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# A Review of the Digitalization of Agriculture in Nigeria

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## Abstract
*It has become difficult to articulate the impacts, needs and challenges of digitalization of agriculture due to the extensive nature of publications relating to the digitalization of the agricultural sector. This review evaluated the effect of digitalization of agriculture on improved food production and standard of living, identified the training needs of extension staff and clientele for digitalization of agriculture, and highlighted the challenges of digitalization of agriculture. From an initial search of 208 articles, only 87 articles met the inclusion criteria using the PRISMA guidelines. Most articles were published between 2016 and 2020; more studies were carried out in the South Western region of the country.*

*Digitalization of agriculture has reduced the role of middlemen, provided opportunities for farmers to expand their markets, and improved the linkage between extension and research centers, and productivity and livelihood of small-scale farmers. Training needs for effective digitalization of agriculture were in skills, use of relevant digital services, digital privacy and security risks. Challenges of digitalization of agriculture were lack of technical skill, poor infrastructure and high cost of purchase and maintenance. The government should focus on initiating agricultural technology transfer programs and provide the necessary rural infrastructure to support the sector's digitalisation.*

## Introduction

In 2015, all members of the United Nations embraced the 17 Sustainable Development Goals (SDGs) as an international term to terminate inequality, hunger and poverty as well as guarantee sustainable peace by 2030 (International Telecommunication Union –ITU, 2020). These goals are critical and interrelated as they influence the outcome of one another. Given this, digitalization and agriculture are essential facilitators of these goals.

Although reports from World Health Organization–WHO (2022) show that the percentage of Africans that suffer from hunger has reduced from 27.6 percent to 20 percent between 1990 and 2015, yet, there has been an increase in the combined number of hungry citizens from 182 million to 233 million over the period under review. Current estimates by the United Nations stipulate over 690 million persons are exposed to hunger with 250 million of such persons living in Africa (United Nations Conference on Trade and Development (UNCTAD), 2021). This increase is attributed to population growth. The world population has been estimated to rise above 9.8 billion by 2050, hence, there is a growing challenge to provide food for the population (Trendov et al., 2019). Sub-Saharan Africa with a population of 1,136,046.77 persons has the highest population growth among all the sub-regions of the continent with Nigeria (the most populated country in the sub-region) having a population estimate of 211,400,704 persons (World Bank, 2021).

Population increase has unfortunately led to an increase in food demand and hunger, especially in Nigeria. Agriculture contributes about 24 percent of the National Gross Domestic Product (GDP) with the cultivation of 34 million hectares of arable land, 6.5 million hectares of permanent crops while engaging 70 percent of Nigeria's households. (National Bureau for Statistics -NBS, 2021; World Bank, 2021). On the Global Hunger Index, Nigeria moved from 39.5 points in 2000 (alarming) to 28.3 in 2021 (serious) (GHI, 2021). This calls for urgent action if the country must attain the SDGs by 2030.

In view of the foregoing, agricultural production should be stimulated to ensure that the economy grows on a sustainable basis for national food sufficiency. Within the following fifteen years from 2020, it has been stipulated that food demand will rise by 20%. One of the definitive options for highly efficient agricultural productivity is the digitalization of the agricultural system (Kim et al, 2020).

The concept of digital agriculture includes both digitization and digitalization. While digitization is the non-theoretical procedure of changing analogue messages into digital data, digitalization involves the social, mental and economic process of adopting improved technologies (Rolandi et al, 2021; Brennen and Kreiss, 2021). Malabo Montpellier Panel Report (MMPR) (2019) has reported that Nigeria has a prospective supporting sphere for digitalization in agriculture with a score of 4.5 out of 9 in the World Banks' Ease of Business in Agriculture (EBA), Information and

Communications Technology (ICT) (World Bank, 2019) as well as ensuring affordable phones and mobile-specific taxation (Global System for Mobile Communications (GSMC), 2019). Notwithstanding, the utilization of digital agriculture is at its early stage (Farayola, et al, 2020), hence, existing literature on digital agriculture is not vast when compared to other developed countries.

In the area of digitalization of agriculture in Nigeria, various researchers such asDaum et al. (2022); Baumüller and Addom (2020); Farayola et al. (2020); Tsan (2019) and Olagunjuet al. (2021) have accessed it from different perspectives. None of these studies attempted a systematic review of the process.

This review is a presentation of existing academic articles for the advancement of knowledge relating to the digitalization of agriculture in Nigeria. Specifically, the review:

i. identified the distribution of research publications in digitalized agriculture across zones and years of publication,
ii. investigated the factors affecting digitalization of the Nigerian agricultural system,
iii. identified the training needs of extension officers and farmers towards digitalization,
iv. ascertained the effects of the digitalization of agriculture and;
v. described the challenges of digitalization of the Nigerian agricultural sector.

**Methodology**

In a bid to harness existing and relevant data for the study, a literature study was conducted with the Preferred Reporting Items for Systematic Reviews and Meta Analysis (PRISMA) approach as was previously used by Hackfort (2021), Traldi (2021) and Yatribi (2020). This method has 27 items on its checklist which focuses on planning, executing , reporting and distribution of the review.

**Criteria for inclusion and exclusion**

Article inclusion and exclusion criteria were set out in the research. These criteria were:

i. The area of knowledge for the article must be related to digitalization of agriculture in Nigeria;
ii. Articles must be published in English language;
iii. Articles must have been published between 2011 and 2021;
iv. Articles must be of empirical data;
v. All non-peer reviewed articles were excluded;
vi. Full text must be available;

Having set our inclusion and exclusion criteria for the content analysis, five steps towards extracting relevant studies for the review were followed. First, as earlier mentioned, the PRISMA method was chosen to be sure of the scientific standard with guaranteed transparency. The second step was the identification of acceptable databases and the development of a plan of action for the search. The major indexing sources that were used included Web of Science, Scopus, Science Direct, Google Scholar, AgEcon and Springer-link. The keywords that were used in the search which covered titles, keywords, and abstracts were ‘digitalization’ ‘agriculture’, ‘farm’, ‘internet of things’, ‘information and communication technology’,

'artificial intelligence', 'big data', and 'Nigeria'. Next was the identification and retrieval of articles to be included in the review. This was done from December 2021 to February 2022. In the fourth stage, the retrieved articles were sorted to meet the set objectives of the study. All articles that were published in the English language (to avert lack of certainty in interpreting the non-English pieces of literature) from 2011 to 2021, related to agriculture and Nigeria were selected. The final stage was the preparation of a spreadsheet using a standard coding format for the details of the extracted articles including serial numbers, names of authors, titles, journals, volume, sampling period and location etc. This was done in such a manner that the articles that were included could be analysed quantitatively. All the stages were done manually apart from the removal of duplicates which was done using the 2018 Clarivate Endnote X9. Having considered our inclusion and exclusion criteria, articles that scaled through were evaluated using a clear-cut guide assessment (Table 1) as used by Ayim et al, 2022.

The initial search was executed with three databases (Web of Science, Science Direct and Scopus) in December 2021. In January 2022 three more databases (Google scholar, AgEcon and Springer-link) were searched. We extracted 829 articles from these databases which were made up of Web of Science (32), Scopus (128), Science-Direct (210), Goggle Scholar (314), AgEcon (102) and Springerlink (43). After reading through their abstracts and full papers, we subjected the articles to removal of duplicates and 157 duplicates were identified and removed. This provided us with 672 articles. These articles were subsequently evaluated using the exclusion and inclusion criteria as a test for their eligibility. At this point, 541 articles were found to be non-eligible for the review, hence 131 articles scaled through. Detailed quality assessment was done on the 131 articles using the criteria in Table 1. A summarized report of the publications was also distributed to other professionals in digitalization and agriculture for final assessment. Some of these individuals were included as co-authors. The final output was 87 articles which were discussed and analysed using descriptive statistics for this review.

**Table 1 Quality evaluation criteria**

| *No* | Assessment Questions |
|---|---|
| *Q1* | How understandable is the objectives of study? |
| *Q2* | Is the span of the study adequately and clearly defined? |
| *Q3* | How logical is the flow of presentation? |
| *Q4* | Do the research findings provide good answers to the research questions? |
| *Q5* | Did the article discuss digitalization or ICT use in agriculture? |
| *Q6* | Are the study objectives connected to the conclusion? |
| *Q7* | Were the study limitations highlighted? |

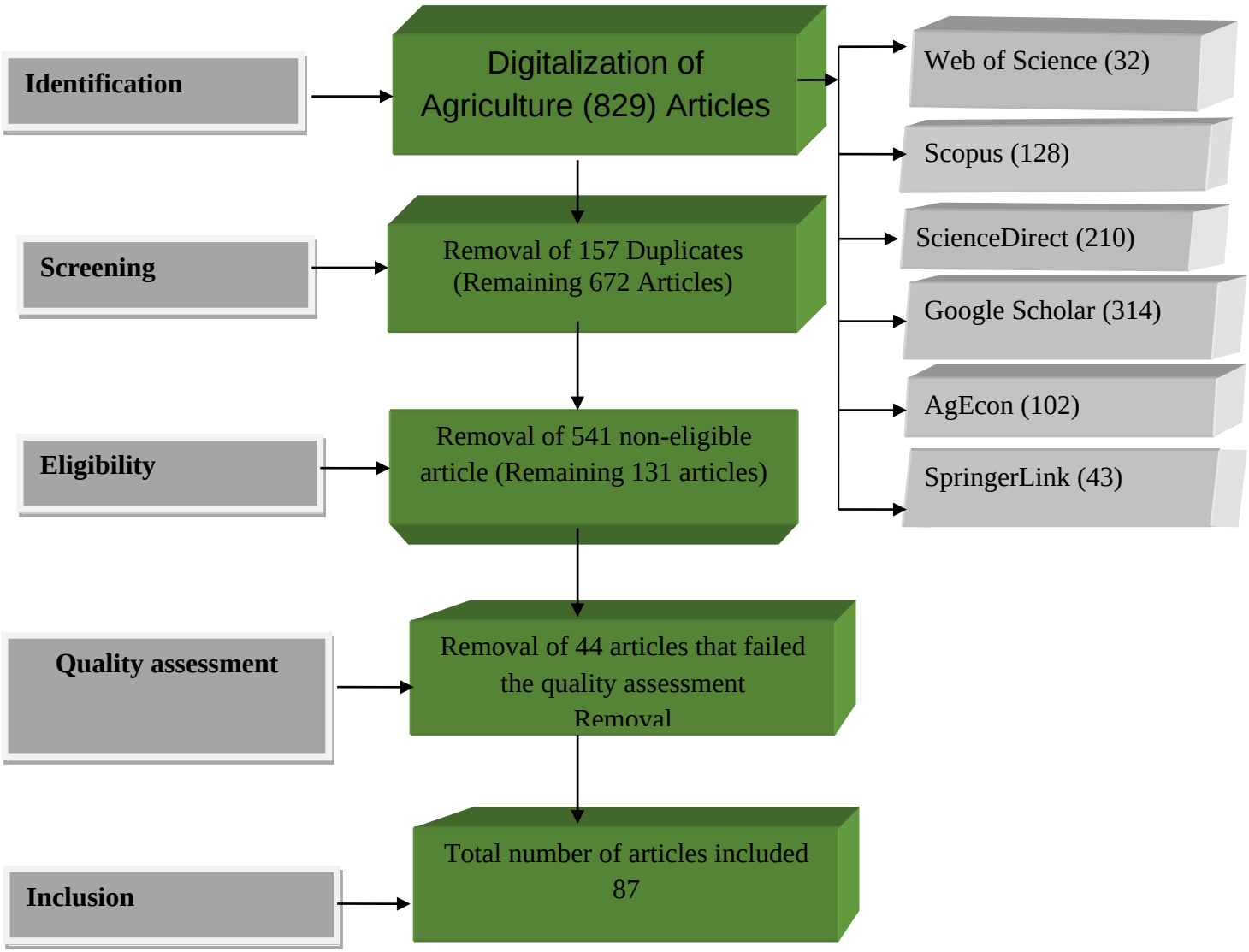


**Figure 1: PRISMA protocol search flow process**

## Results and Discussion

### Distribution of Articles across the Years under Review

As earlier stated, this review had a set boundary of 2011 till 2021. Entries in Figure 2 show that there is an emerging dynamism in researches relating to digitalization of agriculture in Nigeria. While 3.40% of the articles were published in 2011, 17.44% were published in 2021. Apart from 2020, the number of published articles maintained an ascending order from 2014 -2021 with 66.28% of the articles published within this period. Given the low level of internet use among researchers in developing countries, the decrease in the number of articles published in 2020 may be attributed to the out-break of the Covid-19 pandemic which necessitated such policies as lockdown and restriction of movement.

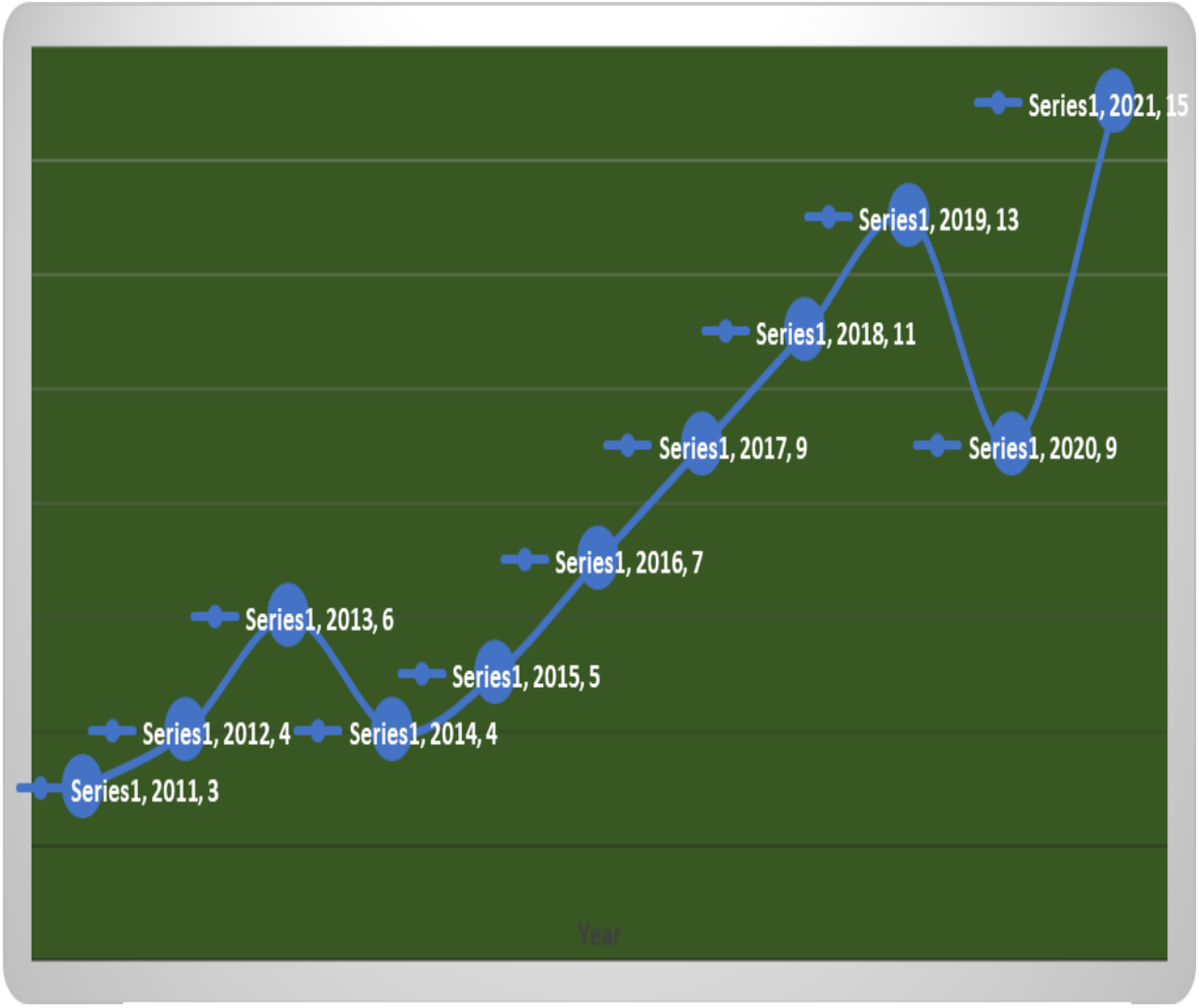


Figure 2: Article distribution across years

### Distribution of Articles across Geographical Zones

The selected articles were distributed across all the geographical zones of the country (Figure 3) with a significant bias towards the South Western geographical zone (36.05%). Okon et al. (2021) had in a previous study opined that the South-Western zone accounts for the majority of research publications in Nigeria. This is

understandable considering that the researchers never sought to have an even distribution of articles in their inclusion criteria. It is important to note that the bias towards the South Western geographical zone does not imply that digital agriculture is neglected in other zones but rather that it may not be a major focus for academic research in those zones. Also, the South Western part of Nigeria has the highest number of tertiary institutions in Nigeria (Mogaji, 2019).

When we consider the South - North dichotomy, 62.80% of the articles were published in the Southern region while 37.20% were published in the Northern region of the country. While the increase in insecurity in the Northern region may have contributed to this difference (Akor et al.,2021), World Bank (2019) has also highlighted a low level of literacy rate in Northern Nigeria when compared to the Southern.

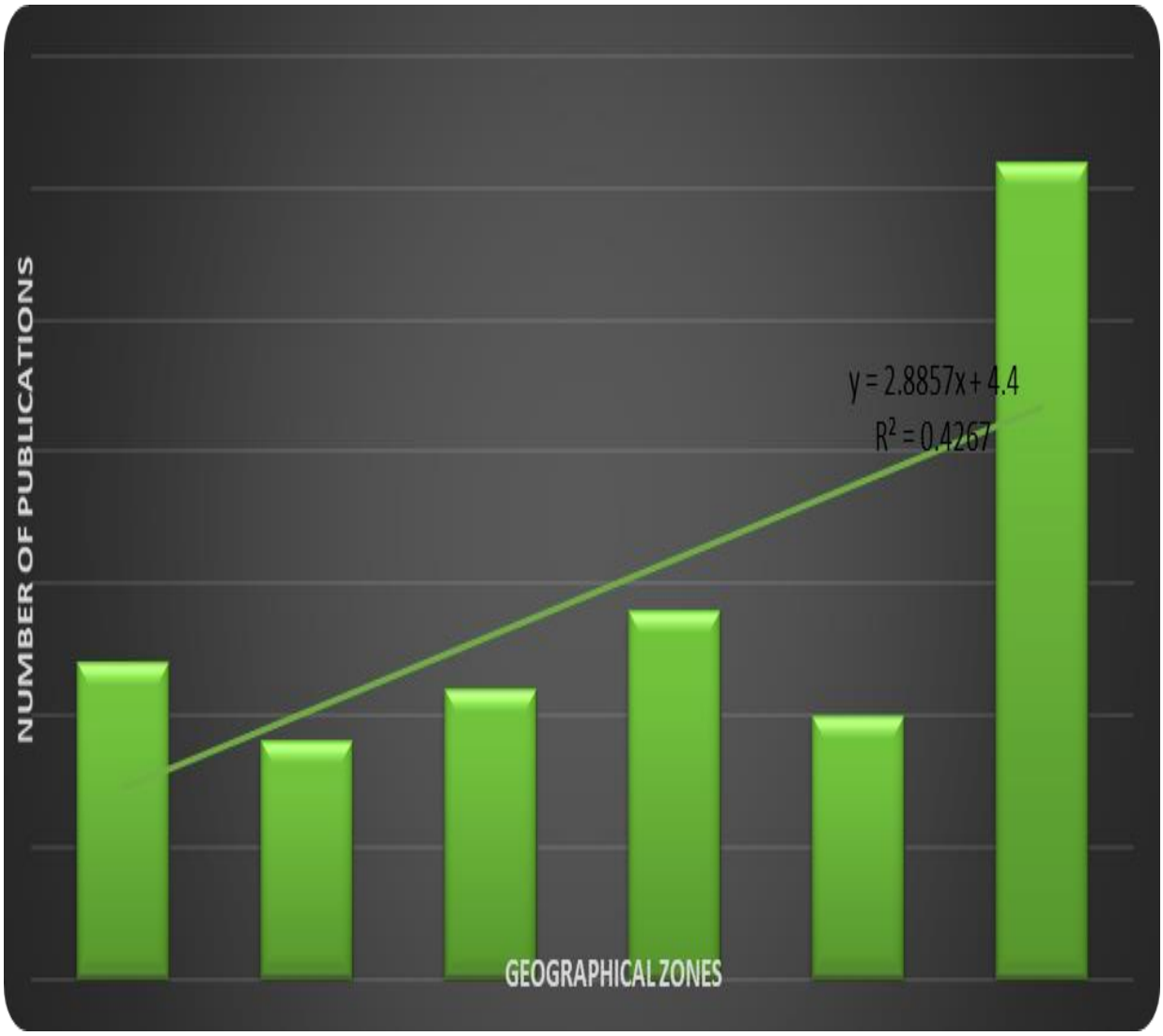


Fig 3: Article distribution across Geographical zone

**Factors Affecting Digitalization of Agriculture in Nigeria**

Digitalization of agriculture in Nigeria is affected by several factors as identified across the selected articles. For concise discussion of these factors, we adopted the approach by Gyata (2019). These factors were classified into individual, institutional and technological factors.

Individual factors are elements that relate to the user of the digital tools such as the farmers, extension officers and other active player in the agricultural sector. Muslem et al. (2018), Hailegebreal et al. (2022) and Marston et al. (2019) had identified household attitude and income, previous ICT experience and perception towards ICTs as essential factors that should not be ignored in the digitalization process. Ajena (2018) established a significant and positive relationship between individual factors such as age and personal income and utilization of digital tools. Also, Schimpf (2020) reported that potential users of digital tools in developing countries express concern over their independence as well as the sustainability of the use of these tools in view of the fact that these tools are sponsored. Some of these ideas may arise from interactions with peers and colleagues as Ugwu et al. (2020) and Solomon and vanKlyton (2020) identified peers and social network as major demographic factors affecting the use of digital technologies. Furthermore, gender, educational level, level of employment and farm size (Okeet al., 2019), personal innovativeness, prior experience (Albaom et al., 2022), are other individual factors affecting utilization of digital tools in agriculture in Nigeria.

Institutional factors relate to the components of digitalization that concern those saddled with the duties of creating an ideal environmental for the digital agriculture. These factors depend on the readiness of the stakeholders to guarantee the digitalization of the agricultural practices in Nigeria. These stakeholders include mainly the agricultural advisory services. Among institutional factors affecting digitalization of agriculture in Nigeria are the size of the organization (Gupta,2018), the characteristics of the organization and other internal and external characteristics (Wiliandri, 2020). Ahmed et al. (2020) and Lencucha et al. (2020) identified policy inconsistency in the national agricultural sector as major consideration in digitalization. Other institutional factors include government and extension management support (Olagunju, 2021), availability of training and provision of support (Fabregas et al., 2022) and distance to training centers (Gyata, 2019). These institutional variables can motivate clients to utilize digital technologies.

**Table 2: Factors affecting digitalization of agriculture in Nigeria**

| Author | Individual | Institutional | Technological |
|---|---|---|---|
| Abdullahi, et al, (2021) | * | | * |
| Ahmed et al. (2020) | * | | * |
| Awoyemi, et al, (2020) | * | | * |
| Gyata (2019) | * | * | * |
| Ibukun, et al, (2021) | * | * | * |
| Mustapha(2022) | * | * | * |
| Oke, et al, (2019) | * | | |
| Okeke, et al, (2020) | * | * | |
| Okorie, et al. (2021) | | * | |
| Olomola and Nwafor (2018) | | * | * |
| Olutumise et al, (2021) | * | | * |
| Solomon and van Klyton (2020) | * | | * |
| Tibi and Oyem (2018) | | * | * |
| Ugwu et al. (2020) | * | | * |
| Wole-Alo and Oluwagbemi (2020) | * | | * |

Technological factors involve considerations about the digital technologies. Such factors include compatibility, cost and cost effectiveness (Fielke et al., 2020) and speed of information transfer (Abdullahi et al., 2021), relative advantage and relevant content (Gyata, 2019).

**Training Needs of Extension Personnel and Farmers**

Small scale farmers in Nigeria usually do not have effective agricultural training as well as extension services (Oyegbami, 2018). This had led to their inability to utilize such farm practices that can improve their yield, ensure soil conservation as well as guarantee adequate use of farm tools (MMPR, 2019). Farmers' capability in terms of securing essential and modern ideas, assimilating such ideas and its utilization is subject to their level of training (Nyarko and Kozári, 2021). Gbughemobi et al. (2021) and Muhammad et al. (2018) reported that farmers in Nigeria do not possess adequate knowledge on the utilization of ICTs and other digital tools, hence, the need to train them on ICT utilization. For digitalization to efficiently improve farmer's knowledge through modern approaches to agricultural extension service there is need for systematic training and re-training of extension staff as well as farmers. Such trainings should focus on production threats and emergencies including climatic changes, natural disasters, price fluctuations, household risks and policy alterations (Muhammad et al.2018).

The challenges from the COVID-19 pandemic especially as they relate to social distancing measures has given rise to a rethink on the utilization of digital tools in Nigeria for extension personnel (Fatty, 2019). Gezahagn (2021) suggested an

intensive digital training on the utilization of internet solutions for farmers and extension officers in order to tackle the gap in digital skills.

**Effects of Digitalization on Agriculture**

Digitalization of the agricultural sector in Nigeria has enhanced the transfer of information and ideas especially as it relates to market information. This has facilitated profit maximization for the farmers (Oke et al, 2019). Farmers need real time information dissemination for efficient agronomic practices. This can also assist remarkably in reducing production cost and risk as farmers are authorized to make healthy decisions (Pesce et al., 2019; Ibukun et al., 2021). Digitalization of the agricultural sector will essentially assist in bridging knowledge gaps, implying that majority of the farmers can access advisory services irrespective of the insufficient number of extension staff (Olagunju et al., 2021).

Utilization of digital tools will increase the adoption of innovations through improving the ability of the farmers to take up new challenges, as well as guarantee access to beneficial sales outlet for their farm produce (Anyoha, et al.,2018; Yousaf, et al., 2021; Green, et al., 2021). Digitalization has led to an increase in food security while reducing agricultural environmental footprint (Fraser and Campbell 2019; Basso and Antle 2020). According to Fabregas et al. (2022) digital tools improve productivity, enhances the standard of living of the rural poor while supplementing the indigenous extension approaches. Weather forecast using up-to-date meteorological equipment in addition to intelligible transfer of ideas through internet services or mobile phones enables farmers in making knowledgeable commitment on the periods of their agronomic practices (Pesce, et al., 2019; MMPR, 2020). Emergence of other automated equipment for agricultural production such as irrigation, light and heat control, satellite photography, Unmanned Aerial Vehicles (UAVs) is altering decision making in the farm labour sector for good (MMPR, 2019; Hermanus, 2021).

Digitalization has also minimized the rate of post-harvest losses on the agricultural value chain by increasing access to value addition facilities (MMPR, 2020). With emerging synergetic preparations which have given rise to increase in agricultural productivity and farm income, digitalization has made the agricultural sector more attractive to young farmers (Saiz-Rubio and Rovira-Más, 2020).

The adoption of digital technologies may come with alterations in the existing agricultural systems for the worse (Fielke, et al, 2019). For instance, Rose et al. (2021) suggested that an increase in technology adoption may give rise to the neglect of the original knowledge and detach farmers from the landscape.

The digitalization of the agricultural sector may increase the level of unemployment in the rural areas. Trendov et al. (2019), Beirne and Fernandez (2022), Olomola and Nwafor (2018) and **Osabohien et al. (2019)** opined that the reduction in the cost of labour as a result of digitalization of the agricultural sector will invariably augment for the unemployment.

**Challenges of Digitalization of Agriculture in Nigeria**

Several challenges are militating against the effective digitalization of the agricultural sector in Nigeria (Fuglie, et al., 2020; Jellason, et al., 2020, Bolfe, et al., 2020). Farmers in Africa have over the years depended on indigenous knowledge for

weather forecasting as a result of the absence of modern climatic data (Owusu, et al., 2018). For efficient digitalization, the existence of the technical know-how for manipulating and assessing data is of utmost importance (Baumüller and Addom, 2020). Less attention has been given to digitalization in many developing countries due to lack of knowledge of its possible capabilities in controlling production risks in agriculture (Olagunju, et al. 2021).

Foster et al. (2018) identified deficiencies in digital skill, poor financial strength as the core exclusionary barriers to digitalization. According to MMPR (2019), the absence of digital innovation hubs and other ICT public access spaces in rural areas is a major challenge of digitalization in many developing countries. When these hubs are created, they will facilitate the development of innovation habitat which is very necessary in stimulating the conversion of the agricultural system as well as availing the sector the convenience for youths in agriculture.

The absence of infrastructure is among the core challenges impeding the utilization of digital technologies in Nigeria (Nigerian Communications Commission, 2021). African Development Bank Group (2019) opined that when compared to 13, 000 kWh and 6,500 kWh electric power utilization per capital/year in the United States of America and Europe respectively, Africa (with the exception of South Africa) experiences the least tariff (AfDB, 2019). This ideally should have created an enabling environment for digitalization in the agricultural sector. Unfortunately, the core challenge of electricity in Nigeria is not about the cost but availability (Edomah et al., 2021; Babatunde et al., 2019). With the potential capacity to generate 12,522 MW of electric power, Nigeria is only able to dispatch 4,000MW which is insufficient for a country of about 195 million people (USAID, 2020). Worse still, only 55.40% of Nigerian has access to electricity (World Bank, 2019). It is expected that the electricity demand for agriculture in Africa which currently stands at 9 gigawatts will require additional 4.2 gigawatts before 2030 (Lawrence et al., 2020)

In 2017, ownership of mobile phones in Sub Saharan Africa was 75 percent with 34 percent ownership of smart phone (Okano et al., 2022). This is an improvement from the 20 percent in 2014 (GSMC, 2018b). With the rate of smart phone ownership expected to double in 2025, prices of mobile phones possess major challenge for its adoption. This is more evident in the rural areas where most of the farmers reside. MMPR (2019) has opined that in line with Mobile Connectivity Index-MCI) (measure of infrastructure, affordability, consumer readiness and service content), African countries present the most unfavourable statistics globally.

GSMC (2018a) highlighted that the class and speed within the cyberspace link in sub- Saharan Africa (SSA) are lagging behind. In 2018, only about 60 percent of the sub-region had 2G coverage, 36 percent had 3G coverage and 4 percent had 4G coverage. These are poor statistics when compared to Latin America where 43 and 23 percent had 3G and 4G coverage respectively. Also, the cost of accessing the internet in Africa is still high. About 9 percent of the per capita income of an African is spent on 1GB of data subscription against 1.5 percent and 3.6 percent that is obtainable in Asia Pacific and Latin America respectively (MMPR, 2019)

Aside the absence of skilled labourers in the agricultural sector (Kim et al., 2020), UNCTAD (2021) has identified the increasing youth population of Nigeria which is expected to raise farm labour supply and reduce wages as a factor that will reduce the incentives for digitalization.

The arrival of digital technologies has led to an increasing suspicion that bigger firms will be empowered more than the weaker firms thereby widening the already existing gap. Moreover, connectivity might empower stronger firms at the expense of weaker ones (Foster et al., 2018; Trendov et al., 2019; Tsan et al., 2019) while in many cases, the tacit idea of farmers may be depleted and overtaken by digital knowledge (Soma and Nuckchady, 2021). Also, the slow rate of economic diversification among developing countries does not support digitalization.

## Conclusion and Recommendations

Nigeria clearly has a booming supportive environment for agricultural digitalization. The study identified an increase in the trend of research on digitalization from 2011-2021. Several authors identified the availability of government and extension support with consistent government policies as factors that affect the digitalization of the agricultural sector in Nigeria. An efficient support of the digitalization of the agricultural sectors in Nigeria will ameliorate the negative influence that has hampered its success. Digitalization can enhance the ability of agricultural producers for poverty reduction and other livelihood improvements. Farmers and extension staff need more training on the utilization of digital tools for agricultural production. Among the core challenges of digitalization of the agricultural sector in Nigeria were absence of infrastructure and the slow rate of economic diversification among developing countries. There is a need to create more awareness of agricultural digitalization, especially through the institution of ICT hubs. Government should commit resources towards the implementation of policies that would make digital agriculture more acceptable to farmers. This will include adequate training of extension agents and farmers. Efforts must be made by the government and other non-governmental agencies to revamp the infrastructure in the rural communities to facilitate access to digital tools.

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