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Adoption of Android IoT Smart Technologies for Rural Agricultural Innovation and Implementation of Green Economy Reforms

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Abstract: A macroeconomic strategy for achieving sustainable economic growth is offered by the green economy, with a particular emphasis on investments, jobs, and digital skills among farmers. To hasten and solidify the sustainable changes in consumption and production patterns required Internet of Things (IoT) smart technologies, multi-stakeholder engagements and grassroots digital agricultural implementation for the development of the green economy. A modern and dynamic way to helping farmers, extension services, agri-business, and policy-makers grasp creative solutions to technology-driven food security is the use of IoT Smart technologies for sustainable rural agricultural employment. In this research, a sample size of 385 farmers from Agricultural Development Project in the Selected States of Katsina, Kano and Jigawa were included in the study, which used a survey methodology. Three hundred and eighty-five (385) respondents who provided the primary statistical data for this study through the application of a series of pre-tested and structured questionnaires were chosen using a multi-stage, combined with purposive and random sampling approaches. Descriptive statistics were used to analyse the collected data relating to the study. The research discovered that accurately priced goods, better market placement, and enhanced production methods will all be possible with the use of IoT smart technology connectivity chain in farming as Information communication technology (ICT) in agriculture will give farmers more knowledge and guidance on best practices through the government extension service engagements. The paper concluded that agricultural research and investment will have a big impact on the increase of the food supply due to technological improvements, and this will be crucial for guaranteeing future food security and sustainable food production through innovative IoT farming.

Keywords: Android IoT Smart Technology, ICT Innovation, Food Security, Green Economy Reform, Sustainable Agricultural Economy, Agro Economy

1. Introduction

The United Nations' population division in the department of economic and social affairs had predicted that by 2030, there will be 8.5 billion people on the planet, and by 2050, there will be 9.7 billion [1]. To that effect, food production must increase by 70% in ratio by 2050 in order to feed this expanding population [2]. The increase of the food supply through technical developments will play a crucial part in agricultural research and investment's ability to achieve sustainable food production and food security in the future. To enhance sustainable agricultural productivity, a renewed focus on innovation and investments in research, technology, and capacity building are required. The term "Agricultural Green Economy" (GEA) refers to a comprehensive set of rights to adequate food along with nutrition security in terms of food availability, access, stability, and utilization that may improve the standard of rural livelihoods while effectively managing natural resources and enhancing resilience and equity along the entire food supply chain, taking into account different nations' and individuals' unique situations [3]. The GEA can be accomplished by taking a comprehensive approach to managing agriculture, forestry, and fisheries in a way that meets a variety of societal needs and desires without jeopardizing the chances that future generations will be able to take advantage of the full range of goods and services provided by terrestrial, aquatic, and marine ecosystems [4]. As a result, GEA aims to:

1) Encourage the use of a macroeconomic strategy to achieve sustainable economic growth through regional, sub-regional, and national agricultural forum.
2) Green Economy concepts being demonstrated, with a particular emphasis on investments, technology, and financing available for the green sector.
3) Promote nations in terms of macroeconomic policy development and mainstreaming to support the shift to a green economy.
4) Secure access to food and nutrition through striking a balance between domestic production and trade.
5) Help ensure that everyone has access to enough food, and help rural areas have liveable economies.
6) Maintain healthy ecosystems that incorporate food production and respect natural resource restrictions using both conventional wisdom and scientific knowledge.

In order to achieve the comprehensive Sustainable Development Goals (SDG) with regard to global food sustainability and nutrient security, the GEA fundamentally transformed government agricultural objectives [5]. The GEA is a universal and revolutionary agenda for global agricultural industry reform. The GEA offers a macroeconomic strategy for long-term economic expansion with a primary emphasis on investments, employment, and skills [6]. It adopts a long-term outlook on the economy, generating wealth and resilience that serve the needs of present and future citizens while also responding quickly to address the multifaceted poverty and inactivity of the present.

In this study, emphasis were laid on the socioeconomic and demographic characteristics of farmers, the mobile phone apps available, the awareness and usage levels of agricultural mobile apps, and the extent, intensity, purpose, and limitations of farmers' app usage in anticipation to the smartest agricultural reforms. It also looked at the availability of mobile phone apps adoption by the rural farmers. The sum of 385 farmers from Agricultural Development Project in the Selected States of Katsina, Kano, and Jigawa made up the study sample. Three hundred and eighty-five (385) respondents were chosen by the application of a series of pre-tested and structured questionnaires using a multi-stage, coupled with purposive and random sampling approaches. These respondents provided the major statistical data for this study.

The findings indicated that the average age of farmers in the zone was 36.5 years, and the average amount of agricultural experience was 16 years. The majority of the respondents were men with only one or two type of formal education and a typical household size of seven people. They were not members of any farmer organizations, yet farming was their main source of income. Additionally, the majority of respondents (96%) possessed a mobile phone, of which 60.5% were ordinary phone owners. The majority of farmers in the area were generally knowledgeable and utilized voice call and SMS apps: call app (95 percent) and SMS (78 percent) were reported. Further research found that call apps are the most frequently used by farmers to contact family and friends (96 percent), to buy agricultural supplies (70 percent), and to get marketing and general information (65 percent), while SMS is mostly used to communicate with family and friends (59 percent). The use of mobile phones and the related technology were largely viewed favourably by farmers in the study area.

The accessibility of inexpensive android hardware and software will present opportunities that will ensure simplicity while using benchmark software programs that precisely fit the requirements for agricultural management. This study examines the present contributions of android technology to the advancement of society attentiveness, learning techniques and social interconnectedness that promote agricultural cultivation and rural incentives. It also analyzed the potential for agricultural management adaption to meet current agricultural demands in Nigeria and Sub-Saharan Africa. With the variety of features that smartphones offer, which make it simple for users to access information when they need it, this research will essentially harness the enormous resources of the android device and adapt it to suit agricultural extension services management, particularly for developing countries. The paper is structured into introduction, literature review, aims and objectives, research questions, research design and methodology, analysis of the findings, future research focus, recommendation and conclusion.

2. Literature Review

This part gave a thorough analysis of the literature on the significance of smart agriculture, the background, and the ideas behind agroecology and agro-base technology. It highlights many agricultural innovations and chains of functional digital ecosystems of suitable agro-based innovations and agroecology and goes on to describe how these specifically relate to smallholder traditional methods and organic farming. The political economy of agro-ecological transition was covered in detail, as well as how cooperatively sharing smallholders' ecological knowledge with other pertinent agricultural actors might promote the shift to sustainable agricultural policy for food security. The literature review were expanded to agro-based technology innovation**,** digital technologies and ICTs facilitated interactive communication with smallholder farmers for supplementary inclusiveness.

2.1. Agro-Based Technology Innovation

In order to achieve the SDG on food security, rural farmers should be able to access agricultural services linked to the GEA program through the deployment of disruptive technologies for agricultural innovation [7]. Achieving food security and the SDGs requires agricultural innovation, which is essential to rescuing family farmers from poverty and addressing youth and rural women's unemployment. Agriculture can undergo the transition required to respond to feeding a larger and more urbanized population by accelerating and scaling up innovation in the sector. The moment is now to gather stakeholders in order to share expertise, invest, and open up the policy, pathways, and business models targeted at fostering innovation in agricultural programme. A global set of transformative goals and targets have been agreed upon by nations with the establishment of the 2030 Agenda for Sustainable Development [8]. The SDGs acknowledge that combating poverty requires policies that promote inclusive economic growth, food security, employment opportunities, addressing social needs like education and health, safeguarding the environment and the planet's natural resources [9]. The 2030 Agenda specifically mentions innovation as a vital tool for implementation, recognizing its significance in hastening the fulfilment of the SDGs. In order to increase access to technology and innovation, it calls for: increased cooperation and knowledge sharing across the nations; emphasizing the urgency of developing, transferring, disseminating, and diffusing environmentally sound technologies; and highlighting the needs for least developed countries' capacity building mechanisms [10].

To scale up innovation in agriculture, decision-makers and stakeholders must get a deeper understanding of the actionable routes, fresh alliances, and commercialization strategies including the public and private sectors, civil society and farmer organizations. Governments at all levels in collaboration with civil society, farmer organizations, and the private sector, must foster the conditions necessary for the agricultural innovation to thrive. To do this, they must connect various actors, develop the capacities for the farmers and other stakeholders to collaborate, together with offering of incentives to innovate. The basic component of the agricultural innovations are researches and extension services that promote scientific knowledge sharing and digital collaborations within the agricultural supply chains [11]. The Food and Agriculture Organization (FAO) of the United Nations which coordinates efforts to end hunger and improve nutrition and food security, has pushed for a change from interventions focusing on individual agricultural innovation components to a system-approach aimed at strengthening institutions and stakeholders' networks as a comprehensive ecology of complete food system, taking into account ecological, economic and social factors [12]. In fact, agroecology seeks to improve agricultural systems by utilizing natural processes, fostering advantageous biological interactions and synergies among agroecosystems' constituent parts, minimizing synthetic and toxic external inputs, and utilizing ecological processes and ecosystem services in the design and application of agricultural practices [13].

The inauguration of Agricultural Research and Innovation Fellowship for Africa (ARIFA), was to train young Africans with 21st-century skills and the capacity for digital agricultural innovation, launched in Brazil by the Forum for Agricultural Research in Africa (FARA) [14]. The inauguration of ARIFA in partnership with Brazil Africa Forum 2019 highlighted the significances of technology innovation to advance Africa's agricultural productivity, which is at the centre of ARIFA initiative, indicating that it would be challenging for Africa to achieve food and nutrition security without advances in technology deployment in agriculture [15]. The FARA is the leading continental body in charge of coordinating and promoting agricultural research and development (R&D), being the official technical arm of the African Union Commission and the African Union Development Agency for issues relating to agricultural sciences, technology and innovation [16]. In order to re-engineer the African agri-food sector and provide the change element for rapid agricultural transformation in the ensuing ten years, FARA is executing the Agricultural Research and Innovation Fellowship for Africa. Through Innovative Platforms (IP) and rural learning pathways found in and around African institutions, universities, technical colleges, and rural communities, ARIFA will support the regular admission of cohorts of graduates and agri-preneurs into the innovation systems designed by FARA. Dr. Irene Annor-Frempong, Director of Research and Innovation at FARA, spoke about the goals of ARIFA and how they fit into the larger Africa developmental agenda. The advancement in the disruptive technology paradigms will revolutionize agricultural activities with incredible productivity via active engagement, and globalization [17, 13]. In the 21st century's technological development, the employment of smart technology is crucial for knowledge application in agricultural incentive toward food security [18].

With an estimated 1.2 billion people in Africa, more than 60 percent of whom are under 25, and with minimal job growth in the rural areas where the majority of the population lives, there is rising doubt about the continent's ability to lift its people out of poverty [19]. To develop Africa's agribusiness, close the rural-urban gap, and support smallholder and family farmers, fishers, pastoralists, and forest dwellers, digital innovation and the use of ICTs will be crucial. Innovative methods and technology approaches can boost output and earnings, enhance nutrient intake, give women and young people greater access to markets and information, and ensuring that agricultural practices are environmentally sustainable for future generations [20]. In order to create opportunities for actionable digital inclusion as well as the expansion of cutting-edge digital services, FAO must collaborates with key stakeholder and partners to design digital inclusion that will provide social economic empowerment for rural agriculturist [21]. A direct way to combat poverty and ensure food security is to bring solutions closer to the needs of hungry households in Africa and other regions through ICTs enablement to maximize opportunities for social safety, financial empowerments and agricultural extension services in the rural areas [22]. Access to markets, knowledgeability in agri-business projects are easier through ICTs initiatives for digital inclusion, focusing on infrastructure and legislation, cost, digital literacy and the accessibility for agricultural incentive [23].

Accelerating sustainable development in both consumer and agricultural output is assisted by the ICTs' partnerships in fostering innovations for GEA in order to boost Africa's economic growth [24]. The notion of green economy does not abrogate sustainable development, but creates a new focus on the economy, investment, capital and infrastructure, employment, skills and environmental outcomes across Nigeria, Africa and the global world in direction of agricultural sustainability [25]. In order to fulfil the requirements of the GEA, Nigeria would need a thorough agricultural education to incorporate technological advancements and inventions into their main stream rural agricultural program through early adoption of scientific hybrid methods. Such a methodology will call for combining the existing agricultural programs and practices with a number of other scientific approaches. It will also call for the adoption of artificial intelligence, machine learning, the Internet of Things (IoT), cloud computing, and software innovations, all of which have the potential to advance the production of scientific knowledge in the 21st-century agricultural management using mobile android smart computing technology [26].

2.2. IOT Smartphone Interactivity and ICT Communication in the Agricultural Supply Chain

Digital technologies, commonly referred to as information and communication technologies (ICTs), are the group of tools used to facilitate communication and information exchanges [27]. These technologies consist of both software and hardware, such as internet services and media for information transmission and hardware such as personal computers (PCs) and mobile phones [28]. The ICTs, particularly mobile phones, can facilitate efficient information sharing by connecting more people—even in faraway locations and Africa has also shown the effectiveness of mobile phones in this regard. Farmers can contact with extension agents, marketing representatives, and other farmers while also learning about new agricultural knowledge through the use of mobile phones. Mobile devices can make it easier for agricultural actors to engage and communicate more frequently. The many benefits of mobile phones, such as their accessibility, instantaneous two-way communication, and user-friendliness made possible by the growing adoption and use of internet services, spur international and local companies/developers and vendors to create a variety of mobile applications, also known as "m-apps," to support agricultural development and educational engagement. [29].

The software programs known as "m-apps" are those that are designed for mobile phone operating systems that improve the productivity of feature of smartphone devices [30]. These capabilities enable users of such phones to perform particular tasks, such as voice recording, sharing of graphics, locations, text messaging, social networking on platforms, and sharing of images [31]. Different operating systems, like Google's Android and Apple's iOS play shops, give third-party developers the ability to create, sell, or offer for free apps for users, and allow people to download those apps. Mobile phone applications with features of smartphone phones can help with feedback and/or interaction in communication, and some have been used to provide smallholder farmers to obtain agricultural information including finance options, market pricing, weather conditions, etc [32]. As a matter of fact, it is possible to create an interactive platform that allows farmers to share their knowledge and communicate with extension agents, as well as other agricultural actors like academics and policymakers. ICT ventures can occasionally run into difficulties as studies have showed that several elements should be taken into account when thinking about employing ICT-assisted initiatives in addressing issues that smallholder farmers are facing [23]. When examining the arguments more deeply, it is crucial to recognize the social dynamics and power structures that are an essential element of any growth or societal changes. The mobile operating system (OS) for android devices has been modified to primarily give perceptions for touchscreen device setup, mobile phones, tablets, and other android accessories [33].

With finger actions that mimic typical gestures like pinching, swiping, and tapping, Android's operating system architecture will allow the generation of digital natives to handle mobile devices naturally [34]. Under the Apache License Agreement, Google created the Android mobile operating system, which is now the standard for touchscreen mobile devices like smartphones and tablets. Android is based on a customized, personalized, and amended version of the Linux kernel in addition to other open source software. Google Mobile Services (GMS), a collection of exclusive software that is linked to Android and typically pre-installed on all Android-powered smartphones, is a set of proprietary Google software. Developers of software and applications have converged on the usage of Android technology and innovation to jump into the deep end and create mobile apps that are distributed through App Stores [35]. Because Android was created and is managed by Google, users have the option to connect their mobile devices to other Google products, including cloud storage, email platforms, video services, and IoT enterprise platforms [36]. When used correctly at the grassroots level, these tools will significantly improve the delivery of agricultural and educational services [37].

According to estimates, there are 201 million people living in Nigeria, 172 million of whom are active mobile phone users, and 64 million of whom own both smart phones and digital personal assistances [38, 39]. In 2020, there were over 180 million internet users in Nigeria, and there were over 186 million mobile 3G and 4G internet subscribers [28]. The internet penetration rate was 62 percent enabling significant portion of Nigerian farmers to have access to mobile phones and the internet [40]. In a research conducted by Haruna et al. (2013), 66 percent of the 120 farmers sampled in a few communities in Kaduna State, Nigeria, found mobile phones to be very effective for gathering and sending information about their farming operations, making the task of closing the top-down agricultural information gap practically achievable [23].

3. Research Question

The study was structured to provide answers to the following research questions:

1) Are the mobile computing technologies available for the farmer to negotiate with the smart agricultural innovation?
2) Does the farmers embraced these technologies and are able to use them effectively for the agricultural management?
3) What factors limit the adoption of mobile technology devices in Nigeria rural agricultural implementation?
4) To what extend will the adoption of the smart digital technologies be adequate for rural agricultural innovation?

4. Research Purpose

This research was conducted to achieve the following objectives;

1) To present data related to the social-economic impact of mobile technology adoption among the rural farmers.
2) Compare the impacts of the mobile computing technologies on the agricultural productivity of the rural farmers in the selected states of the North Western Nigeria.
3) To establish the correlation between people (farmers) and technology implementation for agricultural innovation.
4) To establish technology strategies for improving the rural agricultural productivity.

5. Research Design & Methodology

This study gathered information through primary and secondary sources. The primary sources required the distribution of the questionnaires to the participants that were randomly selected. This research examined the awareness and use of mobile phone applications in the North-West Nigeria and specifically investigated the demographic and socio-economic characteristics of farmers, mobile phone apps availability, awareness and usage levels of agricultural mobile apps, extent, intensity, purpose, knowledge, and constraints to apps use by farmers. The study adopted a survey design with a sample size of 385 farmers from an extension block of Agricultural Development Project in the Selected States of Katsina, Kano and Jigawa state. Using a multi-stage, coupled with purposive and random sampling techniques, three hundred and eighty-five (385) respondents, who provided main statistical data for this study through the application of a set of pre-tested and structured questionnaires, were selected. Data were analysed with frequency counts, percentages.

Rural farmers were questioned on the sources of agricultural innovation knowledge, the channels (i.e., individuals or institutions), and the need for such knowledge. The researcher used interview strategy wherever it was practicable, which helped to learn and observe the characteristics of the farms and the nature of their job. Interviews lasted between one and two hours. The Agricultural Development Project documents and official publications of the Federal Ministry of Agriculture and Rural Development, National Agricultural Research Institutes (NAERLS), as well as other secondary sources of data were analyzed. In other hand, the secondary sources of data involved combining the digital archives and scholarly literatures that explored the subject of agricultural technology innovation from the World Bank archives were also pictured.

6. Analysis of Finding

By 2025, it is anticipated that Nigeria, the African continent largest economy and most populous country, would have consumed over 140 million smartphones [41]. Currently, the estimates from various sources put the number of smartphone users in Nigeria at around 40 million [42]. Although it might be challenging to estimate exactly how many people use smartphones, but the Nigerian smartphone market is expected to grow significantly over the next five to ten years, with the number of consumers expected to triple [43]. The year 2019 saw an increase in the market share of the Android Operating System from 85.1 percent to 86.6 percent, refer to table 1. The amount and volume of consumption are anticipated to increase in five years by a factor of 1.7 percent annually, with predicted consignments of 1.4 billion in 2023 worldwide [44]. According to projections, sales of android devices would increase by 1.52 percent in 2019, and all signs point to continued growth in the subsequent years. The fact that 2019 presented a difficult business environment for iPhone consignments in terms of trade and investment, with expectations of volumes declining to 185 million at a proportionate rate of 11.4 percent year after year from the worldwide market, was not funny at all for iOS [45]. According to the International Data Corporation (IDC), between 2020 and 2023's middle, the market will grow by a low point of one percent [46]. The IDC Worldwide Quarterly Mobile Phone Tracker predicted that the number of smartphones sold worldwide would decline by 1.4 percent in 2019 to 1.382 billion units, from 1.402 billion in 2018 [44]. The android and iOS smart phones market is expected to return to optimism by the middle of 2020 with measurements range of 2.9 percent [47]. In a larger sense, International Data Corporation predicted that by 2023, the global smartphone market would reach a magnitude of more than 1.489 billion units [48].

Table 1. *Smartphone Market Share for Android Device and iOS,*

Year	Android Powered	iOS Powered	Others	Total
2017	85.1%	14.7%	0.2%	100%
2018	85.1%	14.9%	0.0%	100%
2019	86.6%	13.4%	0.0%	100%
2020	86.6%	13.4%	0.0%	100%
2021	86.9%	13.1%	0.0%	100%
2022	87.0%	13.0%	0.0%	100%
2023	87.15%	12.9%	0.0%	100%

Source: https://www.statista.com/statistics/272307

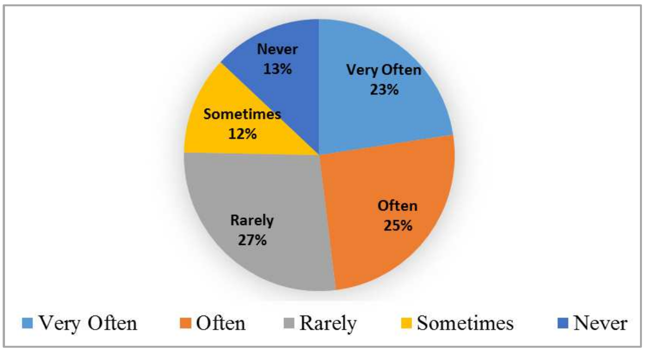

Figure 1. *Mobile Phones Availability to the Rural Farmers.*

In analysing the key research questions, as identified in the current study, the descriptive statistics were adopted for data representation, refer to Figure 1, Table 2 and Figure 2. On the mobile computing devices availability to the farmer to negotiate with the smart agricultural innovation in the selected study area, the study discovered that 23% (89 rural farmers) agreed that mobile digital devices are very often available, 25% (96 rural Farmers) agreed that mobile devices are often available, 27%(104 rural farmers) agreed that mobile smart devices are rarely available, 12%(46 rural farmers) agreed that mobile device are sometimes available while 13%(50 rural farmers) agreed that mobile devices never been available to them for agricultural implementation.

In a similarly development, the research discovered that 200 respondent representing 51.9% of the selected farmers only have access to non-smart mobile phones, 150 (39%) own Smart Android phones, 20 (5.1%) of the rural farmers own Portable smart phones, 10 (2.6%) own Tablets and lastly 5 (1.3%) farmers own Laptop computer.

Table 2. *Digital devices utilization by the farmer for Agricultural supply chain.*

Device Model	Frequency	Percentage
Non-Smart Phones	200	51.94805195
Smart Android Phones	150	38.96103896
PDA& Portables	20	5.194805195
Tablets	10	2.597402597
Laptops	5	1.298701299
Total	385	100

Survey 2021

The Figure 2 represented some of the factors limiting adoption of mobile technologies for agricultural implementation in the studied area. As a matter of fact, 120 rural farmers representing 31.2% of the distribution cited lack of digital literacy as the factors limiting smart agricultural adoption in their respective localities. Subsequently, 60 rural agricultural respondents, representing 15.6% agreed that lack of government are among the factors hindering rural agricultural integration. While 98 (156%) farmers cited economic hardship as factor limiting smart agricultural implementation, 90 (23.4%) cited lack of infrastructure like road, electricity, modern storage facilities, telecommunication, water, irrigation and drainages as factors hindering smart agricultural implementation. Finally, 17 (4.4) of the farmers responded to conservatism to modern implementation as factor limiting the smart agricultural innovation in the studied area.

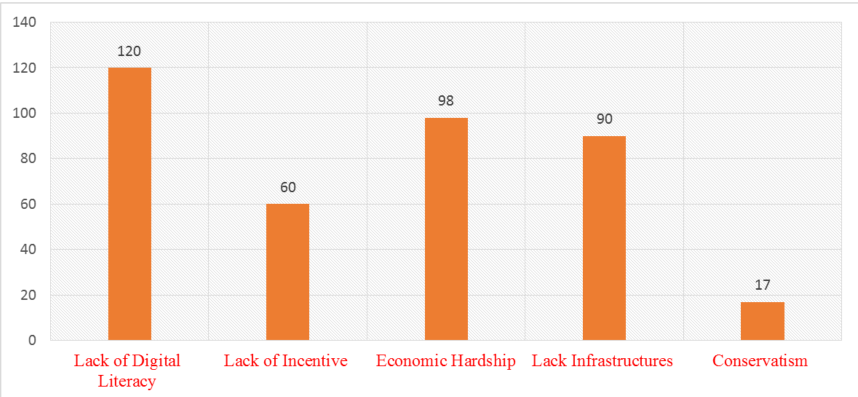

Figure 2. *Factors Limiting Adoption of Mobile Technologies for Agricultural Implementation in the rural area.*

7. Discussion of Findings

Adoption of android tablets, though it was slow-moving, was where the popularity of smartphones initially began [49], the creators were hesitant to devote further funds to creating tablet-based core enterprise apps until there were sufficient financial incentives. Because there weren't any ideal Android tablet apps available for the initial release, the designers of Android tablets rushed to release existing Smartphone apps even if they weren't a perfect fit for the larger screen sizes [50]. Although Android tablet application support is still in its early stages, a sizable number of Android tablets, including the well-known Barnes & Noble Nook and all other OS models like the HP Touch Pad and BlackBerry Play Book, were hastily released for global consumption in an effort to capitalize on the iPad's already-established market acceptance [51]. Tablets running the Android operating system alongside Android 3.0 Honeycomb cannot be customized because of the Graphical User Interface (GUI). Additionally, several Android Tablets, such as the Motorola Xoom, were either similarly priced to or more expensive than the iPad at the time of early development, which had a substantial negative impact on sales. Since 2011, there have been three years, or more than 191.6 million Android tablets in use [52].

Around 2013, business Android tablets surpassed iPads in market acceptance during the aforementioned time period, becoming a well-established and dominating form of tablet. According to data on Stat Counter's website, Android tablets continued to dominate the market in August 2017 in South America (57.46%), Africa (70.07%), and Europe (34.44%). They were second to iOS in North America (65.19%) and Europe (34.44%), and still attracted significant market share in Eastern European, Caribbean, and Central and South American countries (82.18 percent). In most nations, including Nauru, over 80% of tablets are thought to run Android. In contrast, Android device usage is allegedly far behind in Australia (10.71%), Oceania (11.93%), and New Zealand (16.9%) [53].

In the upcoming year, every business will be dominated by the Android operating system and its associated hardware [54]. Similar to how Apple's iOS devices are to the Apple family of mobile devices, Android will play a crucial role in mobile device selection [55]. Due to the fact that Microsoft's exclusive Mobile Office programs were improved and are much more compatible with iOS and Android than with its exclusive Windows 10 or Windows 8 Mobile Computing devices, the adoption of Android operating system will be robust in the upcoming year [56]. The Android devices included a wide range of hardware upgrades that could be added, including GPS, pressure sensors, orientation sensors, dedicated gaming controls, proximity sensors, HD video cameras for augmented reality, thermometers, accelerometers, barometers, magnetometers, touch screens, and gyroscopes [57]. In the upcoming year, Android OS and Android smartphones will predominate throughout all of Africa [58]. With several modifications and adaptations, Techno Android Mobile and Infinix Mobile will proliferate the mobile phone industry. Techno Mobile and Infinix Mobile will thrive admirably in Africa, with Nigeria serving as the primary market for Android in the near future [59]. Due to the fact that SLOT Technologies, one of the founders of Techno Mobile and Infinix, is a Nigerian company, Techno Android Mobile and Infinix Android Mobile will dominate the continent of Africa. SLOT Systems Limited sprang to prominence as a leading distributor of affordable and durable mobile Android phones, computers, accessories, and several customized electronics. With significance and domination in Nigeria and the African market as a whole, it is widely regarded as essential for cutting-edge digital technology on a global scale [60].

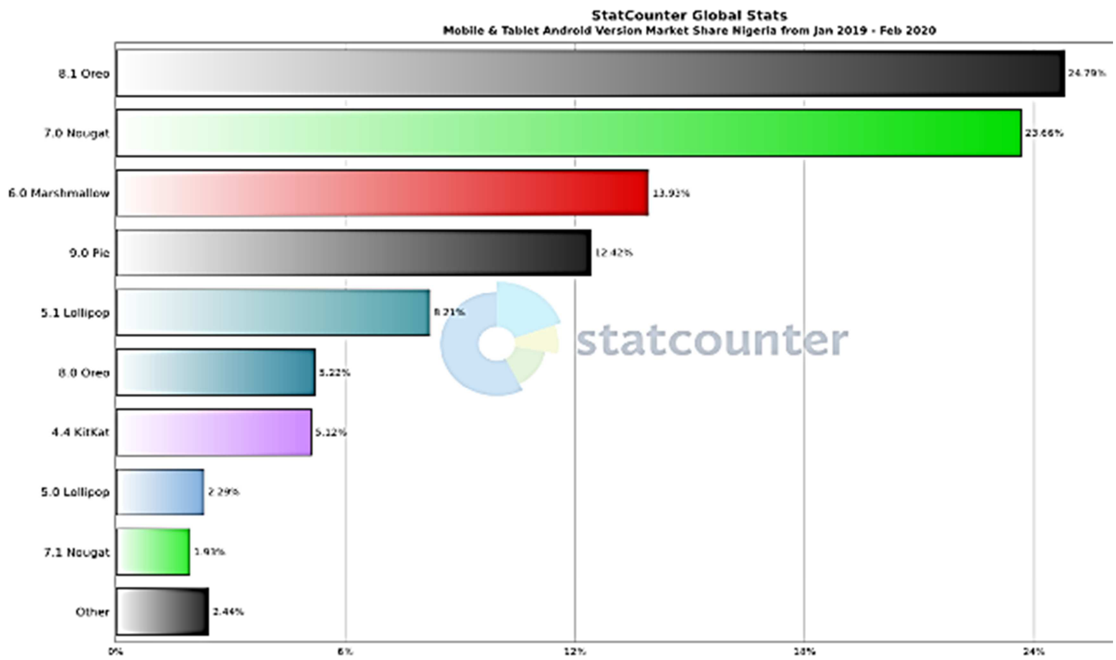

Figure 3. *Market share for Android-powered mobile phones and tablets in Africa from January 2019 to January 2020.*

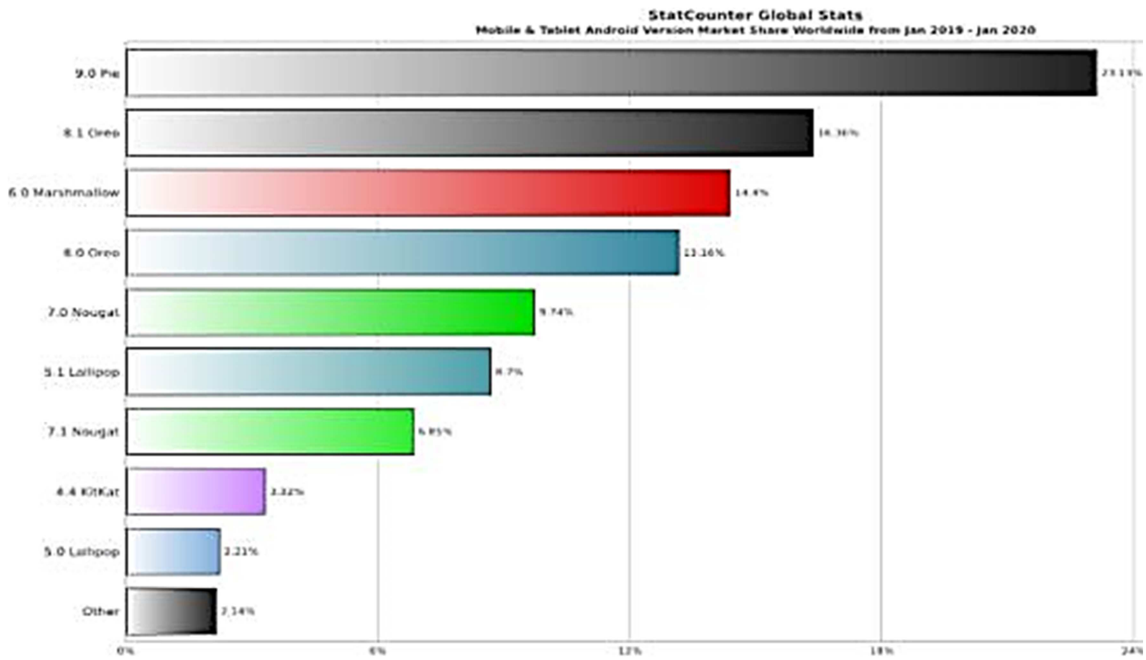

Figure 4. *Market share for Android-powered mobile phones and tablets in Nigeria from January 2019 to January 2020.*

8. Future Research Focus

Future studies will concentrate on reimagining Africa, especially Nigeria toward digital agricultural sustainability. With a projected population increase of 250 million people by 2050, Nigeria would be the largest country in Africa [61]. Currently, there are between 190 and 200 million people living in Nigeria, making it particularly strategic index in the context of international politics and the business environment due to its availability of solid natural resources, including minerals, along with its advantage in human capital. In terms of developing Africa and providing leverage for the entire black race, the international agricultural investment and food security intervention in Nigeria would be quite significant. Such economic, agricultural support and social action should centre on:

i. Digital synchronization and ICT infrastructure for comprehensive Africa-Nigeria development.
ii. Communication technology, including mobile computing, IoT, big data science, enterprise networks of things, data mining, data warehousing, and block chain technologies.
iii. Industry 4.0 or extreme automation, which incorporates artificial intelligence (AI), machine learning, and business intelligence models.
iv. Mechanization and investment in agriculture.
v. Healthcare advancements and food security.
vi. Investment, cooperation, and corporation in education.

Since 2000, African countries have borrowed roughly $145 billion from the People's Republic of China, and throughout that time the percentage of loans to GDP has increased steadily [62]. The majority of Zambia's $8.7 billion debt, or $6.4 billion, was derived from a Chinese loan. The president of the Republic of Congo has flown to Beijing to get forensic debt clarification on how much his nation owes China [63]. In order to address the overextended Chinese loans, the IMF had agreed to assume responsibility for balancing a $500 million debt. Kenya's debt to China had increased geometrically over the course of five years, reaching $5 billion, which led to unsettling insinuations that Kenya's Mombasa Port might be taken away. Angola allegedly owes China $25 billion, and as a condition of repayment, China required Angola to exchange its oil. Concerns about Chinese overreach surrounding a $2 billion infrastructure deal with Sinohydro Corporation, which Ghana would pay back with its aluminium deposit, have grown in Ghana [64]. African nations should make an effort to resist all debt-related temptations and focus on reinventing services and technologies that may solve African challenges in an African context through innovative agricultural productivity.

9. Recommendation

The future research should concentrate on ICT development, digital technology synchronization, agricultural incentives, and the incorporation of disruptive technologies into the mainstream educational system and national agriculture policy. A change in policy in this direction will result in programs that are more focused on training young people for opportunities in self-employment in order to promote sustainable development and economic progress. The following strategies have been suggested for action at various levels of interaction within Universities, Vocational and Technical Education in Nigeria and any country ready for development in Sub-Saharan Africa, and to the grass roots agricultural participations in order to bring about this desirable trend.

i. ICT Infrastructure: The expansion of the digital infrastructure is crucial from the standpoint of bandwidth maintenance through economically sensible framework environments to satisfy individual needs for opportunities brought about by Industry 4.0, as well as specific ventures in developing cutting-edge ecosystems, particularly in network mobility for educational automation and sustainable agricultural investment.
ii. Education Investment: Long-term citizen education and workforce development to produce extremely skilled labour forces to enhance capital investment in human potentials and skills to enable manufacturing, industrialization, and engineering transformation and strengthened the need for agricultural innovations as the top national investment strategy towards food security.
iii. Technology Regulation: Tools to balance the disruptive forces of emerging technologies and business standards to level the economic push and lessen discrimination among the major actors in technology in the digital economy of the twenty-first century.
iv. Government Administration & Policy Plan on Agriculture: In order to balance the effects of the agricultural and educational sectors' underperformance, the budgets linked to the national economic inducement should be reasonably, objectively, openly, and successfully administered.
v. To incorporate electronic development programs into the system of agricultural automation, education, and vocational training, the federal government must design a national policy on ICT democratization, mobile technology adoption, and agricultural extension service sensitization channel.
vi. The Federal Ministry of Agriculture should establish a national program on ICT and agricultural development in collaboration with universities, polytechnics, and colleges of education to facilitate knowledge and diffusion. For the sake of national development, the institution should assess the needs, raise awareness and sensibility, and construct curriculum modules for various levels of vocational/technical education.

10. Conclusion

Technology advancements have led to new breakthroughs in society, agriculture, and education that allow people to learn whenever and wherever they want without being constrained by time or place. In recent years, agricultural technology and educational studies have intelligently interacted with cutting-edge technologies, bringing benefits and convenience through the use of mobile computing technologies that are implementable with Digital Personal Assistants (PDAs), Smartphones, Smart Laptops, and Desktop Computers to enhance learning activities in a variety of subject areas, such as Sciences, Social Sciences, Arts, and Linguistics. The educational study's use of innovative technology gadgets should be viewed as a leverage and support, not a replacement for the established paradigm of teaching and learning. Mobile phones should be gnashed for learning processes in addition to the current development. Therefore, in the digital e-society of the twenty-first century, suitable steps should be taken to promote the development of agriculture and education through digital innovation.

The global agricultural objective should guide the strategic planning, collaboration, and development of the agricultural professionals and facilitators, including Teachers, Instructors, Lecturers, Government Agencies, extension workers, Non-Governmental Agencies, Donors, Contractors, and Vendors. To assure the production of high-quality education, innovative technology development for agriculture, they should be constant and ever-progressive. The distribution and consumption of mobile computing technologies was found to be influenced by a combination of the digital divide, knowledge gap, and social-economic strata, according to the study questions posed in the current work. The study went on to show that the knowledge of how to utilize technology and the capacity to adapt and contextualize learning to an actual setting are the main elements influencing the widespread acceptance of disruptive technologies in today's culture. The availability of smartphones, computer systems, technology itself, and how it is applied in society with regard to agricultural advancements are the motivating factors that informed the current research.

Conflict of Interest

The authors declare that they have no competing interests.

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