest among adopters, and often in contact with only family and close friends. Due to their limited resources and awareness-knowledge, laggards often think up argument against the innovation, in the process help the innovator improve the innovation (reinvention) and make it more inclusive[202].

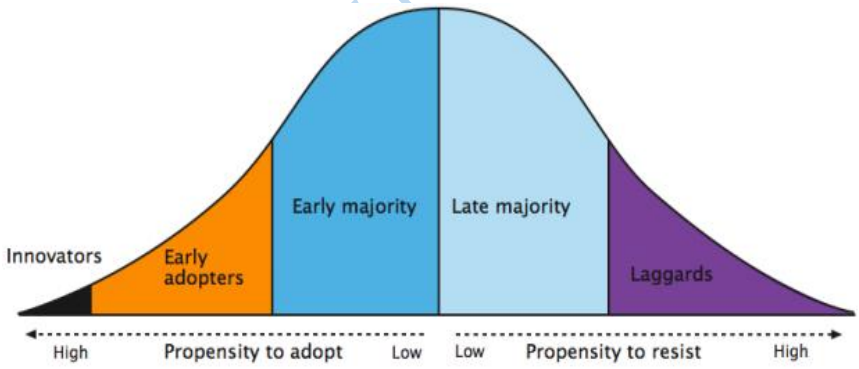


Fig 2.4: **Adopters Categorisation: Diffusion of Innovation Theory**
Source: *linkedin.com*

Thus, the DIT sees change (adoption of innovation) as a product of "reinvention" of ideas, products, technology, and/or behaviours so they become better fit to the needs of farm families and households. Therefore, digital extension services and the delivery system must be compatible with the needs of farmers, easy to understand and use, accessible for experimentation and/or trialability, and offer visible benefits to farmers to prompt their adoptions.

2.2.2 The Unified Theory of Acceptance and Use of Technology (UTAUT)

The theory was developed by Venkatesh in 2003 with four cardinal determinants of behavioural intention to use digital technology viz; 1.) Performance expectancy, 2.) Effort expectancy, 3.) Social influence, and 4.) Facilitating conditions. Farmer's behavioural intention was described as the farmer's expectation he/she executed plans and decisions regarding the use of innovative idea or technology. UTUAT seek to establish acceptance and usage behaviour of farmers on technology.

i. **Performance Expectancy:** This represents the degree to which farmers expect the acceptance and usage of technology to help them attain higher management performance and improve crop productivity. Performance expectancy influences the behavioural intention, and it is moderated by age and gender, with a stronger effect on younger male farmers;

ii. **Effort Expectancy:** This refers to the degree of ease of usage connected with the acceptance and usage of the innovative technology. The construct influences the behavioural intention and it is moderated by age, gender, and experience, with a stronger effect on young women and older farmers at the early stages of experience;

iii. **Social Influence:** It connotes the degree to which an individual farmer perceives as important others believe in his/her usage of the new technology, that is, the influence of people's opinion on the farmer's initiation and continuous use of an innovation. The construct influences the behavioural intention of farmers, and it is moderated by age, gender, experience, and voluntariness, with stronger effect on older women, particularly in mandatory usage in early stages of experience; and

iv. **Facilitating Conditions:** The degree to which a farmer believes that an organizational and technical infrastructure exists to support the use of innovative technology. Although, the facilitating conditions have no influence on behavioural intentions, it however

influences the usage behaviour that is moderated by age and experience, with stronger effect on older farmers, particularly those with increased experience[207,208].

The impacts of the four exogenous constructs of theory on usage intention and user behaviour was posited to be moderated by age, gender, experience, and voluntariness of farmers. Research that UTAUT is a powerful technology acceptance model due to its parsimonious structure and higher explanatory power that efficiently predict and explain farmers' intentions to use an information system and their subsequent usage behaviour[209,210,211].

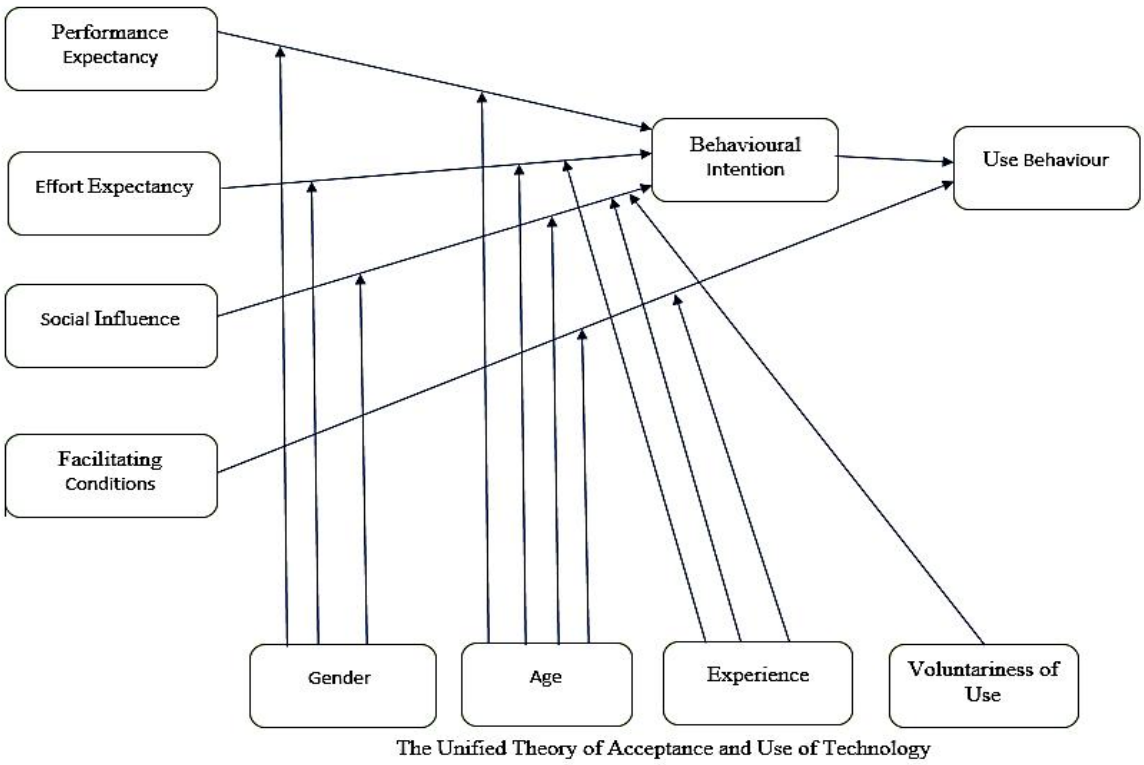


Figure 2.5: The Unified Theory of Acceptance and Use of Technology
Source: *www.researchgate.net/profile/Mohammad-Ahamd-26/publication/270282*.

2.2.3 Technology Determinism Theory

First postulated by American social scientist Thorstein Veblen in mid twentieth century suggests:1) technology has autonomy of development; 2) the development of technology is progressive; and 3) the development of technology is emergent, that is, it is the determinant of all social transformations and cultural modifications. The founder argued that invented

technology shapes society and culture, influencing human behaviour, social structures, and communication patterns[212,213,214].

In the context of digital communication in agricultural extension, technology determinism theory emphasizes the transformative impact of digital technologies on agricultural practices, information dissemination, and extension service delivery. It is argued that digital communication tools, such as the internet, mobile phones, and social media platforms, have revolutionized agricultural extension service delivery by enabling real-time access to information, expert advisory services, weather information, and market opportunities. Farmers and other agro-allied stakeholders can leverage digital platforms to exchange knowledge, share best practices, and collaborate with experts and peers remotely, regardless of geographical constraints[212,213,215]. In addition, digital communication technologies have democratized access to agricultural information and resources, empowering farmers with valuable insights, weather forecasts, pest management strategies, and market prices. By providing timely and relevant information, digital communication enhances farmers' decision-making processes, improves agricultural productivity, and fosters sustainable practices. digital communication facilitates the dissemination of extension services and interventions to remote and underserved agricultural communities. Through online training programs, webinars, and interactive multimedia resources, extension agents can reach a wider audience and deliver targeted support tailored to farmers' specific needs and contexts. This amplifies the reach and impact of agricultural extension initiatives, contributing to rural development and food security goals[216,217,218].

Thus, technology determinism theory sheds light on the profound influence of digital communication technologies on agricultural extension practices. By leveraging digital platforms, extension agents can enhance knowledge sharing, capacity building, and farmer

empowerment, ultimately contributing to sustainability of agricultural production and food security[219,220].

2.3 Review of Empirical Studies

Research has shown that several digital platforms have been efficiently explored in a bid to provide accurate and timely information in various sectors globally[221]. In many developing countries, agriculture is the predominant occupation among the majority of the populace, and traditional extension services are limited by lack of extension personnel, expertise, up-to-date information regarding market access, timeliness, information storage. Digitalization was therefore posited as critical in overcoming the limitations through utilization of various information and communication technology (ICT) tools like Decision support systems, databases, Agri-based Apps, Kiosks. These advanced approaches will not only support the extension and farming communities but also improve their skills and enhance their contributions to the national Gross Domestic Product. Research work also covers various digital tools and their efficiency with a supporting case study on utilization and impact of digital extension services (DES) on farmer's knowledge in terms of agricultural practices. The research has shown that digital extension services play a vital role in the dissemination of updated information necessary for the improvement and promotion of agricultural value-chain management.

How User-Centred Design can be used to develop information services for complex and resource-restricted smallholder farming contexts, to promote Sustainable Intensification (SI) as a rural development paradigm for sub-Saharan Africa was demonstrated in Tanzania[181]. It was illustrated that the achievement of SI requires that smallholder farmers should have access to information that is context-specific, increases farmers decision-making capacities, and adapt to changing environments. The current extension services often struggle to address

agricultural extension services' needs, however, through new mobile phone-based services they were resolved.

Thus, to enhance the public extension service in Tanzania, a digital service was created that addresses smallholder farmers' different information needs for implementing SI. Using a co-designed User-Centred-Design, feedbacks were elicited from farmers and extension agents in Tanzania to create a new digital information service, called Ushauri. The automated hotline gives farmers access to a set of pre-recorded messages. Additionally, farmers were able to ask questions in a mailbox, and extension agents then listen to these questions through an online platform, where they record and send replies via automated push-calls. The result demonstrated that farmers actively engaged with the service to access agricultural advice, and extension agents were able to answer questions with reduced workload compared to conventional communication channels[222].

At the exploration of the role of innovation intermediation in a digital age through comparing public and private new-ICT platforms for agricultural extension delivery in Ghana, it was observed that sub-Saharan African region is currently experiencing a new-ICT revolution[228]. There are high expectations on new-ICTs capabilities to enhance interaction and information exchange in extension service delivery. Using an innovation systems perspective, the roles demand-articulation, and matching demand and supply, innovation process management for innovation-intermediaries were distinguished. The comparative study of public and private extension organisations was carried out through direct interview with extension staff and farmers. Findings indicated that while both platforms aim to support innovation-intermediation roles, the focus areas and level of detail differ due to diverging organisational rationales to service delivery.

In addition, new-ICTs' potential to support innovation-intermediation roles was observed to be far from realised. This was not attributed to (new) ICTs' lack in capacity to link people in

new ways and make information accessible, but to wider social, organisational and institutional factors that define the realisation of their potential. Therefore, more conventional modes of interaction around production advisory services and credit provision continue to be dominant and better adapted to the situation. It was however observed that beyond the two platforms that were developed specifically by the extension organisations, there were indications that more informal and self-organised new-ICT initiatives that can transform and enhance interaction patterns in innovations systems to achieve collective goals through standard virtual platforms such as *WhatsApp* and *Telegram*[223].

On evaluating the overview of the current perspective of social media and agricultural extension service delivery, evidences obtained revealed that there are many social media platforms being used in agricultural extension service delivery worldwide. Facebook had the highest popularity (64.7%). One-third of agricultural stakeholders using social media were versatile users who usually visit only to find information (75.7%). The report further revealed that many challenges are currently faced in use the of social media for agricultural extension service delivery; viz. illiteracy, shortage of infrastructure, limited participation, non-institutionalisation, lack of quality control, lack of adequate yardstick for measuring impact, and need for gender sensitive approach. Although, social media is gradually appreciated in agricultural extension service delivery, the current challenges necessitate the deployment of appropriate structures and required efforts by all stakeholders to enhance usage by extension agents and farmers[224].

In reviewing relevant research literatures to inform future investments into agricultural information services that harness the full potential of digital media, a recently emerging innovation agenda that is, in part, a response to the eventual failure of many new agro-advisory initiatives was described[225]. One important cause of failure was a focus on pushing certain technologies, rather than responding to the particular communication needs of

potential users. To avoid such bias in designing new services, it was posited that the new innovation agenda must rest on two major foundations: strong user-centeredness and problem-orientation. The first described how user-centred design methods could help in specifying both the challenges and solutions of digital agricultural extension delivery services. To inform responses to the communication challenges defined by that analysis, eight emerging aspects of ICT usage for development, and how to address the common deficiencies of agricultural extension delivery services were described. Practical examples from the literature highlighted the possibilities and limitations of these innovations. It was therefore concluded that beyond digital design, technological innovation requires enabling environment and structural institutions[225].

Similarly, in the overview of agricultural extension services in Turkey, public extension service was examined through data collected from 538 extension workers in nine agricultural provinces. It was observed that the Turkish extension service was influenced by the general top-down and training-visit approaches which were employed in the past. These approaches were mainly directed to conventional production and yield increase, by using a top-down process that gives little place for human resources development for sustainable agriculture. It was then posited that new opportunities of digital devices such as cell phones, internet, and e-mail were generally underutilized during farmers' trainings; and local participation is not at intended level during the formulation of extension programmes and activities[226].

On examination of the digitalisation of agricultural extension service in Ethiopia, recent research showed that Information Systems (IS) developed to improve the livelihoods of smallholder farmers and their farming practices have experienced mixed levels of success[227]. As such, an evaluation of contextual factors and the socio-technical requirements of agricultural were needed to fully understand the challenges of digitalizing Agricultural Extension Information Service (AEIS) in developing countries, and the socio-technical

design and reality features of an AEIS that was intended to digitalize AEIS in Ethiopia were examined. Conceptually, design-reality framework was adopted to unravel the changing socio-technical design requirements and, empirical qualitative case study of an existing AEIS was carried out. The findings showed that gaps existed between the designed artefact and the lived experiences of stakeholders' activities. The need to shift from a simplistic approach that focuses on providing access to digital content and devices to a balanced approach that addresses socio-technical requirements while digitalizing the public agricultural extension information services was advocated[227].

Investigation of the potentials of smartphone applications for strengthening accountability in public agricultural extension services in Uganda was conducted by examining a smartphone application called 'e-diary' that was developed and tested in the country[228]. Individual face-to-face interviews and focus group discussions were used for data collection. Findings indicated that smartphone applications have the potential to strengthen accountability in the public agricultural extension services by enabling remote supervision in real-time, which reduces the costs and time of supervision. However, the study also indicates that the successful implementation of such tools requires incentives such as awards of recognition. The findings also established the potentials of ICTs in strengthening the management of public services (such as agricultural extension) in developing economies.

The examination of farmers' ready to use phone-based digital tools for agronomic advice revealed that digital extension is widely embraced in African agricultural development programmes, with promising outcomes and impact[229]. Phone-based services reportedly attracted special attention as effective and efficient tools for agricultural extension service delivery. However, previous assessments of digital extension services were generally ex-post in nature, thus the consideration of users and broader systems usually occur once an intervention is broadly identified. It noted that early understanding of user needs, readiness,

and relevant context is a prerequisite for successful adoption and sustainable use of digital extension services. Findings however, demonstrated limited capacity to access and utilise phone-based extension services among farmers, especially those that required the use of smartphone. It also revealed a mismatch between expected user-readiness and actual user-readiness, and current capabilities and opportunities. The findings therefore provided an entry point for designing suitable digital extension projects and interventions, and suggested the need for capacity building.

An investigation on farmers' perceptions of agricultural extension agents' performance in Sub-Saharan African communities was conducted, considering the important role of extension agents in the rural community. The research sought to measure the performance of extension workers in relation to agricultural production from smallholder farmers' perspective. The findings revealed extension service delivery did not significantly increase crop production among farmers in the study area. The findings further showed that majority of the farmers perceived lack of regular contacts with extension agents as a great challenge, and that extension agents were grossly inadequate and ineffective. Since contact with extension agents was ineffective, the results obtained also showed that smallholder farmers resorted to their preferred traditional ICT, mainly radio as their main source of accessing agricultural information. The employment, training and deployment of graduate as extension workers to improve the current ratio of extension agent to farm families was thus recommended[73].

Broadcast digitalization with its enormous benefits to the broadcasting industry is believed to have the potentials to improve the quality of programme contents delivered by television stations[11]. However, majority of the farmers who are agrarian and depend on existing agricultural extension delivery systems to improve their productivity of food and fibre for consumption and provision of raw materials for the industry are left out in the discourse by

other stakeholders and policy makers. Examination of the effect of broadcast digitalization on agricultural information dissemination in Nigeria showed that the use of mass media such as television for agricultural extension service delivery will not only hasten information dissemination but afford farmers the opportunity to hear and watch new agricultural practices.

The findings revealed the importance of mass media such as television cannot be underscored in the delivery of timely agricultural information for the purpose of ensuring increased productivity among the farming households. The result also established that audio-visual broadcast was a better means of information delivery in agricultural extension. Despite the potential benefits of digital broadcasting to extension service delivery, the cost implication placed it far beyond the reach of rural poor farm families. It was therefore recommended that agricultural extension services should be aired on national television stations that are digitally compliant to avoid extra charges by state owned stations[168].

Investigation into how India is transforming agriculture with digital technologies showed that although agriculture continues to be the most important sector of the Indian economy and remained more or less a compulsion for livelihood of millions of farm families, Indian agriculture faces several challenges such as low yield, inconsistent product quality, lack of knowledge about domestic as well as international markets and poor access to diversified agriculture information[230]. Farmers need timely and location specific information at all stages of agricultural cultivation in their local language, and to mitigate the problems, adoption of digital technology which improves the speed of information dissemination, networking embraced by the government. Findings revealed application of digital communication technologies in rural areas improved farmers' knowledge and skills through timely information dissemination and participation in innovative farm practices. In order to further solve the problems of low yield, poor product quality, and poor access to international market,

the adoption of digital initiatives such as Digital green, mobile technology, e-Choupal, precision farming, and agricultural drones were recommended at larger scale[230].

A field experiment was conducted among maize-farming households in eastern Uganda to test how video-enabled extension messaging affects outcomes directly related to maize management and production. Men, women, and couples were randomly assigned to view videos about improved maize management practices in which male, female, or both male and female actors were featured. Investigation was first carried out to determine whether targeting women with information increases their involvement in productive decision-making processes; and exploration was later carried out to determine if the provision of information in videos featuring a woman-challenging the idea that maize cultivation is a predominantly male activity- affects outcome for women. The findings revealed that screening videos containing information on maize management and production to women increased their knowledge about improved maize management practices, their role in agricultural decision-making, the adoption of recommended practices and inputs, the quantity of maize sold to the market, and production-related outcomes on women-managed maize plots. However, it was also found that challenging role incongruity by featuring women in videos has limited effects[231].

The implication of digital transformation (digitalisation) on agricultural knowledge was conducted by examining how digital agriculture will intersect with the established modes of knowing and decision-making. Also considered were the implications for the wider Agricultural Knowledge and Innovation System (AKIS), especially the roles and capabilities of those who provide advice to farmers (extension workers), as well as those responsible for data analytics, and the organizations and institutions that link and support them. The findings revealed that the new data driven processes on farm, as well as the changing AKIS dynamic under digital agriculture, create new demands, relations and tensions to agricultural decision-

making, but also create opportunities to foster new learning by harnessing synergies in the AKIS in fulfilment of the expectation that smart farming approaches will ultimately improve knowledge about an individual enterprise, or via efficient sharing and learning of data from multiple enterprises[128].

The design of digital agricultural extension tools in the provision of site-specific advice and information to farmers was using data from a choice experiment in Nigeria. Data was elicited and analysed on the preferences of extension agents for major designed features of digital-enabled decision support tools (DSTs) aimed at site-specific nutrient management extension advice. The findings revealed extension agents were willing to use DSTs with special preference to those with high user-friendly interface that requires less time to generate results. The findings further showed heterogeneity of preference as some extension agents care more about effectiveness-related features of decision-support tools such as information accuracy and level of detail, while others prioritise practical features, such as tool platform, language and interface ease-of-use. It was recommended that the recognition and accommodation of the differences in preference will facilitate the adoption of DSTs by extension agents and thus enhance the scope for such tools to impact agricultural production decision-making capacity of farmers[131].

The impact of improved access to mobile extension on agricultural productivity was investigated to establish the significance of SMS-based agricultural information on farm productivity; since it was unclear if the variations in programmes design or the methodological challenges in evaluating the programmes could cause a wide-range impacts. It was observed that extension hotline services provide rapid, unambiguous information by agricultural experts over the phone, tailored to time- and crop-specific shocks. Thus, using the methods from experimental economics, hotline numbers were randomly distributed to farmers to generate exogenous variations in access to farming information. The results

showed that eliminating informational inefficiencies increases farmers' average yields for a high-stakes pigeon pea crop that faced adverse aggregate shock. The impact on the yield was attributed to the adoption of cost-effective and improved farming practices, and concluded that advisory recommendations customized to time- and crop-specific shocks are associated with a greater positive impact on agricultural productivity[129].

Literature was reviewed on the potentials and current contribution of digital technologies to sustainable agri-food systems in Middle East and North African (MENA) countries. Although digitalisation of agriculture offers potential solutions toward improved economic, social, and environmental sustainability of agri-food systems globally, and developed nations have led the innovation and adoption of digital agriculture, the potentials in the developing nations including MENA is still massive[193]. It was observed that improvements in primary production, supply chain and logistics performance, and optimised use of scarce natural resources (notably agricultural water) would be pronounced, if digital technologies can be implemented as envisioned. Available evidence also showed that adoption of digital agriculture is at early stages, generally led by high-value agricultural production targeting domestic markets in Gulf countries and export markets in Mashreq countries; economic sustainability appears the strongest force for current adoption, with less focus on social or environmental sustainability. It was recommended that public policies should not only promote the adoption of digital technologies in MENA but also ensure equity of access, transparency of use, and data and labour protections. Moreover, policymakers were also urged to move beyond the traditional, production-centred approach to deliver also on social and environmental sustainability[125].

2.4 Conceptual Framework

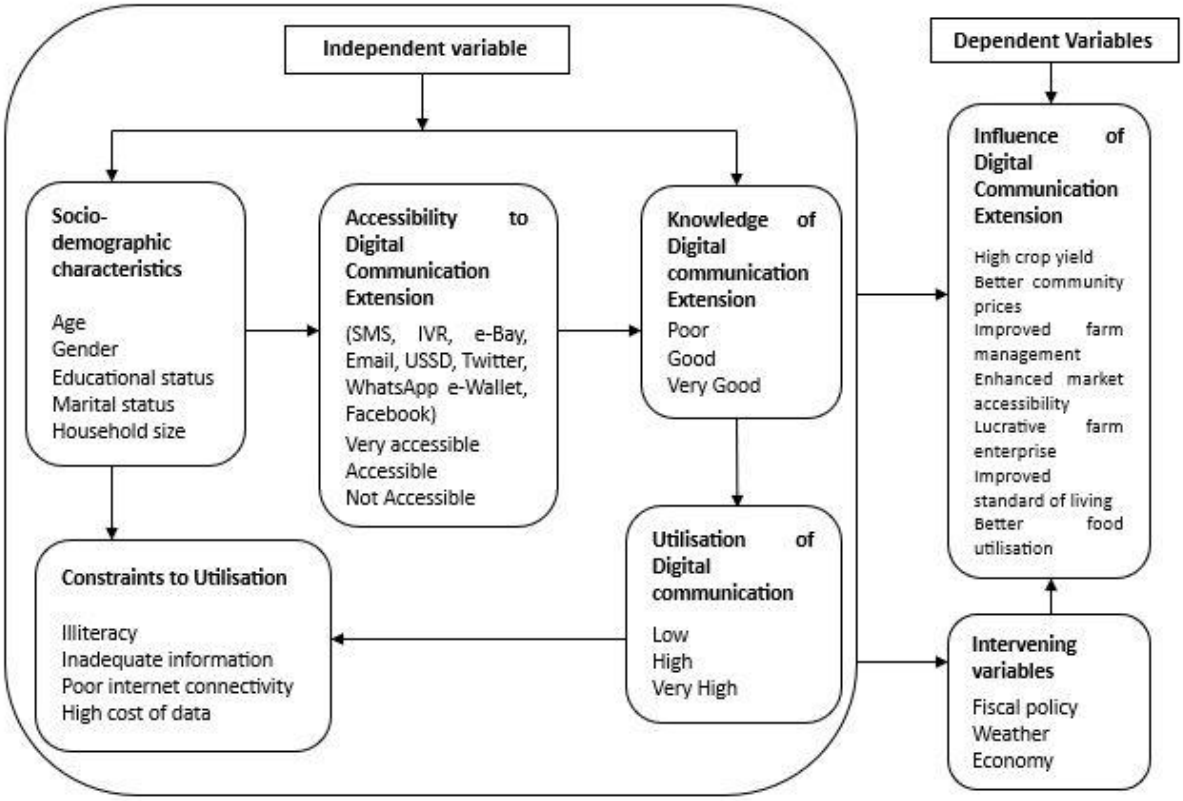


Figure 2.6: Conceptual Framework for the Study

This is a written or visual representation that illustrates the expected relationships between variables in research. It can be described as a system of concepts, assumptions, expectations, beliefs and theories that support and inform research. Conceptual framework defines the relevant variables for the study, and elucidate how they might be related and the implication of the relationships[232,233]. The concepts employed in the framework are generative and include abstractions, ideas, thoughts or beliefs typically associated with the objectives of the research that explained how the research questions will be explored[234,235]. The concepts that inform the research construct often contain diverse variables that serve as subsets to the holistic idea being considered by the researcher.

Socio-demographic characteristics of farmers refer to a combination of social and demographic variables like age, sex, educational attainment, religion, ethnicity, marital status,

household size, social status, occupational status among others that define and built the persona of a specific group or population; and the dissemination and adoption of modern agricultural techniques among farmers is significantly influenced by these socio-demographic characteristics[236,237,238]. Age is a critical factor that influences decision making as people of same age group have shared experiences that affect their preferences. Research has shown significant age-based digital divide; where young farmers are reported to be more digitally proficient than older farmers.

It is thus argued that young farmers are energetic and quick adopters of innovative technologies and users of information digitally disseminated[239,240,241]. Male-headed households have also been reported to use more digital extension than women farmers, although the claim has been disputed by other researchers. The proponents of higher internet utilisation among male attributed it to resource control which gives the male better access to modern digital devices[242,238]. Education has a strong positive correlation with technical efficiency and the use of digital extension required certain level of formal educational attainment. It increases the ability to obtain, process and use information relevant to the adoption of a new technology. Farmers' educational level could significantly motivate and determine the types of digital tools as well as extent of digital extension usage. Thus, socio-demographic characteristics such as age, gender, household size, educational attainment, and social status are among the major predictors of digital extension usage among farmers[80,242,243].

Enterprise Characteristics are variables that define the farm enterprise and they include but not limited to farm size, type of farm, years of farming, sources of capital, sources of input, land ownership type, and source/type of labour. Research has shown significant positive correlation between farm size and adoption of digital technology[131]. It was argued that a unit increase in the hectares cultivated potentiate the adoption of innovative technologies by farmers. Similarly, availability and accessibility of capital relaxes liquidity constraints and

boost farmers' risk-bearing capabilities. This enables them purchase innovative technological inputs including devices like smartphones and drones that encourage digital extension usage. The type of farm enterprise and its productivity greatly influence the use of digital extension. It was further posited that among those with higher likelihood of embracing digital extension were commercial farmers, farmers that cultivate crops with high-cash values, and size of farmland[190,244].

The knowledge of digital communication agricultural extension goes beyond awareness to entail digital communication extension literacy as well as the possession of required basic skills necessary for efficient use of digital extension tools to access updated modern agricultural information and harness the advantage associated with digital extension services (M. B. Naika, 2021)[326]. A key determinant of digital extension knowledge among farmers is educational attainment. Higher educational attainment increases farmers' exposure to current information and enable them accumulate more knowledge though reading, which in turn influences the attitudes and perception of farmers, making them receptive, rational, and willing to utilise digital agricultural extension. Other socio demographic variables such as social status, family income, age and gender have been found to influence farmers' knowledge and use of digital agricultural extension[221,242,243].

Digital communication agricultural extension platforms are media through which digital extension services like innovative ideas, modern agricultural techniques, current input prices, weather information, among others are disseminated to farmers efficiently and reaching a wider audience in the shortest possible time. These platforms include Short Messaging Services (SMS), Interactive Voice Response (IVR), Unstructured Supplementary Service Data (USSD), e-Bay, E-mail, e-Wallet, Facebook, Twitter, WhatsApp, Telegram, LinkedIn, and Instagram. Access to digital platforms can offer significant advantages to smallholder farmers by providing links to suppliers and timely information and allowing users to tap into

workforce talent, build strategic partnership, access support services such as training, finance and legal services and critically reach markets and customers[128,139].

The potentials of digital communication agricultural extension are enormous; however, these can only be harness when fully embraced, adopted and used by farmers and other key players along the agri-food value-chain. Utilisation of digital extension entails dissemination of agricultural information and innovative ideas using the various digital platforms as conduits. Usage of digital communication extension could enhance the effectiveness of extension service delivery by reducing outreach costs and help tailored the information to farmers' individual needs and situations; improve farmers' bargaining power by providing transparency and additional supplier options; improved access to personalized information and new technologies and inputs can increase the levels of commercialization; and promote agricultural productivity and market efficiency[190,245,246]. However, the level of usage is influenced by level of digital literacy and digital skills among farmers, availability of technology, accessibility of digital platforms, and accessibility of internet facilities[45].

Although, digital communication agricultural extension utilisation has the potentials to revolutionise agricultural productivity, these potentials have been constrained by some factors. Chiefly among these constraints is high level of illiteracy among farmers. This is particular challenging since proficiency in digital extension requires acquisition of certain level of knowledge and skills, and majority of the farmers do not have the basic education necessary to acquire this knowledge[247,248]. Digital skills and e-literacy remain a significant constraint to the use of new technologies and are particularly lacking in rural areas, especially in developing countries. Other constraints to digital extension utilisation include inadequate information on digital extension services delivery; poor internet accessibility and connectivity in rural areas; high cost of data; poor knowledge of digital-enabled technologies among

farmers; poor ICT infrastructure; complexity in usage; and erratic power (electricity) supply[45,136].

Digital communication extension has already changed the dynamics of the agri-food sector. Management of resources through digital agricultural extension services have become highly optimized, individualized, and anticipatory; driven by data and functioning in real time in a hyper-connected way. Agri-food value chain has become more traceable and coordinated at the most detailed level, while different field crops and market information can be accurately managed to their own optimal prescriptions[267]. Influence of digital extension has manifested in high crop yields, better commodity pricing, improved farm management systems, better food crop utilisation, enhanced market accessibility, and lucrative farm enterprise.

2.5 Summary of Gaps in Reviewed Literature

This chapter presented the review of relevant literatures related to the research. Literature reviewed on the concept of digital communication agricultural extension explored the meaning and relevance of digital communication extension to agricultural productivity, especially in food production, the economy of the smallholder farm families, and that of the nation.

The review of literature reveals agricultural extensions exposes smallholder farmers to innovative farm practices and technologies that enhance their productivity, increased income levels, improved livelihoods, and promote food security through the provision of critical up-to-date and timely information to farmers. The paradigm shift from conventional extension service delivery systems to digital extension services is brought about by the evolution and revolution of digital technologies with the array of potential benefits. Literatures reviewed describe digital communication agricultural extension as the use of phenomenal digital technologies and innovations in an increasing ubiquitous trend in the entire agricultural

value-chain, including sensors, robotics, digital communication tools, block-chains, computational decision and analytical tools, system integration, ubiquitous connectivity, artificial intelligence, machine learning, internet of things, cloud-based technologies, among others.

Literature revealed that although global food production has increased tremendously in the past few decades, developing nations like Nigeria is suffering from severe food shortage due to poor adoption of modern farming practices. The situation is exacerbated by population explosion, climate change, Covid 19 pandemic, and conflicts. The review further reveals that smallholder farmers are the engine-room in food crop production, and the major food crops produced by these farmers include cassava, yam, maize, beans, rice, millet, sorghum, tomatoes, pepper, oil palm trees, among others; and the quantity produced exceedingly fall short of the domestic demands.

The reviewed literature also shows digital communication extension and advisory services influence crop production and diversification which is an adaptation response mechanism to climate change. Timely information and knowledge acquisition on modern cultural practices, drought resistant cultivars with competitive nutritional and market values made available to farmers through various digital extension platforms were considered drivers of crop diversification. Improved access to personalised advisory extension services and adoption of precision agriculture was reported by literature to have the potential to significantly improve yield by 70%, while digital marketplaces and e-platforms for agricultural products provide direct linkages between producers and consumers, shortened agri-food value chains, expands producers' access to new markets, improved price transparency, and creates business opportunities to farmers.

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Chapter Three

Methodology

This chapter describes the study area, research design, population of the study, sample size and sampling techniques, descrption of the research instruments, and the procedures for collecting and analysing data necessary for the completion of the research. The chapter is presented under the following sub-headings:

3.1 Research Design

The study adopted descriptive survey research design. Descriptive survey research involves collection of data about the prevailing conditions or situations for the purpose of analysis, interpretation, comparisons, and identification of trends and relationships in order to proffer answers to questions covering the current status of the subject in the study. It also allows for quick data collection across different sections that belong to the same group at comparatively cheaper cost.

3.2 Population of the Study

The study population comprised all the 5250 registered farmers in Oyo State under the auspices of All Farmers' Association of Nigeria (AFAN), Oyo State Chapter. This includes but not limited to cassava, yam, rice, maize, tomatoes, pepper, and plantain farmers' resident

in Oyo State. All cash crop farmers' resident in the state will be excluded from the study as they do not fall within the scope of this study.

3.3 Sample and Sampling Technique

A sample size of 408 was used for the study. The minimum sample size was determined using the Taro Yamane formula and ten percent non-retrieval rate was added. The Taro Yamane formula is stated as follow;

$$n = \frac{N}{1 + N(e)^2}$$

Where;

n = Sample size

N = Population size = 5250

e = error margin = 0.05

Therefore;

$$n = \frac{5250}{1 + 5250\ (0.05)^2}$$

$$n = \frac{5250}{1 + 5250(0.0025)}$$

$$n = \frac{5250}{14.125}$$

$$n \approx 371$$

n + 10% non-retrieval

$$n = 371+37$$

$$n = 408$$

Thus, the minimum sample size for the study as calculated was 408 respondents.

A well-structured Google form was administered on the WhatsApp platform of the All Farmers Association of Nigeria (ALFAN), Oyo State Chapter with the consent of the State Chairman.

3.4 Description of the Research Instrument

A well-structured Google form titled "The Influence of Digital Communication Agriculture Extension on Food Crop Production in Oyo State" (IDCAEFCP) was used to elicit information from the respondents. The instrument was divided into seven sections (A-G). Equally Focused Group Discussion (FGD) sessions were conducted among Food Crops Farmers in the state under review to further validate the information from the respondents thereby making the research works robust.

Section A: This comprised structured questions designed to elicit relevant information about the socio-demographic characteristics of respondents such as age, gender, religion, educational attainment, household size, ethnicity, and estimated monthly income. The respondents gave relevant information about their socio-demographic characteristics as applicable.

Section B: This was designed to elicit information on the enterprise characteristics such as years of farming experience, types of food crop cultivated, size of farmland, sources of farm labour, sources of farm capital, sources of farm inputs, and avenues of produce sales.

Section C: This is a cognitive test that measures the level of knowledge of digital communication extension among respondents. It has three scale of True/False = 3; False/No = 2 and Not Sure = 1.

Section D: This was designed to determine the digital communication platforms accessible to the farmers. The farmers were presented with various digital communication extension platforms and were allowed to indicate by ticking the digital communication platforms accessible to them.

Section E: This was designed to assess the level of utilisation of digital communication Agricultural extension services among food crop farmers in the study area. A 4-point Likert response scale of Often = 4; Sometimes = 3; Rarely = 2; Never = 1. The respondents were expected to tick as applicable.

Section F: This was designed to investigate the constraints militating against utilisation of digital communication Agricultural extension services among food crop farmers in Oyo State. Farmers were presented with a list of constraints which were measured on a 4-points Likert response scale of Very Severe Constraint = 4; Severe Constraint = 3; Mild Constraint = 2; Not a Constraint = 1. The farmers were expected to tick as applicable.

3.5 Validity of the Research Instrument

The instrument was subjected to face validity by the Thesis Supervisor, while content validity was carried out by three other experts in statistics and evaluation. All corrections were subsequently made and comments incorporated as recommended before the link was shared at All Farmers Association of Nigeria, Oyo State Chapter WhatsApp platform for the of collecting data for this study.

3.6 Reliability of the Research Instrument

Reliability of a research instrument refers to the extent to which the instrument yields almost the same results over multiple trials. The link on the Google form was first shared on the WhatsApp platform of small groups of farmers who were in cooperative societies in the neighbourhood of Ogun State; a population homologous to the population of this study. The

researcher retrieved the Google forms where 41 forms, representing ten percent of intended sample size, were completely filled by the farmers. Data from the retrieved Google form was subjected to Cronbach's Alpha test, and the coefficients are as presented below;

Table 3.1: Reliability Coefficients of the Research Instrument

SN	Section	Number of variables	Reliability coefficient
1	B	10	0.72
2	C	15	0.69
3	D	13	0.81
4	E	10	0.72
5	F	10	0.76

Fieldwork, 2024

3.7 Method of Data Collection

A letter of introduction was obtained from the Department of Mass Communication and Media Technology, Lead City University to gain access to conduct the research with registered farmers in Oyo State under the auspices of AFAN, Oyo State Chapter. Data collection was carried out by the researcher with two research Assistants using the Google form on ALFAN, Oyo State Chapter WhatsApp platform. The forms were administered electronically for two weeks and completed forms were retrieved for analysis. For the qualitative study, two Focused Group Discussions (FGDs) were conducted in Atiba represting Oyo Zone and Ogbomoso representing Oke-Ogun Zone and Iseyin respectively. The interview schedule captured the socio-demographic characteristics of the respondents, Agricultural enterprise characteristics, accessibility to digital communication platforms, knowledge of digital communication Agricultural extension, level of utilisation of digital communication Agricultural extension services, constraints to utilisation of digital communication Agricultural extension services.

3.8 Method of Data Analysis

Data collected was systematically coded and analysed with the aid of Statistical Package for Service Solution (SPSS) version 27. The study adopted both descriptive and inferential statistical tools for the analysis. Descriptive tools such as mean and standard deviation, frequency distributions, and percentages were used to analyse the research question; and the outputs were presented on Tables. The hypotheses were tested using relevant inferential statistical tools like Analysis of Variance (ANOVA) at p-value ≤ 0.05 level of significance. The results from the analysis were used for interpretation and discussion of the research findings.

Endnotes

1. All Farmers Association of Nigeria (AFAN), Oyo State Branch, 2024.

Chapter Four

Results and Discussions of Findings

This chapter presents the results and discussion of the findings in line with the research questions and hypotheses of the study.

4.1 Demographic Data Analysis

Table 4.1: Socio Demographic Data of Respondents (N=408)

Variables	Description	Frequency	Percent
Age (Years)	20-30	111	27.2
	31-40	83	20.3
	41-50	132	32.4
	≥ 51	82	20.1
Gender	Male	289	70.8
	Female	119	29.2
Educational attainment	No formal education	12	2.9

	Primary	25	6.1
	Secondary	36	8.8
	Tertiary	335	82.1
Marital status	Single	101	24.8
	Married	269	65.9
	Separated	12	2.9
	Divorced	11	2.7
	Widowed	15	3.7
Religion	Christianity	167	40.9
	Islam	158	38.8
	Traditional worship	83	20.3

Source: Field Survey, 2023

Table 4.1 presents the frequency distribution of farmers' socio demographic characteristics in Oyo State, Nigeria. The result shows that the age bracket of one hundred and thirty-two (132): 32.4% of the farmers was between 41-50 years, followed by one hundred and eleven (111): 27.2% who were between 20-30 years; eighty-three (83): 20.3% who were between 31-40 years; and eighty-two (82): 20.1% who were 51 years and above. This implies that majority of the farmers were in their active and economically productive ages. It also signifies the entrant of young adults into agricultural farming and specifically, food crop production. The study was dominated by male gender as two-hundred and eighty-nine (289): 70.8% of the respondents were male farmers, while the female farmers accounted for one hundred and nineteen (119): 29.2%.

Concerning educational attainment, three hundred and thirty-five 335: (82.1%) of the respondents have attained tertiary education; thirty-six 36: (8.8%) had attained primary education; twenty-five 25: (6.1%) had only primary education; and twelve 12: (2.9%) had no formal education. These findings mean that the farmers are highly educated and well read, and only a fraction had below secondary education. It also signifies that majority of the respondents are expected to be familiar with digital communication. Two hundred and sixty-nine 269: (65.9%) of the respondents were married farmers; while one hundred and one 101: (24.8%) were unmarried farmers; fifteen 15: (3.7%) were divorced; while twelve 12: (2.9%)

and eleven 11: (2.7%) were separated or divorced, respectively. The result on religious affiliation showed that one-hundred and sixty-seven 167: (40.9%) of the respondents were of Christian faith; one hundred and fifty-eight 158: (38.8%) professed Islam; and eighty-three 83: (20.3%) were affiliated with traditional worship.

Table 4.2: Enterprise Characteristics in Food Crop Farming (N=408)

Variables	Description	Frequency	Percent
Years of farming experience	1-5	112	27.5
	6-10	119	29.2
	11-15	60	14.7
	16-20	117	28.7
Farm size (Hectares)	1-5	182	44.6
	6-10	125	30.6
	11-15	47	11.5
	16-20	30	7.4
Land ownership	Inheritance	140	34.3
	Purchase	146	35.8
	Communal	33	8.1
	Lease	89	21.8
Source of farm capital	Personal savings	220	53.9
	Family savings	56	13.7
	Loan from friends	24	5.9
	Loan from Cooperatives	72	17.6
	Loan from microfinance bank	25	6.1
	Government grant	11	2.7
Avenue for produce sales	Open market	307	75.2

	Off-takers	101	24.8
Profit of Product sales per hectare (₦)	≤ ₦100,000	9	2.2
	₦101,000-₦200,000	96	23.5
	₦201,000-₦300,000	116	28.4
	₦301,000-₦400,000	113	27.7
	≥ ₦401,000	74	18.1

Source: Field Survey, 2023

The frequency distribution on enterprise characteristics of food crop farmers as presented on Table 4.2 shows that one hundred and twelve (112): 27.5% of the respondents had between 1-5 years of farming experience, one hundred and nineteen (119): 29.2% had between 6-10 years of farming experience, sixty (60):14.7% had between 11-15 years of farming experience, and one hundred and seventeen (117): 28.7% had between 16-20 years of farming experience. The result also shows that one hundred and eighty-two (182): 44.6% of the farmers owned between 1-5 hectares of farmland, one hundred and twenty-five (125): 30.6% owned between 6-10 hectares of farmland, forty-seven (47): 11.5% owned between 11-15 hectares of farmland, and thirty (30): 7.4% owned between 16-20 hectares of farmland. One hundred and forty (140): 34.3% of the respondents claimed their land ownership was through inheritance, one hundred and forty-six (146): 35.8% claimed they acquired the land farming through direct purchase, thirty-three (33): 8.1% claimed the land they used for farming was communally owned, and eighty-nine (89): 21.8% claimed the land used for farming was leased.

It was further shown that two hundred and twenty (220): 53.9% of the respondents sourced their farm capital through personal savings, fifty-six (56): 13.7% sourced farm capital from family savings, twenty-four (24): 5.9% sourced their farm capital through loans from friends, seventy-two (72): 17.6% obtained loans from cooperatives, twenty-five (25): 6.1% obtained loans from microfinance banks, while a fraction, eleven (11): 2.7% acquired government grants as their farm capital. In addition, majority of the farmers, three hundred and seven (307): 75.2% sell their farm produce in the open market, while one hundred and one (101):

24.8% sold their farm produce directly to off-takers. Food crop production as measured in sales per hectare shows nine (9): 2.2% of the farmers made ₦100,000 or less per hectare, ninety-six (96): 23.5% made between ₦101,000-₦200,000 per hectare, one hundred and sixteen (116): 28.4% made between ₦201,000-₦300,000 per hectare, one hundred and thirteen (113): 27.7% made between ₦301,000-₦400,000 per hectare, and seventy-four (74): 18.1% made ₦401,000 and above per hectare.

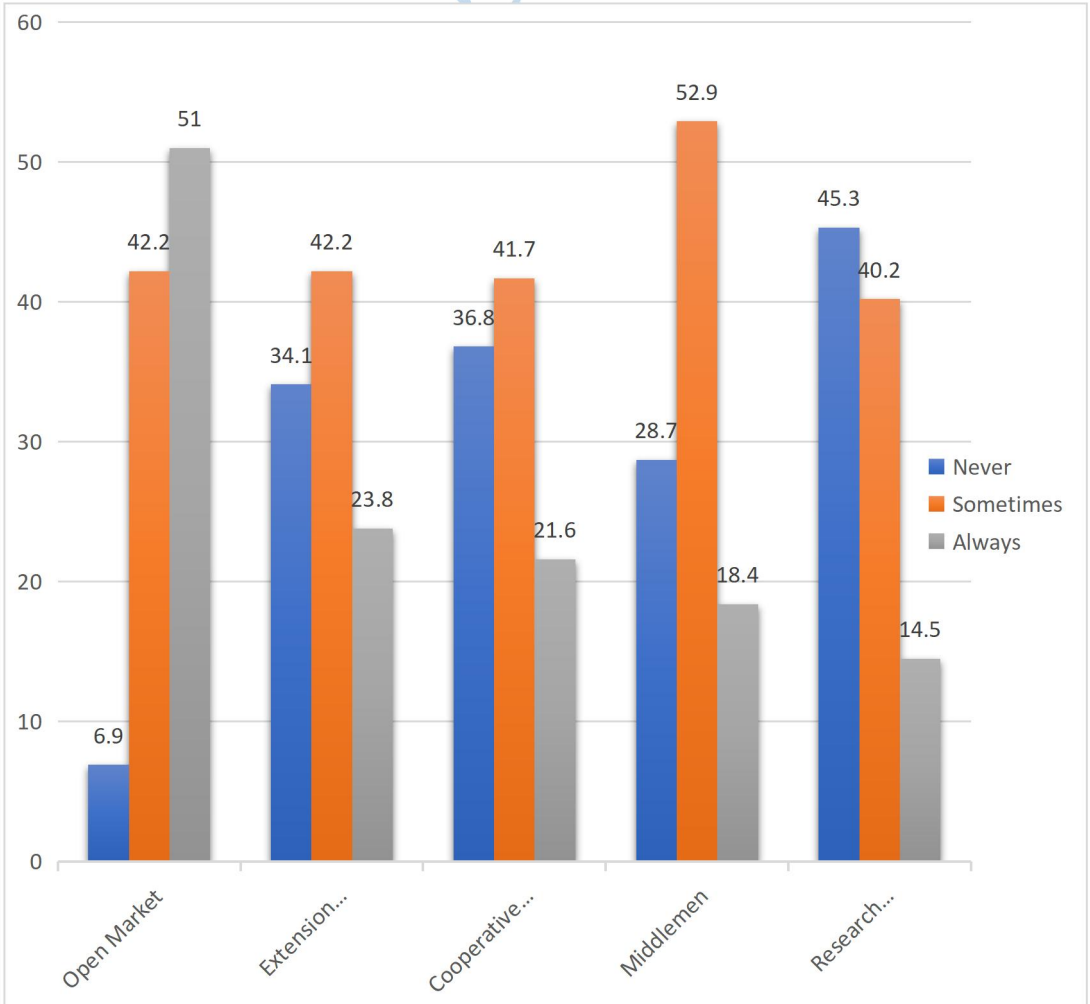


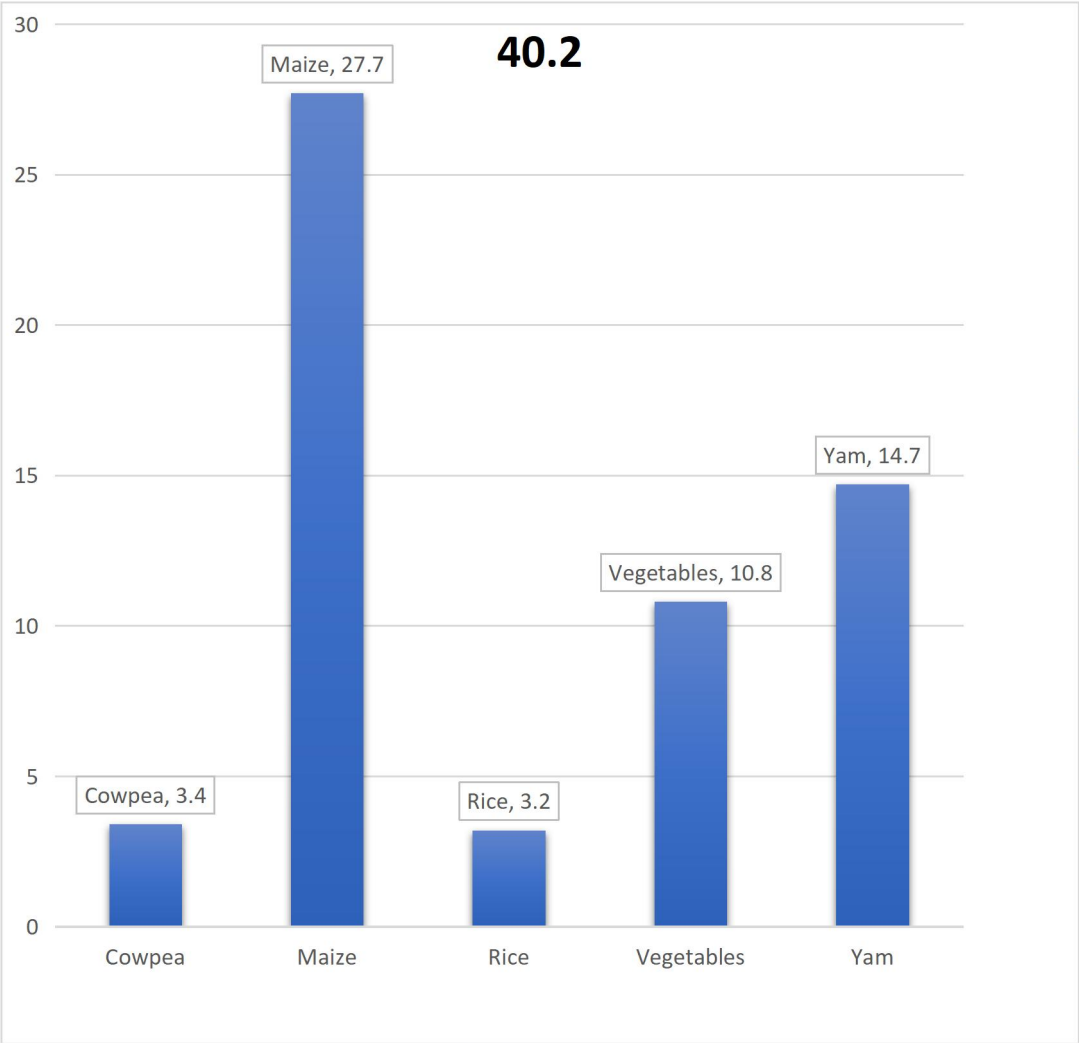
Figure 4.1: Sources of farm inputs
Source: Field Survey, 2023

Figure 4.1 presents the sources of farm inputs such as seeds and seedlings, fertilisers, herbicides, pesticides, equipment, and implements among others. The result as presented shows that one hundred and seventy-two (172): 42.2% sometimes source their farm inputs from open market, two hundred and eight (208): 51.0% claimed they always source their farm inputs from open market; one hundred and seventy (172): 42.2% sometimes approach extension agents for their farm inputs and ninety-seven (97): 23.8% claimed they always source their inputs extension agents. The result also shows that one hundred and seventy (170): 41.7% and eighty-eight (88): 21.6% of the respondents claimed they sometimes and always source their inputs from cooperative societies; two hundred and sixteen (216): 52.9% and seventy-five (75): 18.4% sometimes and always sources inputs from middlemen; one hundred and sixty-four (164): 40.2% and fifty-nine (59): 14.5% sometimes and always source inputs from research institutes. The findings indicate that farmers in this study usually sourced their inputs from any available source that can meet theneeds of planting seasons.

4.2 Presentation of Data

4.2.1 Analysis of Research Questions

Research Question One: What are the major food crops facililated by digital agricultural extension communication services in Oyo State?



sFigure 4.2: Major Crops Cultivated by Food Crop Farmers
Source: Field Survey, 2023

Figure 4.2 presents the major crops faciliatated by digital communication agricultural extension services in Oyo State. As observed in the Figure, one hundred and sixty-four (164): 40.2% specialised in the cultivation of cassava, one hundred and thirteen (113): 27.7% cultivated maize, sixty (60): 14. 7% were into cultivation of yam, forty-four (44): 10.8% were into vegetable production, fourteen (14): 3.4% were into cowpea production, and thirteen (13): 3.2% were into rice production. In summary, this clearly indicated that cassava, maize, and yam were the three most cultivated crops by farmer in the study area.

Research Question Two: What is the level of accessibility to Digital Communication Agricultural Extension Sserivces to food crop farmers in Oyo State?

Table 4.3: Accessibility of Digital Communication Platforms by Food Crop Farmers (N=408)

Digital platforms	Not Accessible		Barely Accessible		Very accessible				Remark
	Freq	%	Freq	%	Freq	%	$\bar{x}$	Std	
WhatsApp	96	23.5	183	44.9	129	31.6	2.08	0.74	**Accessible**
Instagram	210	51.5	127	31.1	71	17.4	1.66	0.76	Barely Accessible
E-Bay	245	60.0	105	25.7	58	14.2	1.54	0.73	Barely Accessible
Telegram	179	43.9	162	39.7	67	16.4	1.73	0.73	Barely Accessible
Facebook	82	20.1	181	44.4	145	35.5	2.15	0.73	**Accessible**
LinkedIn	248	60.8	120	29.4	40	9.8	1.49	0.67	Barely Accessible
Twitter	213	52.2	137	33.6	58	14.2	1.62	0.72	Barely Accessible
E-Wallet	254	62.3	106	26.0	48	11.8	1.49	0.70	Barely Accessible
Short Messaging Services (SMS)	75	18.4	185	45.3	148	36.3	2.18	0.72	**Accessible**
Webpage	169	41.4	168	41.2	71	17.4	1.76	0.73	Barely Accessible
Email	122	29.9	204	50.0	82	20.1	1.90	0.70	Barely Accessible
Interactive voice response (IVR)	192	47.1	150	36.8	66	16.2	1.69	0.73	Barely Accessible
Unstructured supplementary service data (USSD)	170	41.7	159	39.0	79	19.4	1.78	0.75	Barely Accessible

Weighted mean ($\bar{x}$)= 1.76±0.76; Criterion mean ($\bar{x}$)= 2.00; General decision =Barely Accessible

Source: Field Survey, 2023

***Threshold: Mean value of 0.01-1.99 = Barely Accessible; 2.00-2.59 = Accessible; 2.60-3.00= Very Accessible; $\bar{x}$ = Mean; Std= Standard Deviation**

Table 4.3 presents the accessibility of digital communication agricultural extension platforms available to food crop farmers in Oyo State. The rating scale of "Not Accessible (1), Barely Accessible (2), and Very Accessible (3)" were used; a criterion mean of 2.0 was set for the study, and thresholds were established for remarks. The result as presented on the Table shows that only three (3) of the digital platforms were remarked as "Accessible", and these platforms include WhatsApp ($\bar{x}$= 2.08±0.74), Facebook ($\bar{x}$= 2.15±0.73), and SMS ($\bar{x}$= 2.18±0.73). The result also shows that ten (10) of the digital platforms were remarked barely

accessible, and these include Instagram ($\bar{x}$= 1.66±0.76), e-Bay ($\bar{x}$= 1.54±0.73), Telegram ($\bar{x}$= 1.73±0.73), Twitter ($\bar{x}$= 1.62±0.72), Webpage ($\bar{x}$= 1.76±0.73), Email ($\bar{x}$= 1.90±0.70), IVR ($\bar{x}$= 1.69±0.73), and USSD ($\bar{x}$= 1.78±0.75), LinkedIn ($\bar{x}$= 1.49±0.67), and e-Wallet ($\bar{x}$= 1.49±0.70), respectively. In addition, the weighted mean of the accessibility index was lower than the criterion mean (1.76 < 2.0). In summary, finding from research question two revealed that the digital communication agricultural extension platforms were barely accessible to food crop farmers in the study area.

Research Question Three: What is the extent of knowledge Digital Communication Agricultural Extension Services among food crop farmers in Oyo State?

Table 4.4a: Knowledge of DCAES among Food Crop Farmers in Oyo State (N=408)

Knowledge statements	False/No		Not Sure		True/Yes		$\bar{x}$	Std	Remark
	F	%	F	%	F	%			
Digital extension involves the use of digital technologies for the purpose disseminating innovative information and technologies	65	15.9	51	12.5	292	71.6	**2.56**	0.75	**Good**
Digitalisation of agricultural extension involve the deployment of digital platforms like Facebook, WhatsApp, e-Bay, Instagram	67	16.4	39	9.6	302	74.0	**2.58**	0.76	**Good**
Digital extension enables quick transfer of agricultural information between researchers, extension agents and farmers	57	14.0	41	10.0	310	76.0	**2.62**	0.72	**Very Good**
The deployment of digital extension can make the transfer of innovative ideas to reach a wider audience within a short time	61	15.0	36	8.8	311	76.2	**2.61**	0.73	**Very Good**
The use of digital technologies always give farmers access to innovative techniques that improve their productivity	63	15.4	47	11.5	298	73.1	**2.58**	0.75	**Good**
The use of digital technologies always link farmers to diverse farm inputs suppliers with opportunities for price negotiation	56	13.7	48	11.8	304	74.5	**2.61**	0.72	**Very Good**

Source: Field Survey, 2023

Table 4.4b: Knowledge of DCAES among Food Crop Farmers in Oyo State (N=408)

Knowledge statements	False/No		Not Sure		True/Yes		$\bar{x}$	Std	Remark
	F	%	F	%	F	%			
Digital extension enables quick transfer of agricultural information from researchers and extension agent farmers	69	16.9	41	10.1	298	73.0	**2.56**	**0.77**	**Good**

The use of digital extension furnish farmers with analytical tools that enhance farm management and decision-making skills	73	17.9	56	13.7	279	68.4	**2.51**	**0.78**	**Good**
Digital extension can hinder farmers from sharing knowledge, ideas, and experiences with other farmers	232	56.9	31	7.6	145	35.5	**2.22**	**0.94**	**Good**
Digital extension could hinder improvement in efficiency, productivity and sustainability in farm and across value-chain	226	55.4	42.	10.3	140	34.3	**2.21**	**0.93**	**Good**
Digital extension can collapse the current commercial agricultural structure resulting in huge financial loss to farmers	257	63.0	54	13.2	97	23.8	**2.39**	**0.85**	**Good**
Digital extension reduces farmers' decision-making capabilities leading to poor choices and low crop yield	232	56.9	55	13.5	121	29.7	**2.27**	**0.89**	**Good**
Digital extension cannot benefit local farmers because of its high-speed connectivity and data driven system	148	36.3	59	14.5	201	49.3	1.87	0.92	Poor
Digital extension cannot meet basic information needs of local farmers' because it is too technical for their understanding	151	37.0	57	14.0	200	49.0	1.88	0.92	Poor
Digital extension can reduce farmer's bargaining power and the option to choose from reputable vendors	198	48.5	51	12.5	159	39.0	**2.10**	0.93	**Good**
Weighted Mean ($\bar{x}$) = 2.39±0.68; Criterion mean ($\bar{x}$) = 2.00; General Decision= Good									

Source: Field Survey, 2023

Key: $\bar{x}$ = Mean; Std= Standard Deviation

Thresholds: mean value of 0.01-1.99= Poor; 2.00-2.59= Good; 2.60-3.00= Very Good

Table 4.4a and Table 4.4b presented the summary of descriptive analysis on knowledge of digital communication agricultural extension services among food crop farmers in Oyo State. Fifteen (15) items were used to measure the knowledge of digital communication agricultural extension services among food crop farmers. The result as presented above showed that three (3) items were marked very good, ten (10) items were remarked good, two (2) items were remarked poor, and the weighted mean was higher than the criterion mean. The general remarking of the items as good implies that majority of the respondents had good knowledge of the items.

Thus, they know and agree that digital extension involves the use of digital technologies for the purpose disseminating innovative information and technologies ($\bar{x}$= 2.56±0.75);digitalisation of agricultural extension involves the deployment of digital

platforms like Facebook, WhatsApp, e-Bay, Instagram ($\bar{x}$= 2.58±0.76); digital extension enables quick transfer of agricultural information between researchers, extension agents and farmers ($\bar{x}$= 2.62±0.72); deployment of digital extension can make the transfer of innovative ideas to reach a wider audience within a short time ($\bar{x}$= 2.61±0.73); the use of digital technologies can give farmers access to innovative techniques that improve their productivity ($\bar{x}$= 2.58±0.75); the use of digital technologies always link farmers to diverse farm inputs suppliers with opportunities for price negotiation ($\bar{x}$= 2.61±0.72); digital extension enables quick transfer of agricultural information from researchers and extension agents to farmers ($\bar{x}$= 2.56±0.77); and the use of digital extension can furnish farmers with analytical tools that enhance farm management and decision-making skills ($\bar{x}$= 2.51±0.78).

The result also indicates that majority of the respondents know and disagree that digital extension can hinder farmers from sharing knowledge, ideas, and experiences with one another ($\bar{x}$= 2.22±0.94); digital extension could hinder improvement in efficiency, productivity and sustainability in farm and across value-chain ($\bar{x}$= 2.21±0.93); digital extension can collapse the current commercial agricultural structure resulting in huge financial loss to farmers ($\bar{x}$= 2.39±0.85); digital extension reduces farmers' decision-making capabilities leading to poor choices and low crop yield ($\bar{x}$= 2.27±0.89), and digital extension can reduce farmer's bargaining power and the option to choose from reputable vendors ($\bar{x}$= 2.10±0.93). Majority of the respondents exhibited poor knowledge on two items and erroneously agree that digital extension cannot benefit local farmers because of its high-speed connectivity and data driven system ($\bar{x}$= 1.87±0.92); and digital extension cannot meet basic information needs of local farmers because it is too technical for their understanding ($\bar{x}$= 1.88±0.92). Cumulatively, the weighted mean ($\bar{x}$= 2.39±0.68) was greater than the criterion ($\bar{x}$= 2.00). In summary, finding for research question three revealed that majority of the food

crop farmers in the study area had good knowledge of digital communication agricultural extension services.

Research Question Four: What is the extent of utilisation of Digital Communication Agricultural Extension Serivces among food crop farmers in Oyo State?

Table 4.5 Utilisation of DCAES among Food Crop Farmers (N=408)

Variables	Never		Rarely		Often		Always		$\bar{x}$	Std	Remark
	F	%	F	%	F	%	F	%			
Access price of farm inputs from vendors	34	8.3	81	19.9	171	41.9	122	29.9	2.93	0.91	High
Access market price for farm produce	46	11.3	57	14.0	153	37.5	152	37.3	3.01	0.98	Very High
Access financial services	78	19.1	115	28.2	124	30.4	91	22.3	2.56	1.04	High
Recruitment of farm labour	86	21.1	89	21.8	108	26.5	125	30.6	2.67	1.12	High
Access innovative ideas on crop husbandry	55	13.5	67	16.4	158	38.7	128	31.4	2.88	1.00	High
Purchase of agricultural input (e.g., seeds, agro-chemicals, equipment, machinery)	42	10.3	66	16.2	143	35.0	157	38.5	3.02	0.98	Very High
Access information on crop disease and management	10.0	10.0	74	18.1	157	38.5	136	33.3	2.95	0.96	High
Access weather information	53	13.0	77	18.9	153	37.5	125	30.6	2.86	1.00	High
Access information on profitability of other agricultural enterprises for diversification purposes	64	15.7	71	17.4	155	38.0	118	28.9	2.80	1.03	High
Weighted mean ($\bar{x}$) = 2.85±0.92; Criterion mean ($\bar{x}$) = 2.50; General Decision= High											

Source: Field Survey, 2023

Key: Always (4); Often (3); Rarely (2); Never (1); $\bar{x}$ = Mean; Std= Standard Deviation

Thresholds: mean value of 0.01-2.49= Low; 2.50-2.99=High; 3.00-3.99= Very High

Table 4.5 presented the utilisation of digital communication extension services among food crop farmers in Oyo State. Nine (9) items were used to assess the utilisation of digital extension services among food crop farmers, out of which seven (7) were remarked "High", and two items (2) were remarked "Very High". The seven (7) items remarked "High" implies majority of the food crop farmers often utilised digital communication extension services to access prices of farm inputs from vendors ($\bar{x}$= 2.93±0.91); access financial services ($\bar{x}$= 2.56±1.04);

recruitment of farm labour ($\bar{x}$= 2.67±1.12); access innovative ideas on crop husbandry ($\bar{x}$= 2.88±1.00); access information on crop diseases and management ($\bar{x}$= 2.95±0.96); access weather information ($\bar{x}$= 2.86±1.00); and access information on profitability of other agricultural enterprises for diversification purposes($\bar{x}$= 2.80±1.03). It was also observed from the Table that two (2) items were remarked "Very High" which imply that majority of the food crop farmers always utilised digital agricultural extension services to access market prices for farm produce ($\bar{x}$= 3.01±0.98); and purchase agricultural inputs ($\bar{x}$= 3.02±0.98). In addition, the result generally reveals that the utilisation of digital agricultural extension services among food crop farmers was High ($\bar{x}$= 2.85>2.50). The summary of the finding for research question four revealed that majority of the food crop farmers often utilise digital communication agricultural extension services in the study area.

Research Question Five: What are the constraints to utilisation of Digital Communication Agricultural Extension Services among food crop farmers in Oyo State?

Table 4.6: Constraints Preventing Utilisation of DCAES (N=408)

Constraints	Not a Constraint		Minor Constraint		Major Constraint		$\bar{x}$	Std	Remark
	F	%	F	%	F	%			
High level of illiteracy among farmers	27	6.6	101	24.8	280	68.6	**2.62**	0.61	VS
Inadequate information on digital extension services delivery	43	10.5	137	33.6	228	55.9	**2.45**	0.68	S
Poor internet accessibility and connectivity in rural areas	39	9.6	76	18.6	293	71.8	**2.62**	0.65	VS
Erratic power (electricity) supply	51	12.5	90	22.1	267	65.4	**2.53**	0.71	VS
Poor ICT infrastructure	53	13.0	79	19.4	276	67.6	**2.55**	0.71	VS
Lack of technical support	52	12.7	120	29.4	236	57.8	**2.45**	0.71	S
Poor access to computer and other internet gadget	47	11.5	100	24.5	261	64.0	**2.53**	0.69	VS
High cost of data	49	12.0	127	31.1	232	59.9	**2.45**	0.70	S
Policy disruption by new government	43	10.5	135	33.1	230	56.4	**2.46**	0.68	S
Poor knowledge of digital-enabled technologies among farmers	37	9.1	105	25.7	266	65.2	**2.56**	0.66	VS

Weighted Mean ($\bar{x}$) = 2.52±0.72; Criterion mean ($\bar{x}$)= 2.00; General Remark= Very Severe

Source: Field Survey, 2023

Key: Major Constraint (3); Minor Constraint (2); Not a Constraint (1); $\bar{x}$= Mean; Std= Standard Deviation; S= Severe; VS= Very Severe

Thresholds: mean value of 0.01-1.99= Minor Constraint; 2.00-2.49= Severe; 2.50-3.00= Very Severe

Table 4.6 presents the constraints preventing utilisation of DCAES among food crop farmers in Oyo State. Ten (10) items were used to measure the constraints preventing utilisation of digital agricultural extension services among food crop farmers; four (4) of the items were remarked "Severe", while six (6) were marked "Very Severe". From the crop farmers' response to the items, it was revealed that majority of the food crop farmers perceived inadequate information on digital extension services delivery ($\bar{x}$= 2.45±0.68); lack of technical support ($\bar{x}$= 2.45±0.71); high cost of data ($\bar{x}$= 2.45±0.70); and policy disruption by new government ($\bar{x}$= 2.46±0.68) as severe constraints.

The result also reveals that majority of food crop farmers perceived that high level of illiteracy among farmers ($\bar{x}$= 2.62±0.61); poor internet accessibility and connectivity in rural

areas ($\bar{x}$= 2.62±0.65); erratic power (electricity) supply ($\bar{x}$= 2.53±0.71); poor ICT infrastructure ($\bar{x}$= 2.55±0.71); poor access to computer and other internet gadgets ($\bar{x}$= 2.53±0.69); and Poor knowledge of digital-enabled technologies among farmers ($\bar{x}$= 2.56±0.66) as very severe constraints. Cumulatively, the weighted mean was higher than criterion mean (2.52>2.00), and was remarked very severe. The summary of the finding for research question five revealed that majority of the constraints were generally inferred as very severe.

Research Question Six: What is the influence of accessibility to Digital Communication Agricultural Extension Serivces on food crops production in Oyo State?

Table 4.7: Cross-tabulation on Influence of Accessibility to DCAES on Food Crops Production (N=408)

	Level of Accessibility			
	Poor		Good	
Food Crops	Freq	%	Freq	%
Cassava	93	56.7	71	43.3
Cowpea	3	21.4	11	78.6
Maize	55	48.7	58	51.3
Rice	3	23.1	10	76.9
Vegetables	16	36.4	28	63.6
Yam	26	43.3	34	56.7
Total	196	48.0	212	52.0

Source: Field Survey, 2023

Table 4.7 presents the summary of cross-tabulation on influence of accessibility to DCAES on food crops production in Oyo State. It was observed that two hundred and twelve (212): 52.0% of the respondents reports good accessibility of digital agricultural extension services while, one hundred and ninety-six (196): 48.0% of the respondents reports poor accessibility of digital agricultural extension services. The result also shows that good accessibility of digital communication agricultural extension services is prominent among cowpea farmers (78.6%); this is followed by rice farmers (76.9%), vegetable farmers (63.6%), yam farmers (56.7%), and maize farmers (51.3%), respectively. Poor accessibility of digital communication agricultural extension services is observed only among cassava farmers (56.7%) in the study area. In summary, finding for research question six revealed that access to digital communication agricultural extension services was highest among cowpea and rice farmers in the study area.

Research Question Seven: What is the influence of knowledge of Digital Communication Agricultural Extension Services on food crops production in Oyo State?

Table 4.8: Cross-tabulation on Influence of Knowledge of DCAES on Food Crops Production (N=408)

	Level of Knowledge			
	Poor		Good	
Food Crops	Freq	%	Freq	%
Cassava	29	17.7	135	82.3
Cowpea	2	14.3	12	85.7
Maize	6	5.3	107	94.7
Rice	4	30.8	9	69.2
Vegetables	2	4.5	42	95.5
Yam	13	21.7	47	78.3
Total	56	13.7	352	86.3

Source: Field Survey, 2023

Table 4.8 presents the summary of cross-tabulation regarding the influence of knowledge of DCAES on food crops production in Oyo State. It is observed from the result that good knowledge of digital agricultural extension services is conspicuous among vegetable farmers (95.5%). This is followed by maize farmers (94.7%), cowpea farmers (85.7%), cassava farmers (82.3%), yam farmers (78.3%), and rice farmers (62.9%), respectively. This implies that vegetable and maize farmers have the highest knowledge of digital agricultural extension services which could be harness to improve food production in the study area.

Research Question Eight: What is the influence of utilisation of Digital Communication Agricultural Extension Services on food crops production in Oyo State?

Table 4.9: Cross-tabulation on Influence of Utilisation of DCAES on Food Crops Production

	Level of Utilisation			
Food Crops	Low		High	
	Freq	%	Freq	%
Cassava	74	45.1	90	54.9
Cowpea	6	42.9	8	57.1
Maize	48	42.5	65	57.5
Rice	9	69.2	4	30.8
Vegetables	22	50.0	22	50.0
Yam	25	41.7	35	58.3
Total	184	45.1	224	54.9

Source: Field Survey, 2023

Table 4.9 presents the summary of cross-tabulation on influence of utilisation of digital agricultural extension services on food crops production in Oyo State. The result as presented on the Table shows that the level of utilisation of digital agricultural extension services is highest among yam farmers (58.3%), maize farmers (57.5%), and cowpea farmers (57.1%). They are followed by cassava farmers (54.9%) and vegetable farmers (50.0%); while rice farmers (41.7%) trailed behind in the study area. This implies that the level of utilisation of digital communication agricultural extension services was above average among the food crop farmers in the study area.

4.2.2 Testing of Hypotheses

$H_0$1: Accessibility of Digital Communication Agricultural Extension Services has no significant influence on food crops production in Oyo State.

Table 4.10a: ANOVA on Influence of Accessibility DCAES **to on Food Crops Production in Oyo State**

Acceptability	**Sum of Squares**	**Df**	**Mean Square**	**F**	**p-value**	**Decision**
Between Groups	64.723	2	32.362	30.962	0.000	Significant
Within Groups	423.313	405	1.045			
Total	488.037	407				

Table 4.10a presents the summary of Analysis of Variance (ANOVA) on influence of accessibility of digital agricultural extension services on food crops production in Oyo State. The result as presented on the Table above shows that accessibility of digital agricultural extension services has significant influence ($F_{2,\ 405}$=30.962; P= 0.000) on food crops production among the respondents in Oyo State. This implies that food crops production in Oyo State is influenced by access to digital extension services. Therefore, the null hypothesis was rejected at 0.05 alpha level of confidence.

Table 4.10b: Least Significant Difference (LSD) Post-hoc Multiple Comparisons Test

Level of Accessibility		**Mean Diff**	**Std. Error**	**p-value**	**95% Confidence Interval**	
					Lower Bound	Upper Bound
Poor	Good	-0.49697*	0.11612	0.000	-0.7252	-0.2687
	Very Good	-1.04720*	0.13374	0.000	-1.3101	-0.7843
Good	Poor	0.49697*	0.11612	0.000	0.2687	0.7252
	Very Good	-0.55023*	0.13095	0.000	-0.8077	-0.2928
Very Good	Poor	1.04720*	0.13374	0.000	0.7843	1.3101
	Good	0.55023*	0.13095	0.000	0.2928	0.8077

***. The mean difference is significant at the 0.05 level.**

Table 4.10b presents further analysis on influence of accessibility of digital communication agricultural extension services on food crops production using Least Significant Difference (LSD) post-hoc multiple comparisons test. The summary as observed in the Table reveals there is significant difference (p= 0.000) in food crops production between farmers with very good access to digital communication agricultural extension services and those with poor access; and food crop production was seen to be 1.047 times (mean difference = 1.04720) higher among farmers with very good access to digital communication agricultural extension services than those with poor access to digital agricultural extension services.

The result also reveals there is statistically significant difference (p= 0.000) in food crops production between farmers with very good access to digital communication agricultural extension services and those with good access; and food crops production was seen to be 0.550 times (mean difference = 0.55023) higher among farmers with very good access to digital communication agricultural extension services than their counterpart with good access. The result furthermore reveals there is significant difference (p= 0.000) in food crop production between farmers with good access to digital communication agricultural extension services and farmers with poor access; and food crops production was seen to be 0.496 times (mean difference = 0.49697) higher among farmers with good access to digital communication agricultural extension services than farmers with poor access.

$H_0$2: Knowledge of Digital Communication Agricultural Extension Services has no significant influence on food crops production in Oyo State.

Table 4.11a: ANOVA on influence of Knowledge of DCAES on Food Crops Production in Oyo State

Knowledge	Sum of Squares	Df	Mean Square	F	p-value	Decision
Between Groups	11.625	2	5.812	4.941	0.008	Significant
Within Groups	476.412	405	1.176			
Total	488.037	407				

Table 4.11a presents the result of analysis conducted to determine the influence of knowledge of digital communication agricultural extension services on food crop production in Oyo State. The result reveals that knowledge of digital communication agricultural extension services has significant influence ($F_{2,405}$= 4.941; P= 0.008) on food crops production in Oyo State. Therefore, the null hypothesis was rejected at 0.05 alpha level of significance.

Table 4.11b: Least Significant Difference (LSD) Post-hoc Multiple Comparisons Test

Level of Knowledge		Mean Diff	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Poor	Good	-0.34949*	0.15814	0.028	-0.6604	-0.0386
	Very Good	-0.63732*	0.20319	0.002	-1.0368	-0.2379
Good	Poor	0.34949*	0.15814	0.028	0.0386	0.6604
	Very Good	-0.28783	0.15583	0.065	-0.5942	0.0185
Very Good	Poor	0.63732*	0.20319	0.002	0.2379	1.0368
	Good	0.28783	0.15583	0.065	-0.0185	0.5942

***. The mean difference is significant at the 0.05 level.**

Table 4.11b presents a Least Significant Difference (LSD) post-hoc multiple comparisons test that was further carried out to determine the level and direction of significance between the level of knowledge. The result of the post-hoc multiple comparison tests shows there was significant difference (p= 0.002) in food crops production between farmers with very good knowledge and those with poor knowledge of digital communication agricultural extension

services; food crop production was 0.637 times (mean difference = 0.63732) higher among farmers with very good knowledge when compared to those with poor knowledge of digital communication agricultural extension services. Significant difference (p= 0.028) is also observed between farmers with good knowledge and those with poor knowledge of digital communication agricultural extension services; and food crops production was 0.349 times (mean difference = 0.34949) higher among farmers with good knowledge than those with poor knowledge of digital communication agricultural extension services. However, there is no significant difference (p= 0.065) in food crops production between farmers with very good knowledge and those with good knowledge of digital communication agricultural extension services.

$H_0$3: Utilisation of Digital Communication Agricultural Extension Services has no significant influence on food crops production in Oyo State.

Table 4.12a: ANOVA on Influence of Utilisation of DCAES on Food Crops Production in Oyo State

Acceptability	Sum of Squares	Df	Mean Square	F	p-value	Decision
Between Groups	14.458	2	7.229	6.182	0.002	Significant
Within Groups	473.578	405	1.169			
Total	488.037	407				

Table 4.12a presents the summary of ANOVA on influence of digital communication agricultural extension on food crops production in Oyo State. The result as seen in the Table above shows the utilisation of digital communication agricultural extension services has significant influence ($F_{2,405}$ = 6.182; p= 0.002) on food crops production in Oyo State. Therefore, the null hypothesis was rejected at 0.05 alpha level of significance.

Table 4.12b: Least Significant Difference (LSD) Post-hoc Multiple Comparisons Test

Level of Utilisation		Mean Diff	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	High	-0.33637*	0.11575	0.004	-0.5639	-0.1088
	Very High	-0.46308*	0.16284	0.005	-0.7832	-0.1430
High	Low	0.33637*	0.11575	0.004	0.1088	0.5639
	Very High	-0.12671	0.16494	0.443	-0.4510	0.1975
Very	Low	0.46308*	0.16284	0.005	0.1430	0.7832
High	High	0.12671	0.16494	0.443	-0.1975	0.4510

***. The mean difference is significant at the 0.05 level.**

Table 4.12b presents further analysis on influence of utilisation of digital communication agricultural extension services on food crop production using Least Significant Difference (LSD) post-hoc multiple comparisons test. The summary of the post-hoc test reveals there is significant difference (p= 0.005) in food crops production between farmers with very high usage of digital communication agricultural extension services and their counterpart with low level usage; and food crop production was seen to be 0.463 times (mean difference = 0.46308) higher among farmers with very high usage of digital communication agricultural extension services than those who low usage. The result further reveals there is statistically significant difference (p= 0.004) in food crop production between farmers with high usage than those with low usage of digital communication agricultural extension services; food crop production was seen to be 0.336 times (mean difference = 0. 0.33637) higher among farmers with high usage of digital agricultural extension services than those with low usage. Conversely, there was no significant difference (p= 0.443) in food crops production between farmers with very high usage and their counterpart with high usage of digital communication agricultural extension services.

$H_0$4: Constraints to utilisation of Digital Communication Agricultural Extension Serivces has no significant influence on food crops production in Oyo State.

Table 4.13a: ANOVA on Influence of Constraints to Utilisation of DCAES on Food Crops Production in Oyo State.

Acceptability	Sum of Squares	Df	Mean Square	F	p-value	Decision
Between Groups	22.601	2	11.300	9.833	0.000	Significant
Within Groups	465.436	405	1.149			
Total	488.037	407				

The summary of a one-way analysis of variance on influence of constraints to utilisation of digital communication agricultural extension services on food crops production in Oyo State is presented on Table 4.13a above. The result as presented shows that constraints to utilisation of digital communication agricultural extension services has significant influence ($F_{2,405}$= 9.833; p= 0.000) on food crops production in Oyo State. Therefore, the null hypothesis was rejected at 0.05 alpha level of significance.

Table 4.13b: Least Significant Difference (LSD) Post-hoc Multiple Comparisons Test

Level of Constraints		Mean Diff	Std. Error	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Minor	Severe	-0.20872	0.16446	0.205	-0.5320	0.1146
	Very severe	-0.59433	0.15486	0.000	-0.8988	-0.2899
Severe	Minor	0.20872	0.16446	0.205	-0.1146	0.5320
	Very severe	-0.38561	0.11815	0.001	-0.6179	-0.1533
Very severe	Minor	0.59433	0.15486	0.000	0.2899	0.8988
	Severe	0.38561	0.11815	0.001	0.1533	0.6179

***. The mean difference is significant at the 0.05 level.**

Further analysis to determine the level and direction of significance using LSD post-hoc test as presented on Table 4.13b shows there is significant difference (p= 0.000) between farmers

who reported minor constraints and those that reported very severe constraints; food crops production was observed to be0.594times (mean difference = 0.59433) higher among farmers who reported minor constraints when compared to farmers that reported very severe constraints to utilisation of digital communication agricultural extension services in the study area. The result also shows there is significant difference (p= 0.001) in food crops production between farmers who experience severe constraints and those that experience very severe constraints; food crops production was observed to be0.385 times (mean difference = 0.38561) higher among farmers who experience severe constraints when compared to those that experience very severe constraints. However, there was no significant difference (p= 0.205) in food crops production between farmers that reported minor constraints and those that reported severe constraints to utilisation of digital communication agricultural extension services. This implies that increase in severity of constraints causes decline in food crops production in the study area.

4.2.3 Discussion of Findings

This research investigated the influence of digital communication agricultural extension services on food crops' production in Oyo State, Nigeria. This section presents the discussion of findings and relate them with previous studies by other researchers for similarity and differences for robustness. In this study, the socio demographic characteristics of the farmers were analysed, enterprise characteristics were highlighted, eight research questions were answered, and four hypotheses were tested.

Results of the farmers' socio demographic characteristics revealed that majority, 289 (70.8%) of the respondents were male, while the female gender accounted for 119 (29.2%). The result also revealed that about one-third, 132 (32.4%) of the farmers were between 41-50 years of age, and this was followed by 111 (27.2%) who were between 20-30 years; 83 (20.3%) who were between 31-40 years; and 82 (20.1%) who were between 51 years and above. This implied that most of the farmers were in their active and productive years who can stand the

rigour involved in farming; however, about one-fifth of the farmers were a bit advance in age. Result on educational attainment revealed that majority, 335 (82.1%) had attained tertiary education, while only a fraction 12 (2.9%) had no formal education, indicating the farmers are highly educated and well read, as only a fraction had below secondary education.

Majority, 269 (65.9%) of the respondents were married; about one-quarter, 101 (24.8%) were single; 15 (3.7%) were divorced; while 12 (2.9%) and 11 (2.7%) were separated and divorced from their spouses, respectively. The high number of married farmers observed in this study is a testament to the importance attached to marriage and family responsibilities. The result on religious affiliation revealed that 167 (40.9%) of the respondents were of Christian faith; 158 (38.8%) professed Islam; and 83 (20.3%) were affiliated with traditional worship. The presence of the three main religious among the respondents indicates a strong religious affiliation and the level societal religiosity.

Results of enterprise characteristics of food crop farmers revealed that 112 (27.5%) of the respondents had between 1-5 years of farming experience; 119 (29.2%) had between 6-10 years of farming experience; 60 (14.7%) had between 11-15 years of farming experience; and 117 (28.7%) had between 16-20 years of farming experience. This indicates that the farmers are endowed with wealth of years of experience which can be productively and profitably harnessed. This was corroborated by Focus Group discussants who noted that;

"*I was born into farming; my parents are farmers and I was trained with the proceeds of farming"* (FGD, Atiba).

"*I have been farming for about 15years now. I was introduced to farming by a friend when I lost my job, and I have been feeding my family from the proceeds of farming*" (FGD, Ogbomoso).

It was further revealed that 188 (44.6%) of the farmers owned between 1-5 hectares of farmland; 125 (30.6%) owned between 6-10 hectares of farmland; 47 (11.5%) owned between 11-15 hectares of farmland, and 30 (7.4%) owned between 16-20 hectares of farmland. This indicates that majority of the farmers were into medium-scale commercial farming. Result on land ownership revealed 140 (34.3%) of the respondents claimed their land ownership was through inheritance; 146 (35.8%) claimed they acquired the land for farming through direct purchase; 33 (8.1%) claimed that the land they used for farming was communally owned; and 89 (21.8%) claimed the land used for farming was leased. Land is an important factor of production in agriculture. It provides the basis for food crop production and most income-generating activities which make land an indispensable asset for economic empowerment and livelihood diversification in developing countries[1,2]. Studies have shown that improve productivities by small- and medium-scale farmers that would promote food security hinge their abilities to step-up and expand land usage above eleven hectares[3,4,5], as there exists inverse relationship between farm size and farm productivity[6,7].

Farm inputs such as seeds and seedlings, fertilisers, herbicides, pesticides, equipment, and implements among others were always 208 (51.0%) or sometimes 172 (42.2%) sourced from open market; always 97 (23.8%) or sometimes 172 (42.2%) from extension agents; 88 (21.6%) always or 170 (41.7%) sometimes sourced from cooperative societies; 75 (18.4%) always or 216 (52.9%) sometimes sourced from middlemen; while 59 (14.5%) always or 164 (40.2%) sometimes sourced their inputs from research institutes. The findings indicated a mix-sources of farm inputs probably due to problems of timely availability and/or accessibility of these inputs to meet the needs during planting seasons; however, open market and middlemen were mostly patronised for agricultural inputs[8,9,10]. The finding is also corroborated by FGD discussants who asserted that;

"*You know it is not possible to get all your agricultural inputs in one place; I always buy agro-chemicals from a vendor in the market, and those I couldn't get from the vendor order from a known supplier (middleman)*" (FGD, Ogbomoso).

"Input buying is based on trust and my vendor has not never disappointed me. I have had dealings with him (the vendor) for years, and I always buy my seeds and other inputs from his store. However, the cooperative society I belong to do supply us agrochemicals like fertiliser at a cheaper rate" (FGD, Atiba).

It was further revealed that 220 (53.9%) of the respondents sourced their farm capital from personal savings; 56 (13.7%) source farm capital from family savings; 24 (5.9%) source farm capital through loans from friends; 72 (17.6%) obtained loans from cooperatives; 25 (6.1%) obtained loans from microfinance banks, while a fraction, 11 (2.7%) acquired government grants as farm capital. This implied that majority of the farmers sourced their farm capital through personal savings, close relatives, and only approach external sources like cooperatives when there are special needs such as expansion and diversification among others[11,12]. The observation is substantiated by FGD discussants' testaments;

"I started with personal savings and kept reinvesting the proceeds. I later secure loan from cooperative society for expansion, and this has really helped my farm business" (FGD, Ogbomoso).

"Our farm enterprise is a product of combine savings, myself and my spouse (family savings); and we have been increasing our investment every year from the profits(FGD, Ogbomoso).

"I started with small personal savings and later got government grant which I invested for the expansion of the farm (FGD, Atiba).

In addition, it was revealed that majority of the farmers 307 (75.2%) sold their farm produce in the open market, while about one-quarter, 101 (24.8%) sold their farm produce directly to off-takers. Food crop production as measured in sales per hectare indicated 9 (2.2%) of the farmers made ₦100,000 or less per hectare; 96 (23.5%) made between ₦101,000-₦200,000 per hectare; 116 (28.4%) made between ₦201,000-₦300,000 per hectare; 113 (27.7%) made between ₦301,000-₦400,000 per hectare; and 74 (18.1%) made ₦401,000 and above per hectare. The finding above is a testament to the profitability of food crop farming; however, it has been argued that most farmers usually quote their gross revenues which are a far-cry from the net-income even when seasonality and crop specialty are taken into consideration[7,13,14,15].

Findings from research question 1 revealed majority of the farmers, 164 (40.2%) specialised in cassava cultivation; more than one-quarter 113 (27.7%) cultivated maize; 60 (14.7%) were into yam cultivation; 44 (10.8%) were into vegetable production; 14 3.4% were into cowpea cultivation; and 13 (3.2%) were into rice cultivation. This clearly indicated that cassava, maize, and yam are the three most cultivated food crops by farmers in the study areas. This concurred with previous studies which asserted that the economy of Oyo State is chiefly anchored on production of cash and food crops such as cassava, yam, maize, and cocoa among others[16,17,18]. The dominance of cassava farming in the study area was further acceded to by FGD discussant;

"Although cassava is the crop I cultivate majorly, I often interplant it with maize. It is very hard to see a farmer that plant only one crop, we also practice mixed-cropping where cassava and maize or vegetables are planted together" (FGD, Atiba).

"I major in cassava cultivation, but I always inter-plant cassava with corn and some vegetables. I don't think you can see any farmers who practice mono-cropping" (FGD, Ogbomoso).

"I specialised in two crops, cassava and yam on separate farmlands. However, I don't plant them alone, I inter-crop cassava with maize while yam is inter-cropped with tomatoes" (FGD, Ogbomoso).

Findings from research question 2 revealed that only three digital communication platforms namely *WhatsApp* ($\bar{x}$= 2.08±0.74), *Facebook* ($\bar{x}$= 2.15±0.73), and *SMS* ($\bar{x}$= 2.18±0.73) were accessible, while others were barely accessible to the farmers. In addition, the weighted accessibility mean ($\bar{x}$=1.76±0.76) was lower than the criterion indicating that the digital communication agricultural extension platforms were barely accessed to food crop farmers in the study area. Thus, more than half of the respondents decry poor accessibility to digital communication agricultural extension services. This finding is in consonance with previous studies whose findings indicated that farmers face the challenge of accessibility that is multifaceted in nature[19,20,21], and this has resulted to poor- or low-level adoption of digital extension services[22]. Despite the challenge of accessibility, studies have shown that farmers still patronise electronic platforms like *WhatsApp, Facebook, SMS*, and *YouTube* for timely agricultural information[23,24]. Thus, it has been posited that the promotion of digital extension accessibility would facilitate access to timely agricultural information and services that strengthens food security[22]. Similar attestations were made by FGD discussants as follow;

"...there is issue with internet connection here, however, WhatsApp is accessible to me, and this is followed by the use of SMS, especially when internet network is very poor" (FGD, Ogbomoso).

"I always access WhatsApp and Facebook with ease. In fact, we have WhatsApp platforms for different farm groups where agricultural information is shared" (FGD, Atiba).

"As for me, WhatsApp, Facebook, and SMS are the most accessible. They play similar functions, and SMS becomes very handy when there is internet problem" (FGD, Atiba).

Findings from research question 3 revealed the weighted mean ($\bar{x}$= 2.39±0.68) was higher than the criterion mean indicating that majority of the farmers had good knowledge of digital communication extension services. Determination of the level of digital communication agricultural extension knowledge among the respondents further reveals that cumulatively, more than three-quarter of the farmers had good knowledge of digital communication agricultural extension services. Similarly, FGD discussants demonstrated good knowledge digital communication in agricultural extension services thus;

"... my understanding is digital communication extension is when you can use mobile phone to access agricultural information like disease management, weather forecast, determine farm input price, or current price of farm produce" (FGD, Ogbomoso).

"... I can say digital communication extension involves the broadcast of agricultural messages to farmers through digital technologies like radio, tv, and other electronic media. Radio programmes like 'Agbelere', 'Ere Agbe', and 'Ageloba' are some digital extension broadcasts used to educate farmers on modern agricultural practices in Oyo State" (FGD, Atiba).

"I think digital communication agricultural extension covers all modern technology that uses internet for information sharing, and platforms like WhatsApp, Facebook, Instagram, and Twitter are some of the platforms for digitally disseminating agricultural innovations and other agriculture-related information" (FGD, Atiba).

On the benefits of digital communication agricultural extension services, an FGD discussant averred that;

"There is this WhatsApp group I belonged to, we usually meet on that WhatsApp group to discuss and share ideas without physically coming together. Also, emergency information on

inputs, disease management, and weather are shared on the platform and farmers got the information almost immediately (FGD, Atiba).

This finding is in consonance with a study whose findings indicated more than three-quarter of farmers knew digital technology can be efficiently used for the dissemination of innovative ideas and technologies to a larger farm audience[25,26]. The widespread knowledge that digital communication agricultural extension involves the use of digital technologies for the purpose of disseminating innovative information and technologies to wider audience within a short time can be leveraged in promoting innovative ideas that enhance food crop production[27].

Findings from research question 4 revealed the aggregated mean utilisation of digital communication agricultural extension by the farmers was high ($\bar{x}$= 2.85±0.92), indicating majority of the farmers of often utilise the available digital communication agricultural extension services. Further analysis revealed that cumulatively, high utilisation of digital agricultural extension services was reported by more than three-quarter of the farmers in the study area. The findings agree with earlier studies which reported high usage of user-driven and user-friendly digital agricultural extension services for their outmost benefits[22,28,29,30]. Although, there is widespread of digital communication extension knowledge among educated farmers, it has been observed that this knowledge does not often translate into adoption and utilisation of digital agricultural extension services by food crop farmer[25,31,32]. The utilisation of digital communication agricultural extension services among food crop farmers was further affirmed as FGD discussants averred:

"...I use digital communication platforms to compare inputs prices like fertiliser, herbicides, and seeds every planting season" (FGD, Ogbomoso).

"...I steadily get information on weather, price of inputs, crop diseases and their managements. I also search for innovative ideas on post-harvest practices in the area of storage techniques to enable me sell at later period after the market glut" (FGD, Atiba).

"... WhatsApp is very accessible to me; this is followed by SMS especially when there is poor internet connection" (FGD, Ogbomoso).

"...WhatsApp and Facebook, and SMS are the most accessible platforms for me. Although, they play similar function, SMS become very handy when there is problem with internet connectivity" (FGD, Atiba).

Findings from research question 5 revealed majority of the constraints variables were seen as very severe (2.52±0.72) by the respondents, indicating they were major constraints on the aggregate. Further analysis revealed more than half of the respondents perceived the constraints as very severe, while about one-third perceived the constraints as severe. Thus, it can be deduced that the constraint variables were a major barrier to the utilisation of digital communication agricultural extension services in the study area. Our finding is in complete agreement with previous study who gave similar findings that poor internet accessibility and connectivity, poor knowledge of digital-enabled technologies, and poor access to computer and other internet gadgets were among the constraints that hinders the adoption and utilisation of digital agricultural extension services among farmers[19,33)]. In addition, the finding was also attested to by FGD discussants who asserted;

"...there is poor internet connection in the rural areas where our farms are located, and so poor internet connection prevents us from accessing timely information" (FGD, Ogbomoso).

"...the poor internet connection is caused by near-absence of telecom infrastructure. You won't believe that at times we have to climb hills to find network at the farm site; thus, access to urgent agricultural information is sometimes very difficult" (FGD, Atiba).

"…to be honest, I don't know how to operate android phone; I always wait for my colleagues to get the latest agricultural information. In the process, I sometimes miss out completely or got the innovations late" (FGD, Ogbomoso).

Research question 6 revealed that more than three-quarter of cowpea farmers (78.6%) and rice farmers (76.9%) reported good accessibility of digital communication agricultural extension services. These were followed by vegetable farmers (63.6%), yam farmers (56.7%), and maize farmers (51.3%), while cassava farmers (48.7%) reported the least accessibility of digital communication agricultural extension services in the study area. This finding implies that cowpea and rice farmers have the highest accessibility of digital communication extension information; and they were followed by vegetable, yam, and maize farmers. The least accessibility was observed among cassava farmers, and indicates that cassava farmers are less likely to get timely innovative information that would improve production. Our findings agree with previous study which posited that access to digital extension services have profoundly revolutionise how information is disseminated and accessed by farmers, facilitate equitable access to agricultural knowledge, empower farmers with innovative ideas, leading to enhanced agricultural productivity[23,34,35,36].

Findings from research question 7 revealed that knowledge of digital communication agricultural extension services was highest among vegetable (95.5%) and by maize (94.7%) farmers. They were followed by cowpea farmers (85.7%), cassava farmers (82.3%), yam farmers (78.3%), and rice farmers (62.9%), respectively. This implies that vegetable and maize farmers have the highest knowledge of digital communication agricultural extension

services which could be harness to improve food production in the study area. A good knowledge of digital communication agricultural extension services could create vantage for timely and effective communication with other stakeholders in the agricultural value chain as well as accessing innovative techniques that empowers farmers to make informed choices and decisions for increased productivity[25,27,37]. The findings also give credence to previous studies which averred that better knowledge brings better understanding of modern agricultural techniques, enhances usability of digital agricultural extension services, and empowers farmers with valuable insight that promotes agricultural productivity, profitability and sustainability[223,34,35].

Findings from research question 8 revealed an average level of digital communication extension utilisation among food crop farmers. The utilisation of digital communication agricultural extension services was highest among yam farmers (58.3%), maize farmers (57.5%), and cowpea farmers (57.1%). They were followed by cassava farmers (54.9%) and vegetable farmers (50.0%); while rice farmers (41.7%) trailed behind. This implies that the level of utilisation of digital communication agricultural extension services was above average among the food crop farmers. This corroborates the findings from previous research which posited that the utilisation of digital agricultural extension services have profound revolutionary impacts on how information is disseminated and accessed by food crop farmers[32,34,35.] Also, numerous studies have shown that utilisation of digital agricultural extension platforms and associated services have help overcome geopolitical barriers, allowing farmers access to timely agricultural knowledge on market prices for farm inputs and products, innovative agricultural techniques and best practices, weather forecast, et cetera, which have empowered farmers with up-to-date practical knowledge that promotes better crop yields[25,34,38,39,40].

Findings from Hypothesis 1 revealed accessibility to digital communication agricultural extension services has significant influence ($F_{2, 405}$ = 30.962; P= 0.000) on food crop production among the respondents in Oyo State, Nigeria. Significant increase in food crop production (mean difference = 1.04720; p= 0.000) was observed among farmers with very good access to digital communication agricultural extension services when compared to those with poor access to digital agricultural extension services. Also, significant increase in food crop production (mean difference = 0.55023; p= 0.000) was observed among farmers with very good access to digital communication agricultural extension services when compared to their counterpart with good accessibility. Significant increase in food crop production (mean difference = 0.49697; p= 0.000) was further observed among farmers with good access to digital communication agricultural extension services when compared to farmers with poor accessibility. This finding is in consonance with previous study which reported significant association exists between accessibility and productivity. The study posited that access to digital extension services exposes farmers to agricultural best practices that reduces inefficiencies and enhance their productivity[41]. The Similarly, experimental study conducted to evaluate the effects of two different extension treatments showed significant increased production by those farmers whose extension treatment was followed by access to additional digital extension information over those without access to digital extension information[42].

Findings from Hypothesis 2 revealed knowledge of digital communication agricultural extension services has significant influence ($F_{2,405}$= 4.941; P= 0.008) on food crop production in Oyo State, Nigeria. Significant increase in food crop production (mean difference = 0.63732; p= 0.002) was recorded among farmers with very good knowledge when compared to those with poor knowledge of digital agricultural extension services. Also, significant increase in food crop production (mean difference = 0.34949; p= 0.028) was observed between farmers with good knowledge when compared to farmers with poor knowledge of

digital communication agricultural extension services in the study area. Worthy of note is the significant increase in food crop productions recorded among farmers with very good knowledge when juxtaposed to farmers with poor knowledge of digital communication agricultural extension services; and farmers with very good knowledge of digital extension at their disposal always poise in making better decision with regards to agricultural best practices that enhance their productivity[23,35].

Findings from Hypothesis 3 revealed utilisation of digital communication agricultural extension services has significant influence ($F_{3,405}$ = 6.182; p= 0.002) on food crop production in Oyo State, Nigeria. In addition, significant increase in food crop production (mean difference = 0.52152; p= 0.005) was observed among farmers with very high level of utilisation when compared to those with low utilisation of digital agricultural services. Also, statistically significant increase in food crop production (mean difference = 0.33637; p= 0.004) was recorded among farmers with high level utilisation of digital communication agricultural extension services when juxtaposed to those with low level utilisation of digital communication agricultural extension services. The finding is in complete agreement with previous studies that reported association between adoption of digitalised extension with farmers' access to timely agricultural knowledge on market prices for farm inputs and products, utilisation of innovative techniques and best practices, and better crop yields[23, 31,34,38].

Findings from Hypothesis 4 revealed constraints to utilisation of digital communication extension services has significant influence ($F_{2,405}$= 9.833; p= 0.000) on food crop production in Oyo State, Nigeria. Also, significant increase in food crop production (mean difference = 0.59433; p= 0.000) was observed among farmers who reported minor constraints when compared to farmers that experience very severe constraints. It was further observed that food crop production significantly increased (mean difference = 0.38561; p= 0.001) among

farmers who experience severe constraints when compared to farmers that experience very severe constraints to utilisation of digital communication agricultural extension services This implies that increase in severity of constraints causes decline in food crop production in the study area. The findings agreed with previous studies that barriers to utilisation of digital communication agricultural extension services could be technical, economic, environmental, cultural, and regulatory-institutional, and the severity, which is more pronounced among small-scale farmers, has been associated with inefficiencies, poor decision-making skills and low productivity[19,20,21,43]. Also, studies have further shown that efficient application of adaptable digital communication in agricultural extension service delivery would directly grow region economy and this would be evident in all life activities in the social system and wellbeing[44,45,46,47].

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Chapter Five

Conclusion

This chapter presents the summary, conclusion, and recommendations of the study. It also discusses the contributions of this study to the body of knowledge as well as suggested areas for further studies.

5.1 Summary of Findings

This study investigated influence of digital communication agricultural extension services on food crop production in Oyo State, Nigeria. Findings of the study revealed that one hundred and thirty-two (132: 32.4%) were between 41-50 years of age and this was followed by one hundred and eleven (111: 27.2%) were between 20-30 years; eighty-three (83: 20.3%) were between 31-40 years; and eighty-two (82: 20.1%) were between 51 years and above. Two hundred and eighty-nine (289: 70.8%) of the respondents were male farmers, while one hundred and nineteen (119: 29.2%) were female farmers. Concerning educational attainment, three hundred and thirty-five (335: 82.1%) had attained tertiary education; thirty-six (36: 8.8%) had attained secondary education; twenty-five (25: 6.1%) had only primary education; and twelve (12: 2.9%) had no formal education. Two hundred and sixty-nine (269: 65.9%) were married farmers; one hundred and one (101: 24.8%) were single unmarried farmers; fifteen (15: 3.7%) were divorced; while twelve (12: 2.9%) and eleven (11: 2.7%) were separated and divorced from their spouse, respectively. Findings on religious affiliation revealed one-hundred and sixty-seven (167: 40.9%) were of Christian faith; one hundred and

fifty-eight (158: 38.8%) professed Islam; while eighty-three (83: 20.3%) were affiliated with traditional worship.

Frequency distribution on enterprise characteristics of food crop farmers revealed one hundred and twelve (112: 27.5%) of the farmers had between 1-5 years of farming experience, one hundred and nineteen (119: 29.2%) had between 6-10 years of farming experience, sixty (60:14.7%) had between 11-15 years of farming experience, and one hundred and seventeen (117: 28.7%) had between 16-20 years of farming experience. It was also revealed that one hundred and eighty-eight (188: 44.6%) of the farmers owned between 1-5 hectares of farmland, one hundred and twenty-five (125: 30.6%) owned between 6-10 hectares of farmland, forty-seven (47: 11.5%) owned between 11-15 hectares of farmland, and thirty (30: 7.4%) owned between 16-20 hectares of farmland. One hundred and forty (140: 34.3%) claimed their land ownership was through inheritance, one hundred and forty-six (146: 35.8%) claimed land ownership was through direct purchase, thirty-three (33: 8.1%) claimed farmland was communally owned, and eighty-nine (89: 21.8%) claimed the farmland was leased.

Findings on farm inputs revealed that one hundred and seventy-two (172: 42.2%) sometimes source their farm inputs from open market, two hundred and eight (208: 51.0%) always source farm inputs from open market; one hundred and seventy (172: 42.2%) sometimes approach extension agents for their farm inputs; and ninety-seven (97: 23.8%) always source farm inputs from extension agents. one hundred and seventy (170: 41.7%) and eighty-eight (88: 21.6%) sometimes and always source inputs from cooperative societies; two hundred and sixteen (216: 52.9%) and seventy-five (75: 18.4%) sometimes and always sources inputs from middlemen; one hundred and sixty-four (164: 40.2%) and fifty-nine (59: 14.5%) sometimes and always source inputs from research institutes.

It was further revealed that two hundred and twenty (220: 53.9%) farmers raised farm capital through personal savings, fifty-six (56: 13.7%) raised farm capital from family savings, twenty-four (24: 5.9%) source farm capital through loans from friends, seventy-two (72: 17.6%) obtained loans from cooperatives, twenty-five (25: 6.1%) obtained loans from microfinance bank, while a fraction, eleven (11: 2.7%) acquired government grants as farm capital. Three hundred and seven (307: 75.2%) sell their farm produce in the open market, while one hundred and one (101: 24.8%) sold their farm produce directly to off-takers. Food crop production as measured in sales per hectare shows nine (9: 2.2%) farmers made ₦100,000 or less per hectare, ninety-six (96: 23.5%) made between ₦101,000-₦200,000 per hectare, one hundred and sixteen (116: 28.4%) made between ₦201,000-₦300,000 per hectare, one hundred and thirteen (113: 27.7%) made between ₦301,000-₦400,000 per hectare, and seventy-four (74: 18.1%) made ₦401,000 and above per hectare.

Answer to research questions revealed that one hundred and sixty-four (164: 40.2%) specialised in the cultivation of cassava, one hundred and thirteen (113: 27.7%) cultivated maize, sixty (60: 14.7%) were into yam cultivation, forty-four (44: 10.8%) were into vegetable production, fourteen (14: 3.4%) were into cowpea production, and thirteen (13: 3.2%) were into rice production. Findings on accessibility revealed that cumulatively, accessibility to digital agricultural extension service was below average ($\bar{x}$= 1.76±0.76) in the study area.

Findings on level of knowledge revealed that cumulatively, majority of the farmers had good knowledge ($\bar{x}$= 2.39±0.68) of digital communication agricultural extension in the study area. Findings on level of utilisation revealed that cumulatively, utilisation of digital communication agricultural extension services was high ($\bar{x}$= 2.85±0.92) among food crop farmers in the study area. On constraints to utilisation, majority of the farmers perceived the constraints as very severe ($\bar{x}$= 2.52±0.72) in the study area.

Findings revealed accessibility was highest among cowpea farmers (78.6%) and rice farmers (76.9%); and these were followed by vegetable farmers (63.6%), yam farmers (56.7%), and maize farmers (51.3%), while the least accessibility was reported among cassava farmers (48.7%). Knowledge of digital agricultural extension services was highest among vegetable (95.5%) and maize (94.7%) farmers. They were followed by cowpea farmers (85.7%), cassava farmers (82.3%), yam farmers (78.3%), and rice farmers (62.9%), respectively. Lastly, utilisation of digital agricultural extension was highest among yam farmers (58.3%), maize farmers (57.5%), and cowpea farmers (57.1%), cassava farmers (54.9%), and vegetable farmers (50.0%); while rice farmers (41.7%) trailed behind.

Accessibility of digital agricultural extension services ($F_{2, 405}$ = 30.962; P= 0.000), knowledge of digital agricultural extension services ($F_{2,405}$= 4.941; P= 0.008), utilisation of digital agricultural extension services ($F_{2,405}$ = 6.182; p= 0.002), and constraints to utilisation of digital extension services ($F_{2,405}$= 9.833; p= 0.000) significantly influenced food crop production in the study area.

5.2 Conclusion

Owing to the findings of this study, it could be deduced that majority of the food crop farmers in Oyo State were male; in their mid-ages; had attained tertiary education; were married; and professed one of the three major religious faiths.

Most of the food crop farmers have acquired wealth of years of farming experience; majority cultivated six hectares and above farmland; majorly acquired farmland through direct purchase and inheritance; majorly sourced inputs from the open market and middlemen; mostly sourced farm capital from personal savings; sold farm produce in open market; and made above two hundred thousand Naira per hectare.

Food crops majorly cultivated were cassava, maize, vegetables, cowpea, and rice; the most accessible digital communication agricultural extension platforms were *WhatsApp, Facebook*, and short messaging services, while on aggregate, digital communication agricultural extension services were barely accessible to food crop farmers.

Majority of the food crop farmers had good knowledge of DCAES; reported high utilisation of digital communication agricultural extension; and mostly inferred that constraints preventing the utilisation of digital agricultural extension services were severe.

The accessibility of DCAES was highest among cowpea farmers, rice farmers, vegetable farmers, yam farmers, maize farmers, and was least among cassava farmers. Knowledge of digital communication agricultural extension services was highest among vegetable, maize, cowpea, cassava, yam, and rice farmers, respectively. Furthermore, utilisation of digital communication agricultural extension was highest among yam, maize, cowpea, cassava, and vegetable farmers, while rice farmers trailed behind in the utilisation of digital agricultural extension services.

Lastly, accessibility, knowledge, utilisation, and constraints to utilisation of digital agricultural extension services had significant influence on food crop production in Oyo State, Nigeria. In addition, very good knowledge, and very high utilisation significantly increase food crop production; while very severe and severe constraints to utilisation of digital agricultural extension services significantly reduce food crop production in the study area.

5.3 Recommendations

Based on major findings from this study, the following recommendations were hereby made:

1. It was reported in this study that accessibility to DCAES was poor, and majority of the digital extension platforms were barely accessible to food crop farmers. Poor accessibility

can cut-off the flow of innovative information to farmers resulting in a decline in food crop production. Accessibility of digital communication agricultural extension services to food crop farmers should be improved upon by ensuring inclusive development of digital agricultural, provision of critical digital infrastructures and facilities and establishment of institutional framework that see to the provision and delivery of digitalised agricultural extension information to food crop farmers especially among those in rural community.

2. Knowledge of digital communication agricultural extension services among food crop farmers was generally good; however, there is always room for improvement. Target-specific educational programmes that enunciate the potentials of digital communication agricultural extension services to food crop farmers should be championed. Capacity building should be embarked upon through community training on digital agriculture, especially among lead-farmers, young farmers, and women farmers to improve their current knowledge of digital information on agriculture. Acquisition of digital agricultural extension knowledge through training will increase adoption and utilisation potentials of food crop farmers.

3. Utilisation of DCAES was observed to be high among food crop farmers. Very higher utilisation of digital agricultural extension services can be achieved through community agents and facilitators approach; these will allow real-time capturing of the challenges farmers encounter in their bid to utilise digital communication extension platforms. The use of community tech-savvy facilitators will also accord developers the opportunity to co-design accessible, affordable, and easy-to-use digital extension tools and services that are demand-driven. In addition, the facilitator will be able to monitor and evaluate food crop farmers' performance in terms of responsiveness, efficiency of use, and satisfaction.

4. Constraints to utilisation of digital extension services were observed by food crop farmers while these constraints can be mitigated through provision of digital infrastructure especially

in the rural area and will promote digital inclusivity and enhance dissemination of innovative ideas to farmers; promotional campaigns through conferences, seminars, and advocacies should be employed to sensitise farmers on benefits of digital agricultural extension and advisory services; and the provision of cheap and efficient internet connectivity that promotes easy access to up-to-date agricultural extension knowledge and services is essential.

5.4 Contribution to Knowledge

This study has contributed to knowledge in the following ways: Theoretically, this study gave a profound insight to the concept used in the study that was richly elaborated beyond what is obtainable among related previous studies. Diffusion of Innovation Theory, Unified Theory of Acceptance Use of Technology and Technology Determinism Theory were the major theories used for the study. Diffusion of Innovation Theory propounded in 1962 and extended in 2003 averred the adoption of any technological innovation such as digital agricultural extension services, involves various stages that is reflective as knowledge acquisition about innovation, evaluation of ease of accessibility and utilisation, and decision for continuum when positive outcome is attained. This theory shows that when food crop farmers acquire knowledge of digital agricultural extension services; ease of access and utilisation would further attract to the innovation; and the outcome as measured by their productivity would influence their decision to assimilate and disseminate the innovation.

The Unified Theory of Acceptance is based on four cardinal determinants of behavioural intention to use digital technology, and these performance expectancy, effort expectancy, social influence, and facilitating conditions. Farmers' desire to improve on crop production usually endeared them to innovative technology such as digital extension platform and digital agriculture and advisory services. However, the efforts (ease or difficulty) required to access

the platforms and effort required to utilise the services are very crucial both before and after adoption of the innovations. Equally crucial is the mass media (social media) influence. Digital agricultural extension platform such as *WhatsApp, Facebook, YouTube, Twitter* (now *X*) among others, would influence timely accessibility of innovative ideas by food crop farmers depending on the knowledge and skills these farmers possess; while the availability or lack of facilities and infrastructure can facilitate or constrained access and utilisation of digital agricultural extension services by food crop farmers, which advertently influence food crop production.

Technology Determinism Theory asserted that technology has autonomy of development; the development of technology is progressive; and the development of technology is emergent, that is, it is the determinant of all social transformations and cultural modifications. The invented technology shapes society and culture, influencing human behaviour, social structures, and communication patterns. In summary, technology determinism theory emphasizes the transformative impact of digital technologies on agricultural practices, information dissemination, and extension service delivery; which will motivate farmers to adopt and utilise digital communication extension to improve their food crop production.

Empirically, this study adds to the pool of empirical literature by reporting the significant influence of accessibility, knowledge, utilisation, and constraints to utilisation of digital communication agricultural extension services on food crop production in Oyo State, which previous empirical studies did not consider thus, bridging the gap in empirical literature.

In addition, findings of this study had also provided useful information that can serve as bedrock for policy formulation by both the Federal and State Ministries of Agriculture and other policy makers in the development of polices that could be used to improve accessibility

and utilisation of digital extension platforms to food crop farmers in order to enhance high productivity.

5.5 Suggested Areas of Further Studies

This study investigated the influence of digital communication agricultural extension services on food crop production in Oyo State, using food crop farmers as its respondents. The study also employed quantitative research. Perchance, mixed research could be employed in further studies to provide a more detailed result on the influence of digital communication agricultural extension services on food crops production.

The study also employed descriptive survey research design investigated the influence of digital communication agricultural extension services on food crops production in Oyo State. A similar study could, however, be conducted using other types of research designs for the purpose of comparison to establish similarities or differences of these studies.

Again, this study was conducted among food crop farmers as respondents. However, new studies could be conducted among cash crop farmers using the same research problems to determine the influence of digital agricultural extension services on cash crop production.

Furthermore, the influence of socio-demographic characteristics of food crop farmers were not considered in this study. Perhaps, further studies that explore the influence of age, gender, educational attainment, and years of farming experience on food crop production. In addition, the influence of enterprise characteristics such as farm size, type of land ownership, types of crops cultivated, sources of capital, and labour, on food crops production could be explored.

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Appendices

Appendix 1: SPSS Computation Results (Raw Scores)

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-30	111	27.2	27.2	27.2
	31-40	83	20.3	20.3	47.5
	41-50	132	32.4	32.4	79.9
	≥ 51	82	20.1	20.1	100.0
	Total	408	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	289	70.8	70.8	70.8

	Female	119	29.2	29.2	100.0
	Total	408	100.0	100.0	

Educational attainment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal education	12	2.9	2.9	2.9
	Primary	25	6.1	6.1	9.1
	Secondary	36	8.8	8.8	17.9
	Tertiary	335	82.1	82.1	100.0
	Total	408	100.0	100.0	

Marital status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	101	24.8	24.8	24.8
	Married	269	65.9	65.9	90.7
	Separated	12	2.9	2.9	93.6
	Divorced	11	2.7	2.7	96.3
	Widowed	15	3.7	3.7	100.0
	Total	408	100.0	100.0	

Religion

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Christianity	167	40.9	40.9	40.9
	Islam	158	38.7	38.7	79.7
	Traditional worship	83	20.3	20.3	100.0
	Total	408	100.0	100.0	

Years Farming Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	112	27.5	27.5	27.5
	6-10	119	29.2	29.2	56.6

	11-15	60	14.7	14.7	71.3
	16-20	117	28.7	28.7	100.0
	Total	408	100.0	100.0	

Size of Farm (Hectares)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	182	44.6	44.6	44.6
	6-10	125	30.6	30.6	75.2
	11-15	47	11.5	11.5	86.8
	16-20	30	7.4	7.4	94.1
	≥ 21	24	5.9	5.9	100.0
	Total	408	100.0	100.0	

Land Ownership

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Inheritance	140	34.3	34.3	34.3
	Purchase	146	35.8	35.8	70.1
	Communal	33	8.1	8.1	78.2
	Lease	89	21.8	21.8	100.0
	Total	408	100.0	100.0	

Major Crop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yam	60	14.7	14.7	14.7
	Cassava	164	40.2	40.2	54.9
	Rice	13	3.2	3.2	58.1
	Cowpea	14	3.4	3.4	61.5
	Vegetables	44	10.8	10.8	72.3
	Maize	113	27.7	27.7	100.0
	Total	408	100.0	100.0	

Sources of farm capital

		Frequency	Percent	Valid Percent	Cumulative Percent
Vali	Personal savings	220	53.9	53.9	53.9
d	Family savings	56	13.7	13.7	67.6
	Loan from friends	24	5.9	5.9	73.5

	Loan from Cooperatives	72	17.6	17.6	91.2
	Loan from microfinance bank	25	6.1	6.1	97.3
	Government grant	11	2.7	2.7	100.0
	Total	408	100.0	100.0	

Source of seedlings- Open market

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	28	6.9	6.9	6.9
	Sometimes	172	42.2	42.2	49.0
	Always	208	51.0	51.0	100.0
	Total	408	100.0	100.0	

Source seedlings-Ext. Agent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	139	34.1	34.1	34.1
	Sometimes	172	42.2	42.2	76.2
	Always	97	23.8	23.8	100.0
	Total	408	100.0	100.0	

Source seedlings- Cooperative

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	150	36.8	36.8	36.8
	Sometimes	170	41.7	41.7	78.4
	Always	88	21.6	21.6	100.0
	Total	408	100.0	100.0	

Source seedlings- Middlemen

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	117	28.7	28.7	28.7
	Sometimes	216	52.9	52.9	81.6
	Always	75	18.4	18.4	100.0
	Total	408	100.0	100.0	

Source seedlings Research Institute

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	185	45.3	45.3	45.3
	Sometimes	164	40.2	40.2	85.5
	Always	59	14.5	14.5	100.0
	Total	408	100.0	100.0	

Avenue Produce Sales

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Open market	307	75.2	75.2	75.2
	Off-takers	101	24.8	24.8	100.0
	Total	408	100.0	100.0	

Estimated sales of farm produce per hectare

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	≤ ₦100,000	9	2.2	2.2	2.2
	₦101,000-₦200,000	96	23.5	23.5	25.7
	₦201,000-₦300,000	116	28.4	28.4	54.2
	₦301,000-₦400,000	113	27.7	27.7	81.9
	≥ ₦401,000	74	18.1	18.1	100.0
	Total	408	100.0	100.0	

WhatsApp

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	96	23.5	23.5	23.5
	Accessible	183	44.9	44.9	68.4
	Highly accessible	129	31.6	31.6	100.0
	Total	408	100.0	100.0	

E-Bay

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	245	60.0	60.0	60.0
	Accessible	105	25.7	25.7	85.8
	Highly	58	14.2	14.2	100.0

	accessible				
	Total	408	100.0	100.0	

Instagram

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	210	51.5	51.5	51.5
	Accessible	127	31.1	31.1	82.6
	Highly accessible	71	17.4	17.4	100.0
	Total	408	100.0	100.0	

Facebook

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	82	20.1	20.1	20.1
	Accessible	181	44.4	44.4	64.5
	Highly accessible	145	35.5	35.5	100.0
	Total	408	100.0	100.0	

Telegram

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	179	43.9	43.9	43.9
	Accessible	162	39.7	39.7	83.6
	Highly accessible	67	16.4	16.4	100.0
	Total	408	100.0	100.0	

Twitter

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	213	52.2	52.2	52.2
	Accessible	137	33.6	33.6	85.8
	Highly accessible	58	14.2	14.2	100.0
	Total	408	100.0	100.0	

LinkedIn

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	248	60.8	60.8	60.8
	Accessible	120	29.4	29.4	90.2
	Highly accessible	40	9.8	9.8	100.0
	Total	408	100.0	100.0	

E-Wallet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	254	62.3	62.3	62.3
	Accessible	106	26.0	26.0	88.2
	Highly accessible	48	11.8	11.8	100.0
	Total	408	100.0	100.0	

Short Message Services (SMS)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	75	18.4	18.4	18.4
	Accessible	185	45.3	45.3	63.7
	Highly accessible	148	36.3	36.3	100.0
	Total	408	100.0	100.0	

Web page created by Agricultural Research Institutes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	169	41.4	41.4	41.4
	Accessible	168	41.2	41.2	82.6
	Highly accessible	71	17.4	17.4	100.0
	Total	408	100.0	100.0	

E-mail

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	122	29.9	29.9	29.9
	Accessible	204	50.0	50.0	79.9
	Highly accessible	82	20.1	20.1	100.0
	Total	408	100.0	100.0	

Interactive Voice Response (IVR)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	192	47.1	47.1	47.1
	Accessible	150	36.8	36.8	83.8
	Highly accessible	66	16.2	16.2	100.0
	Total	408	100.0	100.0	

Unstructured supplemetary service data

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not accessible	170	41.7	41.7	41.7
	Accessible	159	39.0	39.0	80.6
	Highly accessible	79	19.4	19.4	100.0
	Total	408	100.0	100.0	

Level of Accessibility

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor	196	48.0	48.0	48.0
	Good	153	37.5	37.5	85.5
	Very Good	59	14.5	14.5	100.0
	Total	408	100.0	100.0	

Digital extension involves the use of digital technologies for the purpose disseminating innovative information and technologies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	65	15.9	15.9	15.9
	Not Sure	51	12.5	12.5	28.4
	True/Yes	292	71.6	71.6	100.0
	Total	408	100.0	100.0	

Digitalisation of agricultural extension involve the deployment of digital platforms like Facebook, WhatsApp, e-Bay, Instagram

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	67	16.4	16.4	16.4
	Not Sure	39	9.6	9.6	26.0
	True/Yes	302	74.0	74.0	100.0
	Total	408	100.0	100.0	

Digital extension enables quick transfer of agricultural information between researchers, extension agents and farmers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	57	14.0	14.0	14.0
	Not Sure	41	10.0	10.0	24.0
	True/Yes	310	76.0	76.0	100.0
	Total	408	100.0	100.0	

The deployment of digital extension can make the transfer of innovative ideas to reach a wider audience within a short time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	61	15.0	15.0	15.0
	Not Sure	36	8.8	8.8	23.8
	True/Yes	311	76.2	76.2	100.0
	Total	408	100.0	100.0	

The use of digital technologies can give farmers access to innovative techniques that improve their productivity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	63	15.4	15.4	15.4
	Not Sure	47	11.5	11.5	27.0
	True/Yes	298	73.0	73.0	100.0
	Total	408	100.0	100.0	

The use of digital technologies can link farmers to diverse farm inputs suppliers with opportunities for price negotiation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	56	13.7	13.7	13.7
	Not Sure	48	11.8	11.8	25.5
	True/Yes	304	74.5	74.5	100.0
	Total	408	100.0	100.0	

Digital extension enables quick transfer of agricultural information between researchers, extension agents and farmers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	69	16.9	16.9	16.9
	Not Sure	41	10.0	10.0	27.0
	True/Yes	298	73.0	73.0	100.0
	Total	408	100.0	100.0	

The use of digital extension can furnish farmers with analytical tools that enhance farm management and decision-making skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False/No	73	17.9	17.9	17.9
	Not Sure	56	13.7	13.7	31.6
	True/Yes	279	68.4	68.4	100.0
	Total	408	100.0	100.0	

Digital extension can hinder farmers from sharing knowledge, ideas, and experiences with one another

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	145	35.5	35.5	35.5
	Not Sure	31	7.6	7.6	43.1
	False/No	232	56.9	56.9	100.0
	Total	408	100.0	100.0	

Digital extension could hinder improvement in efficiency, productivity and sustainability in farm and across value-chain

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	140	34.3	34.3	34.3
	Not Sure	42	10.3	10.3	44.6
	False/No	226	55.4	55.4	100.0
	Total	408	100.0	100.0	

Digital extension can collapse the current commercial agricultural structure resulting in huge financial loss to farmers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	97	23.8	23.8	23.8
	Not Sure	54	13.2	13.2	37.0
	False/No	257	63.0	63.0	100.0
	Total	408	100.0	100.0	

Digital extension reduce farmers' decision-making capabilities leading to poor choices and low crop yield

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	121	29.7	29.7	29.7
	Not Sure	55	13.5	13.5	43.1
	False/No	232	56.9	56.9	100.0
	Total	408	100.0	100.0	

Digital extension will not be beneficial to local farmers because of its hyper-connectivity and data driven system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	201	49.3	49.3	49.3
	Not Sure	59	14.5	14.5	63.7
	False/No	148	36.3	36.3	100.0
	Total	408	100.0	100.0	

Digital extension cannot meet the basic information need of local farmers' because it is too technical for their understanding

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	200	49.0	49.0	49.0
	Not Sure	57	14.0	14.0	63.0
	False/No	151	37.0	37.0	100.0
	Total	408	100.0	100.0	

Digital extension can reduce farmer's bargaining power and the option to choose from reputable vendors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True/Yes	159	39.0	39.0	39.0
	Not Sure	51	12.5	12.5	51.5
	False/No	198	48.5	48.5	100.0
	Total	408	100.0	100.0	

Access price of farm inputs from vendors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	34	8.3	8.3	8.3
	Rarely	81	19.9	19.9	28.2
	Sometimes	171	41.9	41.9	70.1
	Regularly	122	29.9	29.9	100.0
	Total	408	100.0	100.0	

Access market price for farm produce

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	46	11.3	11.3	11.3
	Rarely	57	14.0	14.0	25.2
	Sometimes	153	37.5	37.5	62.7
	Regularly	152	37.3	37.3	100.0
	Total	408	100.0	100.0	

Access financial services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	78	19.1	19.1	19.1
	Rarely	115	28.2	28.2	47.3
	Sometimes	124	30.4	30.4	77.7
	Regularly	91	22.3	22.3	100.0
	Total	408	100.0	100.0	

Access innovative ideas on crop husbandry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	55	13.5	13.5	13.5
	Rarely	67	16.4	16.4	29.9
	Sometimes	158	38.7	38.7	68.6
	Regularly	128	31.4	31.4	100.0
	Total	408	100.0	100.0	

Recruitment of farm labour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	86	21.1	21.1	21.1
	Rarely	89	21.8	21.8	42.9
	Sometimes	108	26.5	26.5	69.4
	Regularly	125	30.6	30.6	100.0

	Total	408	100.0	100.0	

Purchase of agricultural input (e.g., seeds, agro-chemicals, equipment, machinery, etc.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	42	10.3	10.3	10.3
	Rarely	66	16.2	16.2	26.5
	Sometimes	143	35.0	35.0	61.5
	Regularly	157	38.5	38.5	100.0
	Total	408	100.0	100.0	

Access information on crop disease and management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	41	10.0	10.0	10.0
	Rarely	74	18.1	18.1	28.2
	Sometimes	157	38.5	38.5	66.7
	Regularly	136	33.3	33.3	100.0
	Total	408	100.0	100.0	

Access weather information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	53	13.0	13.0	13.0
	Rarely	77	18.9	18.9	31.9
	Sometimes	153	37.5	37.5	69.4
	Regularly	125	30.6	30.6	100.0
	Total	408	100.0	100.0	

Access information on profitability of other agricultural enterprise for diversification purpose

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	64	15.7	15.7	15.7
	Rarely	71	17.4	17.4	33.1
	Sometimes	155	38.0	38.0	71.1
	Regularly	118	28.9	28.9	100.0
	Total	408	100.0	100.0	

Major crop * Accessibility Cross tabulation

			Accessibility		
			Poor	Good	Total
Majorcrop	Yam	Count	26	34	60
		% within Majorcrop	43.3%	56.7%	100.0%
		% within Accessibility	13.3%	16.0%	14.7%
		% of Total	6.4%	8.3%	14.7%
	Cassava	Count	93	71	164
		% within Majorcrop	56.7%	43.3%	100.0%
		% within Accessibility	47.4%	33.5%	40.2%
		% of Total	22.8%	17.4%	40.2%
	Rice	Count	3	10	13
		% within Majorcrop	23.1%	76.9%	100.0%
		% within Accessibility	1.5%	4.7%	3.2%
		% of Total	0.7%	2.5%	3.2%
	Cowpea	Count	3	11	14
		% within Majorcrop	21.4%	78.6%	100.0%
		% within Accessibility	1.5%	5.2%	3.4%
		% of Total	0.7%	2.7%	3.4%
	Vegetables	Count	16	28	44
		% within Majorcrop	36.4%	63.6%	100.0%
		% within Accessibility_Cat2	8.2%	13.2%	10.8%
		% of Total	3.9%	6.9%	10.8%
	Maize	Count	55	58	113
		% within Major_crop	48.7%	51.3%	100.0%
		% within Accessibility_Cat2	28.1%	27.4%	27.7%
		% of Total	13.5%	14.2%	27.7%
Total		Count	196	212	408
		% within Major_crop	48.0%	52.0%	100.0%
		% within Accessibility_Cat2	100.0%	100.0%	100.0%
		% of Total	48.0%	52.0%	100.0%

Major_crop * Knowledge Cross tabulation

			Knowledge_Cat			
			Poor	Good	Very Good	Total
Major_crop	Yam	Count	13	47	0	60
		% within Major_crop	21.7%	78.3%	0.0%	100.0%
		% within Knowledge_Cat	23.2%	16.0%	0.0%	14.7%

		% of Total	3.2%	11.5%	0.0%	14.7%
	Cassava	Count	29	110	25	164
		% within Major_crop	17.7%	67.1%	15.2%	100.0%
		% within Knowledge_Cat	51.8%	37.4%	43.1%	40.2%
		% of Total	7.1%	27.0%	6.1%	40.2%
	Rice	Count	4	9	0	13
		% within Major_crop	30.8%	69.2%	0.0%	100.0%
		% within Knowledge_Cat	7.1%	3.1%	0.0%	3.2%
		% of Total	1.0%	2.2%	0.0%	3.2%
	Cowpea	Count	2	8	4	14
		% within Major_crop	14.3%	57.1%	28.6%	100.0%
		% within Knowledge_Cat	3.6%	2.7%	6.9%	3.4%
		% of Total	0.5%	2.0%	1.0%	3.4%
	Vegetables	Count	2	38	4	44
		% within Major_crop	4.5%	86.4%	9.1%	100.0%
		% within Knowledge_Cat	3.6%	12.9%	6.9%	10.8%
		% of Total	0.5%	9.3%	1.0%	10.8%
	Maize	Count	6	82	25	113
		% within Major_crop	5.3%	72.6%	22.1%	100.0%
		% within Knowledge_Cat	10.7%	27.9%	43.1%	27.7%
		% of Total	1.5%	20.1%	6.1%	27.7%
Total		Count	56	294	58	408
		% within Major_crop	13.7%	72.1%	14.2%	100.0%
		% within Knowledge_Cat	100.0%	100.0%	100.0%	100.0%
		% of Total	13.7%	72.1%	14.2%	100.0%

Major_crop * Utilisation_ Cross tabulation

			Utilisation_Cat			
			Low	High	Ver High	Total
Major_crop	Yam	Count	25	25	10	60
		% within Major_crop	41.7%	41.7%	16.7%	100.0%
		% within Utilisation_Cat	13.6%	15.1%	17.2%	14.7%
		% of Total	6.1%	6.1%	2.5%	14.7%
	Cassava	Count	74	68	22	164
		% within Major_crop	45.1%	41.5%	13.4%	100.0%
		% within Utilisation_Cat	40.2%	41.0%	37.9%	40.2%
		% of Total	18.1%	16.7%	5.4%	40.2%
	Rice	Count	9	1	3	13
		% within Major_crop	69.2%	7.7%	23.1%	100.0%
		% within Utilisation_Cat	4.9%	0.6%	5.2%	3.2%
		% of Total	2.2%	0.2%	0.7%	3.2%
	Cowpea	Count	6	5	3	14

		% within Major_crop	42.9%	35.7%	21.4%	100.0%
		% within Utilisation_Cat	3.3%	3.0%	5.2%	3.4%
		% of Total	1.5%	1.2%	0.7%	3.4%
	Vegetables	Count	22	19	3	44
		% within Major_crop	50.0%	43.2%	6.8%	100.0%
		% within Utilisation_Cat	12.0%	11.4%	5.2%	10.8%
		% of Total	5.4%	4.7%	0.7%	10.8%
	Maize	Count	48	48	17	113
		% within Major_crop	42.5%	42.5%	15.0%	100.0%
		% within Utilisation_Cat	26.1%	28.9%	29.3%	27.7%
		% of Total	11.8%	11.8%	4.2%	27.7%
Total		Count	184	166	58	408
		% within Major_crop	45.1%	40.7%	14.2%	100.0%
		% within Utilisation_Cat	100.0%	100.0%	100.0%	100.0%
		% of Total	45.1%	40.7%	14.2%	100.0%

Major_crop * Constraints Cross tabulation

			Constraint_Cat			
			Minor constraint	Severe constraint	Very severe constraint	Total
Major_crop	Yam	Count	9	22	29	60
		% within Major_crop	15.0%	36.7%	48.3%	100.0%
		% within Constraint_Cat	16.1%	16.3%	13.4%	14.7%
		% of Total	2.2%	5.4%	7.1%	14.7%
	Cassava	Count	20	56	88	164
		% within Major_crop	12.2%	34.1%	53.7%	100.0%
		% within Constraint_Cat	35.7%	41.5%	40.6%	40.2%
		% of Total	4.9%	13.7%	21.6%	40.2%
	Rice	Count	6	4	3	13
		% within Major_crop	46.2%	30.8%	23.1%	100.0%
		% within Constraint_Cat	10.7%	3.0%	1.4%	3.2%
		% of Total	1.5%	1.0%	0.7%	3.2%

	Cowpea	Count	4	7	3	14
		% within Major_crop	28.6%	50.0%	21.4%	100.0%
		% within Constraint_Cat	7.1%	5.2%	1.4%	3.4%
		% of Total	1.0%	1.7%	0.7%	3.4%
	Vegetables	Count	9	11	24	44
		% within Major_crop	20.5%	25.0%	54.5%	100.0%
		% within Constraint_Cat	16.1%	8.1%	11.1%	10.8%
		% of Total	2.2%	2.7%	5.9%	10.8%
	Maize	Count	8	35	70	113
		% within Major_crop	7.1%	31.0%	61.9%	100.0%
		% within Constraint_Cat	14.3%	25.9%	32.3%	27.7%
		% of Total	2.0%	8.6%	17.2%	27.7%
Total		Count	56	135	217	408
		% within Major_crop	13.7%	33.1%	53.2%	100.0%
		% within Constraint_Cat	100.0%	100.0%	100.0%	100.0%
		% of Total	13.7%	33.1%	53.2%	100.0%

ANOVA

Estimated sales of farm produce per hectare

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	64.723	2	32.362	30.962	.000
Within Groups	423.313	405	1.045		
Total	488.037	407			

Multiple Comparisons

LSD

(I) Accessibility Level	(J) Accessibility Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound

Poor	Good	-.49697	.11612	.000	-.7252	-.2687
	Very Good	-1.04720	.13374	.000	-1.3101	-.7843
Good	Poor	.49697	.11612	.000	.2687	.7252
	Very Good	-.55023	.13095	.000	-.8077	-.2928
Very Good	Poor	1.04720	.13374	.000	.7843	1.3101
	Good	.55023	.13095	.000	.2928	.8077

ANOVA

Estimated sales of farm produce per hectare

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	11.625	2	5.812	4.941	.008
Within Groups	476.412	405	1.176		
Total	488.037	407			

Multiple Comparisons

LSD

(I) Knowledge	(J) Knowledge	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Poor	Good	-.34949*	.15814	.028	-.6604	-.0386
	Very Good	-.63732*	.20319	.002	-1.0368	-.2379
Good	Poor	.34949*	.15814	.028	.0386	.6604
	Very Good	-.28783	.15583	.065	-.5942	.0185
Very Good	Poor	.63732*	.20319	.002	.2379	1.0368
	Good	.28783	.15583	.065	-.0185	.5942

*. The mean difference is significant at the 0.05 level.

ANOVA

Estimated sales of farm produce per hectare

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	15.665	3	5.222	4.466	.004
Within Groups	472.372	404	1.169		
Total	488.037	407			

Multiple Comparisons

LSD

(I) Utilisation Level	(J) Utilisation Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Very Low	Low	.17067	.16800	.310	-.1596	.5009
	High	-.22413	.16001	.162	-.5387	.0904
	Very High	-.35085	.19677	.075	-.7377	.0360
Low	Very Low	-.17067	.16800	.310	-.5009	.1596
	High	-.39480*	.12925	.002	-.6489	-.1407
	Very High	-.52152*	.17269	.003	-.8610	-.1820
High	Very Low	.22413	.16001	.162	-.0904	.5387
	Low	.39480*	.12925	.002	.1407	.6489
	Very High	-.12671	.16493	.443	-.4509	.1975
Very High	Very Low	.35085	.19677	.075	-.0360	.7377
	Low	.52152*	.17269	.003	.1820	.8610
	High	.12671	.16493	.443	-.1975	.4509

*. The mean difference is significant at the 0.05 level.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.965	2	4.983	4.221	.015
Within Groups	478.072	405	1.180		
Total	488.037	407			

Multiple Comparisons

LSD

(I) Constraint Level	(J) Constraint Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Minor constraint	Severe constraint	.00384	.17269	.982	-.3357	.3433
	Very severe	-.31048	.16285	.057	-.6306	.0096

	constraint					
Severe	Minor constraint	-.00384	.17269	.982	-.3433	.3357
constraint	Very severe	-.31432*	.11909	.009	-.5484	-.0802
	constraint					
Very severe	Minor constraint	.31048	.16285	.057	-.0096	.6306
constraint	Severe constraint	.31432*	.11909	.009	.0802	.5484

*. The mean difference is significant at the 0.05 level.

APPENDIX 2

QUESTIONNAIRE

Lead City University, Ibadan

Faculty of Communication and Information Sciences

Department of Mass Communication and Media Technology

Dear Respondent,

I am a postgraduate student of the above-named University, undertaking research on the ***Influence of Digital Communication Agricultural Extension Services on Food Crops Production in Oyo State, Nigeria.*** The questionnaire is aimed at eliciting data for an on-going PhD research work; the information solicited is required for research purpose only and will be treated with utmost confidentiality. Your frank and candid response will be highly appreciated.

Thanks for your compliance.

Shittu, Morufu Adewale
(Researcher)

Section A: Demographic characteristics

1. Age of Respondent 20-30 ( ) 31-40 ( ) 41-50 ( ) 51 and above ( )
2. Gender: Male( ) Female( )
3. Educational attainment: No formal education( ) Primary( ) Secondary( ) Tertiary( )
4. Marital status: Single( ) Married( ) Separated( ) Divorced( ) Widowed( )
5. Religion: Christianity( ) Islam( ) Traditional worship( )

Section B: Enterprise Characteristics

Instruction: Tick As Many As Appropriate In this Section.

1. Years of farming experience: 1-5( ) 6-10( ) 11-15( ) 16-20 ( ) 21 and above
2. Size of farmland (hectare): 1-5( ) 6-10( ) 11-15( ) 16-20( ) 21 and above
3. Type of land ownership: Inheritance ( ) Purchase ( ) Communal land ( ) Lease ( ) Others specify……..
4. Major type of food crop cultivated: Yam( ) Cassava( ) Maize( ) Rice( ) Cowpea( ) Vegetables( ) Others, specify …….
5. Source of farm capital: Personal savings ( ) Family savings ( ) Loan from friends ( ) Loan from cooperative( ) Loan from Microfinance bank( ) Government grants( ) Others, specify……..
6. Source of farm inputs:
   i. Open market: Always( ) Sometimes( ) Never( )
   ii. Extension agents: Always( ) Sometimes( ) Never( )
   iii. Cooperative society: Always( ) Sometimes( ) Never( )
   iv. Middlemen: Always( ) Sometimes( ) Never( )
7. Research Institutions (e.g. IITA, NIFOR, IAR&T): Always( ) Sometimes( ) Never(Avenues for produce sales: Open market ( ) Off-takers ( ) Others specify…….
8. Estimated sales of farm produce per hectare: ₦100,000 and below( ) ₦101,000-₦200,000 ( ) ₦201,000-₦300,000 ( ) ₦301,000-₦400,000 ( ) ₦401,000 and above

Section C: Digital Platforms accessible to Farmers

S/N	**Digital platforms**	**Very accessible**	**Accessible**	**Not accessible**
1	WhatsApp			
2	Instagram			
3	E-Bay			

4	Telegram			
5	Facebook			
6	LinkedIn			
7	Twitter			
8	E-Wallet			
9	Short Messaging Services (SMS)			
10	Webpage			
11	Email			
12	Interactive voice response (IVR)			
13	Unstructured supplementary service data (USSD)			

Section D: Knowledge of Digital Commuincation Agricultural Extension Services

S/N	**Knowledge statements**	**False/No**	**Not Sure**	**True/Yes**
1	Digital extension involves the use of digital technologies for the purpose disseminating innovative information and technologies			
2	Digitalisation of agricultural extension involve the deployment of digital platforms like Facebook, WhatsApp, e-Bay, Instagram			
3	Digital extension enables quick transfer of agricultural information between researchers, extension agents and farmers			
4	The deployment of digital extension can make the transfer of innovative ideas to reach a wider audience within a short time			
5	The use of digital technologies can give farmers access to innovative techniques that improve their productivity			
6	The use of digital technologies can link farmers to diverse farm inputs suppliers with opportunities for price negotiation			
7	The deployment of digital extension grant can farmers access to local and international market enhancing competitiveness			
8	The use of digital extension can furnish farmers with analytical tools that enhance farm management and decision-making skills			
9	Digital extension can hinder farmers from sharing knowledge, ideas, and experiences with one another			
10	Digital extension could hinder improvement in efficiency, productivity and sustainability in farm and across value-chain			
11	Digital extension can collapse the current commercial agricultural structure resulting in huge financial loss to farmers			
12	Digital extension reduces farmers' decision-making capabilities leading to poor choices and low crop yield			

13	Digital extension will not be beneficial to local farmers because of its hyper-connectivity and data driven system			
14	Digital extension cannot meet the basic information need of local farmers' because it is too technical for their understanding			
15	Digital extension can reduce farmer's bargaining power and the option to choose from reputable vendors			

Section E: Level of Utilisation of Digital Communication Agricultural Extension Services

S/N	**Variables**	**Never**	**Rarely**	**Often**	**Always**
1	Access price of farm inputs from vendors				
2	Access market price for farm produce				
3	Access financial services				
4	Recruitment of farm labour				
5	Access innovative ideas on crop husbandry				
6	Purchase of agricultural input (e.g., seeds, agro-chemicals, equipment, machinery, etc.)				
7	Sales of farm produce				
8	Access information on crop disease and management				
9	Access weather information				
10	Access information on profitability of other agricultural enterprise for diversification purpose				

Section F: Constraints to Utilisation of Digital Commuincation Agricultural Extension Services

S/N	Constraints	Not aConstraint	Minor Constraint	Major Constraint
1	High level of illiteracy among farmers			
2	Inadequate information on digital extension services delivery			
3	Poor internet accessibility and connectivity in rural areas			
4	Erratic power (electricity) supply			
5	Poor ICT infrastructure			
6	Lack of technical support			
7	Poor access to computer and other internet gadget			
8	High cost of data			
9	Policy disruption by new government			
10	Poor knowledge of digital-enabled technologies among farmers			

APPENDIX 3

FOCUS GROUP DISCUSSION GUIDE

Lead City University, Ibadan

Faculty of Communication and Information Sciences

Department of Mass Communibiocation and Media Technology

Dear Discussant,

I am a postgraduate student of the above-named University, undertaking research on the ***Influence of Digital Communication Agricultural Extension Services on Food Crops Production in Oyo State, Nigeria*.** The goal of this meeting is to hear your views on how digital communication in agricultural extension influence food crop production. Responses solicited is for the on-going PhD research purpose only and will be treated with utmost confidentiality. Your frank, accurate and comprehensive response will be highly appreciated.

Thanks for your compliance.

Shittu, Morufu Adewale
(Researcher)

Date of Focus Group Discussion: _____

Name of Facilitator: _____

Type of Group: _____

Local Government Area: _____

State: _____

Section A: Enterprise Characteristics

1. How many years have you been farming? _____
2. How did you acquire the land you are using for farming? _____
3. What is the main type of crop you are cultivating? _____
4. How did you raise capital for your farm enterprise? _____
5. Where do you get your farm inputs (e.g., seeds/seedlings, herbicide, fertilizer, etc.) from?

_____

Section B: Knowledge of Digital Communication Agricultural Extension Services

1. What is digital communication agricultural extension? _____ _____
2. *Further Probe*: What does digital communication Extension entail? _____
3. Can you explain some of the benefits of digital communication extension services to farmers? _____

Section C: Accessibility to Digital Communication Agricultural Extension

1. Do you have access to digital extension platforms? _____
2. Which of the digital communication platforms is/are accessible to you? _____

Section D: Utilisation of Digital Communication Agricultural Extension

1. Do you use digital communication agricultural extension services as a farmer? _____-
2. What do you use digital communication agricultural extension services for? _____

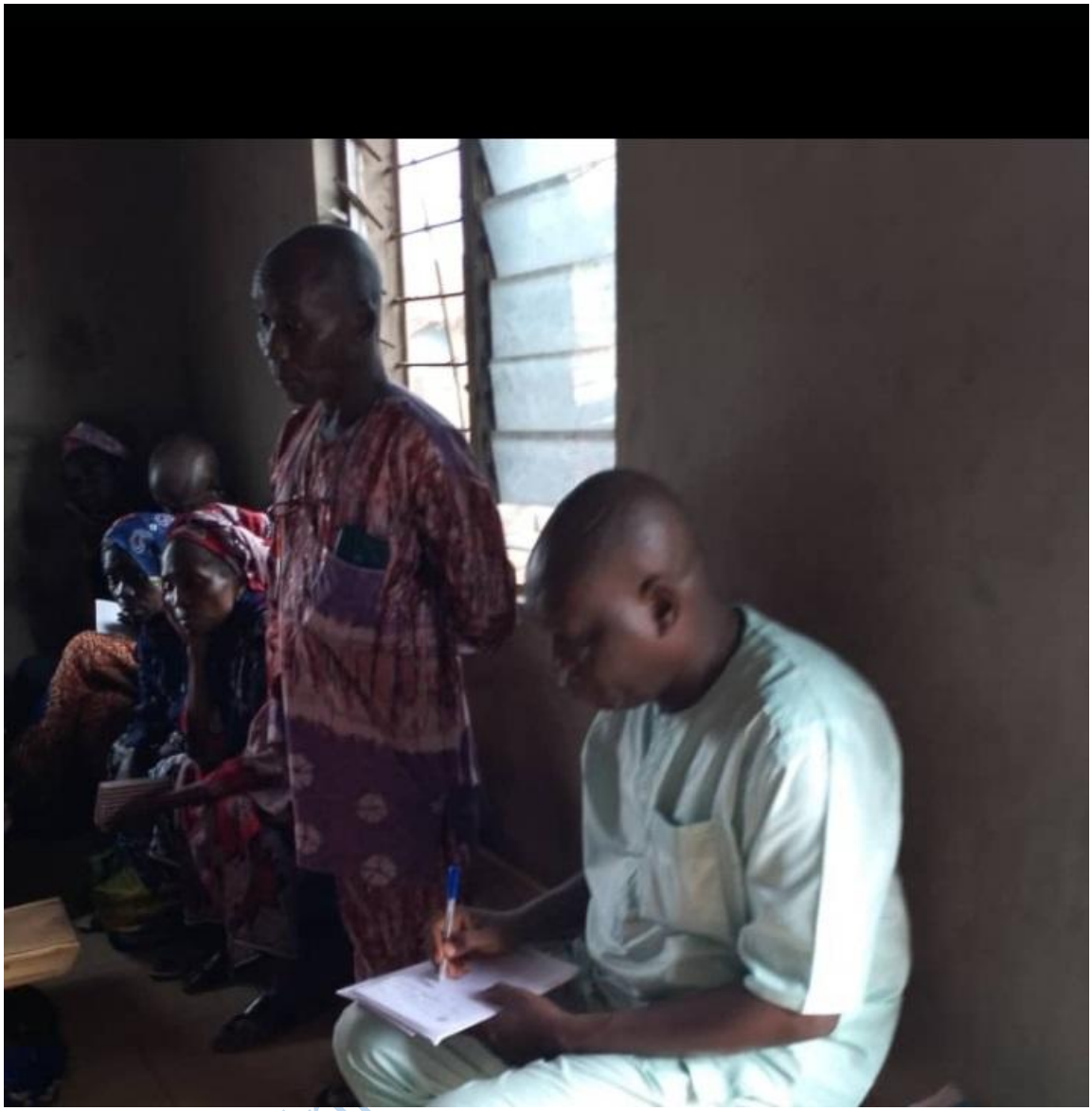
Section E: Constraints Preventing Utilisation of Digital Communication Agricultural Extension Services

1. Are there constraints that prevent utilisation of digital communication agricultural extension services among farmers? _____
2. Can you describe these constraints? _____

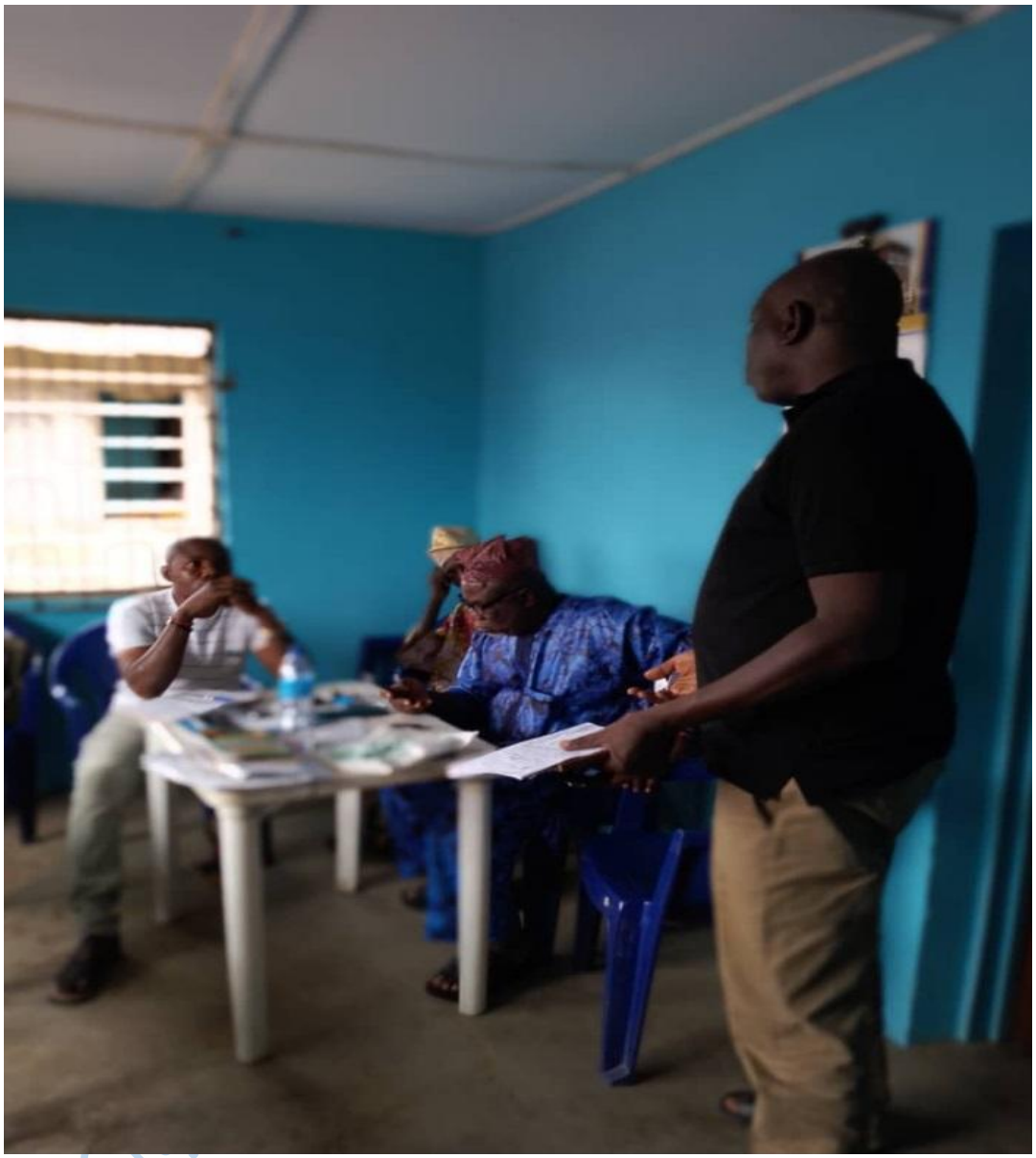
APPENDIX 4

PICTURES TAKEN AT THE FOCUS GROUP DISCUSSION CENTRES

CENTRE 1OGBOMOSO (OKE-OGUN ZONE)



CENTRE 2 ATIBA (OYO ZONE)



Biodata

A. Personal Data

Name:	Morufu Adewale SHITTU
Address:	Ebedi Layout Barrack Area Iseyin, Oyo State
E mail:	madewale.shittu@gmail.com
Phone No:	+23488137952403
Date of Birth: `	14-04-1970
Place of Birth:	Iseyin, Oyo State
Nationality:	Nigerian
Next of Kin:	SHITTU, Rokibat Adedolapo SHITTU,
	Ebedi Layout Barrack Area Iseyin, Oyo State
	Tel: +23488137952403

B. Education Background

1. Educational Institutions Attended with Date

(a)	A. U. D. Primary School, Atori, Iseyin	1976 - 1982
(b)	Origbo Community High School, Ipetumodu	1982 - 1987
(c)	Oyo State College of Arts & Science, Ile Ife	1987 - 1989
(d)	University of Ibadan, Ibadan	1993 - 1997
(d)	University of Ibadan, Ibadan	2000 - 2002

C. Work Experience:

Oyo State Teaching Service Commission, Class Teacher 1999 - 2006

Oyo State College of Education, Lanlate: 5 April, 2006

Name of School/Department: General Education/General Studies Education

D. Awards and Fellowships: Nil

E. Membership of Academic Professional Bodies

(a) Adviser, Federation of Iseyin Local Government Students (FILGS), National Body 2007 to date

(b) Staff Adviser, Federation of Iseyin Local Government Students (FILGS) EACOED, Oyo, Lanlate Campus 2007 to date

(c) Member, Governing Council, Muslim Model Secondary School, Iseyin 2008 – 2020

(d) Treasurer, Muslim Welfare Association, The College of Education, Lanlate 2008 - 2020

(e) Public Relation Officer, Benevolent League, Iseyin. 2009 to date

(f) Patron, Civilization Club, Iseyin 2010 to date

(f) Chairman, Ebedi Layout Community Development Association 2019 to date

(g) Member, Nigeria English Studies Association (NESA)

(h)Member, Colleges of Education Academic Staff Union (COEASU)

F. Publications

1. Thesis Nil

2. Contribution to Books:

1. Falade, M. O., Okedigba, S. O. & Shittu, M. A, *Corrupt tendencies of Nigerian politicians and their cathartic effects on English language usage and literature in the 21st century.* In F.R. Buhari and H. Alilonu (eds.), Language, Literature and Good Governance: The Nigerian Experience. 2009, 564-583. Ibadan: Kingdom Heritage Printing and Publishing Ventures.

2. Shittu, M. A. *Listening comprehension*. In A. Kehinde (Ed.), Essential Guide to Literature and Language, 2011, 1-17. Ibadan: Freeman Production.

3. Shittu, M. A. & Adekoya-Olapade, A. O, *A survey of pedagogical implications of dominant use of English language over indigenous language in pupils teaching and learning process.* In A. S. Gbadegesin, R. A. Adefabi, B. A. Ogunsola, J. B. Jimoh, & M. O. Falade (eds.), Developmental Issues in Ibarapa Region. 2013, 97-104). Ibadan: Golden Touch Printing and Publishing.

4. Adeleke, G. & Shittu, M. A, *Introduction to basic grammar of English.* In O. A. Adekoya (Ed), A Compendium of English Language and Literary Studies, 2013, 251-300. Lagos: Wealthsmith Global Services Ltd.

5. Shittu, M. A, *Composition writing.* In A. Odebunmi (Ed.), Topics in English and Literature. 2015, 83-122. Ibadan: Scholarship Publishing and Educational Consult Services (Nig.) Ltd.

6. Shittu, M. A, *The use* of *humor as a comic device*: *COVID-19 experience.* InB. T. Opoola, S. O. Okedigba & A. O. Ogundepo, (eds.), Revitalizing Nigeria's Education: Emerging Issues. (pp. 2021, 173 - 195. Ibadan: Grace Media & Publishers Company.

3. Journal Publications

7. Shittu, M. A. & Olaniyan, G. A, *Effects of social media usage on the performance of colleges of education sandwich students in English Language.* **Lanlate Journal of Languages and Literature,** 1 (1), 2019, 101-115.

8. Shittu, M. A. & Olaniyan, G. A, *Teachers' attitudes towards the teaching of Literature-in-English at junior secondary school. A study of selected secondary schools in Iseyin and Itesiwaju Local Government Areas, Oyo state.* **Lanlate Journal of Educational Research,** 4 (1),2019,241-252

9. Shittu, M. A, *Multimedia as a potent tool for curbing the scourge of corona virus (COVID-19).***Capital Journal of Education Studies,** 6 (1), 2020,138-147.

10. Shittu, M. A. *Mother tongue(s) intrusion in the acquisition of English as a second language: The examples of selected secondary schools in Osogbo metropolis, Osun State.* **Oyo Journal of Languages and Literature,** 7 (1), 2020, 317-334.

11. Shittu, M. A, *Multilingualism as a pathway to the extinction of indigenous languages in Nigeria.***Lanlate Journal of Languages and Literature,** 2 (1), 2020, 132-142.

12. Olaniyan, G. A. & Shittu, M. A. *Improving students' performance in composition writing through error analysis: The examples of selected secondary schools in Iseyin Local Government, Oyo State, Nigeria.* **Journal of Contemporary Education Research,** 17 (8), 2020,115-129.

13. Shittu, M. A. *Teacher's qualification: A correlate to students' performance in English.* **NagwamatseJournal of Research and Innovation,** 2 (1), 2022,333-344

14. Shittu, M. A. (2023, May) *Effective Communication: A potent tool towards enhancing teaching and learning activities in schools.* **Trailblazer International Journal of Educational Research**. 2 (2),

Referees

Prof. Taye Babaleye,

Professor,

Department of Mass Communication & Media Technology,

Lead City University Ibadan,

Oyo State.

08022732589.

Prof. Lambert Ihebusor,

Professor,
Department of Mass Communication & Media Technology,
Lead City University Ibadan,
Oyo State.
08033419512.

Dr.Bayo Busari
Department of Mass Communication & Media Technology,
Lead City University Ibadan.

+2348023720078

…….. ……
Signature *Date*

The University Compliance Certification

This is to certify that this thesis by Morufu Adewale SHITTU with Matric No: LCU/PG/001266in the Department of Mass Communication and Media Technology, Faculty

of Communication and Information Science, Lead City University, Ibadan is in full compliance with the approved University format and style.

_____ _____

Signature Date