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Cloud Computing and Other ICT advancements Use in Kenya's Agricultural Sector

Jeremiah Osida Onunga[1], Alice Nambiro[2]

[1]*Tutorial Fellow, Turkana University College and PhD Candidate, Kibabii University, Kenya.*
[2]*Director, Open Distance & Elearning (ODeL), Kibabii University Kenya.*

Abstract: According to the latest World Economic Forum study, agriculture provides a living for over 70% of Kenya's people. As a result, agriculture is a crucial sector in Kenya. Agricultural productivity is still low, and food poverty remains a problem. This has resulted in a number of projects in recent years to use ICT advancements to boost agricultural output. Cloud computing is one of the advancement that can be used by organizations that still have the traditional on premise IT systems. Agriculture is one of the most important areas that has shaped the socioeconomic growth of most countries. Over time, the benefits of widespread adoption and usage of information and communication technologies in agriculture have included improved agricultural productivity and linkages to remunerative markets, food security, and national economies, among other things. E-agriculture is a branch of activity that involves the use of information and communication tools and technology to boost agricultural productivity and make information pertinent to agricultural research, planning, extension, production, monitoring, marketing, and trade available. The goal of this desktop review research is to look into how ICT advancements have been used in Kenya's agriculture sector. Cloud computing as an advancement was reviewed. Cloud computing saves money by removing the need for costly infrastructure and it also gives businesses an easy-to-use, cost-effective, adaptable, dynamic, and secure environment in which to do business. Radios are still commonly utilized to disseminate agriculture information to rural farmers, according to the analysis, while computers are primarily used by researchers. Despite the fact that mobile-based services aimed to improve access to accurate and timely agriculture information, previous literatures show that adoption is hampered by poor technological infrastructure, ineffective ICT policies, and low user capacity, particularly among farmers, to use the technologies.

Keywords: Development, Information and Communications Technology (ICT), Innovation, Kenya, Agriculture

1. Introduction

Kenya's agriculture industry is underdeveloped, and food insecurity remains a problem. Kenya is still a net importer of food, despite its abundant natural resources and strong agricultural potential. According to an African Development Bank research (Moyo, Bah, & Verdier-Chouchane, 2019), Kenya imports 14.6 percent of its food

Agricultural commodity value addition and processing are similarly low, and postharvest losses are substantial. Agriculture, on the other hand, continues to be an important sector in the country. It is the primary source of income for the vast majority of the country's rural residents. Agriculture employs about two-thirds of the workforce and contributes for roughly 75 percent of all domestic trade (World Bank, 2010). The bulk of the rural population relies on agriculture for a living, hence the sector's growth and development are vital. The

agricultural sector's growth and development can be aided by the appropriate use of information and communication technology (ICT)

ICTs has been a key contributor to growth and socio-economic development in nations and sectors where they are properly deployed, according to the Food and Agriculture Organization (FAO, 2017). The effective integration of ICT in the agriculture sector in American and European countries has resulted in a significant increase in the efficiency and productivity of the agriculture value chain. Traceability technologies such as block-chain and radio frequency identification (RFID), for example, have enabled transparency and efficiency throughout the food chain by allowing food to be tracked and traced from farm to fork. Kenya, on the other hand, has yet to undergo such a shift. Efforts to reform the sector have resulted in the proliferation of various mobile-based applications and services in recent years.

Cloud computing as an ICT advancement is defined as a methodology for providing on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be quickly supplied and released with minimal administration effort or Cloud provider interaction.

Cloud computing is sweeping the IT world today, bringing significant changes to how IT services are created, distributed, consumed, and maintained. The residual consequences of the global recession, which caused many firms to slash their cost structure (capital and operating) while still meeting customer needs, have spurred demand for cloud computing – and its antecedents, virtualization and off-premise services.

Cloud computing is a strategic endeavor for businesses that tries to achieve the correct balance between cost reduction and growth potential. Cloud computing is a tried-and-true method for lowering IT capital expenses and increasing operational efficiencies. Many CIOs have been put off by concerns about data security, service availability, performance, and integration complexity.

According to the Technical Centre for Agriculture and Rural Cooperation's (TCARC) recent digitalization research (Digitalization of African Agriculture, 2019), 33 million smallholder farmers are already accessed by digital applications, with this number expected to rise to 200 million by 2030. Advisory and information services, market connections, financial access, and supply chain management are among the applications targeted, with advisory and information services dominating the market (Digitalization of African Agriculture, 2019). Kenya, as an African country, fits under this group as well. According to (El Bilali and Allahyari 2018), ICT-based innovations can improve rural livelihoods and empower smallholder farmers in Kenya's developing counties by boosting connectivity and access to accurate and timely agriculture information. Data mining applications, for example, which are a popular technology platform in Kenya, combine mobile and web services to improve access to extension services and market information. This lowers the expense of searching for market data and allows farmers to receive real-time weather and extension guidance.

Cloud Computing, radio, television, and mobile phones have all advanced in recent years, as have sophisticated technologies such as block-chain, artificial intelligence, cloud computing, the Internet of Things (IoT), and big data analytics (OECD, 2017). According to (El Bilali and Allahyari 2018), these disruptive ICT developments have the potential to help agricultural migrate to sustainability by increasing efficiency, transparency, and traceability. (Iliyas, 2014) emphasized that satellite-based remote sensing and geographic information systems can be used to boost agricultural output. 2020)

In addition, big data analytics can be applied in farming operations to deliver predictive insights, drive real-time operational choices, and rethink business processes (Wolfert et al., 2017) (Ahoa et al..2020) (Kassahun et. al, 2020). Precision agriculture, which employs a variety of technologies such as GPS, GIS, mobile computing, advanced information processing, and software, can provide comprehensive data on production variability in both place and time (Zhang et al, 2002) (Koksal & Tekinerdogan, 2019). (Verdouw et al., 2019).

There exist little research on ICT breakthroughs in the past. (Zewge and Dittrich 2017) used a systematic mapping approach to describe the current level of ICT for Agriculture research in underdeveloped nations. Their research focused on journal and conference articles published in developing countries between 2006 and 2014. Mobile phones, PCs, tele-centers, and the internet were recognized as the key ICTs in developing countries, with the mobile phone being the favored technology, particularly in rural regions, according to their research. Similarly, (Lwoga and Sangeda 2019) conducted a systematic review in developing countries to describe ICT for development research trends, techniques, and conceptual frameworks.

According to Kevin Yin (2016), data centers serve as platforms for typical enterprise IT applications. IT resources and separate IT apps are part of their stack architecture. Traditional data center architecture, on the other hand, will no longer be able to meet market expectations as the number of enterprise IT applications grows. In previous years, the overall number of resources (including servers and storage devices) expanded by 40% to 70% each year, while typical resource usage was only 10% to 25%. He further opines that a data center is a physical facility that organizations use to house their critical applications and data. A data center's design is based on a network of computing and storage resources that enable the delivery of shared applications and data. The key components of a data center design include routers, switches, firewalls, storage systems, servers, and application-delivery controllers. In the world of enterprise IT, data centers are designed to support business and agricultural applications and activities that include: email and file sharing, productivity applications, Customer Relationship management (CRM), Enterprise resource planning (ERP) and databases, Big data, artificial intelligence, and machine learning and Virtual desktops, communications and collaboration services, this are used to provide the vital information to farmers and also inform the general public on the availability of different agricultural needs in Kenya.

2. Methodology

The main methodology employed was a desk-top review of past studies in ICT and its use in agriculture. In addition, desktop review revealed that user-centered design research is rarely used in the development of ICT applications. In order to gather insights and improve collective problem definition in the given environment, the study advocates a paradigm change from developing technologies for users to designing and developing applications with users. This will improve the adoption and actual use of ICT advancements to improve our livelihoods. In this review work not much was available on ICT advancements for agricultural development in Kenya. As a result, the goal of this study is to carry out a desktop review examine the current condition of ICT advancements in Kenya's agriculture sector. The desktop review included a thorough examination of the previous literature on agriculture and ICT. This review of work on ICT advancements in Kenya is important for adding to the body of knowledge in Kenyan agriculture.

In this desktop review article, the researcher adopted (Kitchenham et al., 2019) method which entailed; identification of research questions, defining research strategy, defining quality assessment criteria, defining data extraction strategy, performing data extraction and defining data synthesis methods. The research topics identified for review were addressed using this approach. The search technique, which included identifying study selection criteria, was then detailed. After that, the researcher created quality assessment criteria in the form of a well-defined checklist to evaluate the studies that were chosen. The selection and quality criteria were then used to choose primary studies. The researcher next extracted and examined the pertinent review data from the primary studies.

The researcher's interest in this work is to look into empirical studies on the current state of ICT advancements in Kenya's agriculture industry. The review further put more emphasis on cloud computing as an emerging ICT advancement in agriculture in regards to data mining. The following research questions were developed to attain this goal:

i Who are the agriculture stakeholders?

ii What are the common ICT technologies utilized in agriculture?

iii What are the benefits of using Cloud Computing in Agriculture Sector?

Data Synthesis

The data synthesis's goal is to summarize and present the findings of the desktop review in a way that is appropriate for answering our research objectives. This work fits into a qualitative study based on the research purpose and findings from the primary studies that were chosen, hence a descriptive synthesis of the retrieved data was undertaken. The researcher looked at each study individually as well as the group of studies as a whole. Studies with similar or identical meanings but distinct concepts were found and placed together under a single heading.

3. Results

The results of this desktop review are presented in this section. To begin, descriptive data of the chosen reviewed previous related papers are presented. This part also includes the outcomes that match this review topic. The results will be presented as per the questions that this review work sought to answer.

a) **The Agriculture Stakeholders Identified in the Reviews**

The purpose of this review question is to identify the agriculture stakeholders who are being investigated in the papers under evaluation. A large number of studies have looked into the usage of ICTs by farmers. Farmers, according to the study, utilize ICTs like mobile phones to communicate with extension workers and access prices for agricultural inputs and commodities. The use of ICTs by researchers, extension workers, and agribusinesses is discussed in a study by Mugwisi, T., Mostert, J., and Ocholla, D.N. (2015).

The application of ICTs in agriculture research is the focus here. Other studies looked into researchers' and extension workers' access to and use of ICTs. Another study (Aleke, B., Ojiako, U., & Wainwright, D. 2011) looked at the social determinants that influence agribusinesses' adoption of ICTs in rural areas. Socio-technical variables that limit the use of ICTs by agriculture researchers are examined in another study (Barakabitze, A.A., Kitindi, E.J., Sanga, C., Shabani, A., Philipo, J., & Kibirige, G. 2015).

This review paper agrees with the previous studies that identified the stakeholders in the agriculture sector. The stakeholders are farmers, researchers, extension workers and individuals in agribusiness. This review paper also agrees that the all stakeholders in the agriculture sector also use ICT applications.

The targeted agriculture domain of the selected publications in the study was examined to address this review question. The bulk of the publications (56%) focused on the agriculture industry as a whole while researching ICT developments within it. The agricultural sub-domain was highlighted in 36% of the studies, while the livestock and agroforestry sub-domains were highlighted in 2% and 6% of the papers analyzed, respectively.

b) Common ICT technologies utilized in agriculture

The purpose was to figure out which ICT technologies were most commonly used in Kenya's agriculture industry. In the majority of polls, mobile phones were identified as the most widely utilized ICT tool in the agriculture industry. According to surveys, the growth of mobile phones on the African continent has resulted in the development of mobile-based apps and services in the business. Farmers are the primary target of these services and applications, which range from providing agriculture information such as market prices for farm produce, weather, agriculture input, and improved agriculture techniques to providing farmers with agriculture information such as market prices for farm produce, weather, agriculture input, and improved agriculture techniques. In the study (Kiambi, D. 2018) a farmer's helpline service in Kenya that provides agricultural assistance and information to smallholder farmers was mentioned. Farmers can receive information on increasing agricultural productivity, inputs, processing, climate, and market information by using a cell phone. Farmers that use this service call a toll-free number with specific questions, and agricultural specialists and subject matter experts respond.

Studies (Hudson et al. 2016, 2017), (Barakabizwe et al. 2017), (Mwombe et al. 2014), (Misaki et al. 2014), (Magesa et al 2017), (Mitegi W.P. and Msungu A.C. 2013), (Kiambi D. 2018), (Mubichi F and Freeman K. 2017), Radio remained the most extensively utilized medium in rural Kenya, Studies used the example of an interactive radio project in Tanzania, Uganda, Malawi, and Ethiopia to help small-scale farmers increase their production. Regular radio broadcasts on agricultural information for farmers were part of the radio program. Farmers may send questions to the program through SMS or phone, and the answers were broadcast on the radio. Studies alos show most farmers use radio, according to (Hudson et al... 2017), (Barakabitze et al...2017), and (Mwombe et al 2014), since radio programs are broadcast on community radio stations and in the farmers' own language, making it simple for them to absorb the information.

ICT technologies like as computers and remote sensing technologies are widely employed by both researchers and agribusiness professionals, according to studies (Mugwisi et al.2015), (Akele et al.2011), (Barakabitze et al. 2015), (Mtega W.P and Msungu A.C 2013), (Kiambi D. 2018), (Awuor et al...2016) these technologies, however, were identified as being inaccessible to most farmers due to a lack of knowledge and financial resources to purchase them.

The findings of the desktop review on the use of ICTs in Kenya's agriculture area were provided in this desktop review. The researcher discovered that high-quality studies on ICT adoption have been published in recent years. The proliferation of ICTs such as television, radio, computer, and mobile phone in the agriculture sector was revealed by the review of the studies. The mobile phone was selected as the most often used ICT in the sector, which corresponds to the findings of (Zewge and Dittrich 2017).

Farmers can obtain financial and extension-advisory services such as weather, market, and agriculture advice through apps and services on their mobile phones, which are primarily geared at farmers. The usage of remote sensing technologies, which is one of the internet of things' enabling technologies, is also available in the industry, but it is mostly available to researchers and agribusinesses. The majority of these ICTs are employed for research reasons. However, poor infrastructure and regulatory environment, fragmentation and low coordination in the agricultural research sector, and low ICT skills and capabilities of farmers continue to limit utilization and accessibility.

From the above review this study confirms that the most commonly used ICT technologies in the agriculture sector are Mobile Phones, Radio, Television, Computer and Remote Sensing in order of the most commonly used to the least commonly use

c) Benefits of using Cloud Computing in the Agricultural Sector

After the desktop review of previous literature the following benefits of using cloud computing in the agricultural sector discussed:

I. A High Level of Availability

DR (Disaster Recovery) and Business Continuity Plans (BCP) solutions are used by most cloud-based services to back up user data. This means that even if the primary server goes down or is taken offline for maintenance, the EUs will continue be served by the backup system. Furthermore, most cloud-based services are likely to be run from world-class datacenters, reducing the danger of any form of outage in the first place.

II. Location Independence

You access your data through an end terminal in a cloud-based computer environment by putting in an identifying key or password. This password can be used on any computer. The end user does not have to worry about a corrupt hard disk or malfunctioning RAM because the data is not stored on a specific end user (EU) terminal. Even if your machine fails, you will not lose your data. Consider it like signing into Facebook or Gmail on a friend's computer when yours fails.

III. No Updates

Because programs are also hosted on service provider servers, all updates are carried out there. In other words, the service provider is responsible for any operating system (OS) or application patches, new versions, or any other type of modification that needs to be implemented.

IV. No Need for an Antivirus

Because the data is stored on service providers' servers, security methods are implemented to protect the data.

V. Lower Computer Costs

To use Cloud computing's web-based services, you don't need a powerful and expensive computer. Because apps run in the cloud rather than on your desktop PC, you don't need the processing power or hard disk space that traditional desktop software requires. When you use web-based apps, your PC can be less expensive because it has a smaller hard disk, less memory, and a more efficient processor. In fact, your PC doesn't even need a CD or DVD drive in this scenario because no software packages or document files need to be saved.

VI. *Improved Performance*

You'll get greater performance from your computer if you have fewer bloated programs sucking its RAM. Simply put, because cloud computing computers have fewer programs and processes stored into memory, they boot and function faster.

VII. Reduced Software Costs

Instead of spending money on software, you may acquire the majority of what you need for free. That's right: most cloud computing programs today are completely free, such as the Google Docs suite.

VIII. Instant Software Updates

Another benefit of cloud computing in terms of software is that you no longer have to choose between outdated software and excessive update charges. When you use a web-based application, changes are automatically applied and are available the next time you log into the cloud. You obtain the most recent version of a web-based application without having to pay for or download an upgrade.

IX. Improved Document Format Compatibility

You don't have to be concerned about your documents being compatible with other people's apps or operating systems. All documents written by web-based apps can be viewed by any other user accessing that application, even if Word 2010 documents can't be opened on a computer running Word 2003. When everyone shares documents and apps in the cloud, there are no format mismatches.

X. Unlimited Storage Capacity

Cloud computing allows you to store nearly unlimited amounts of data. The 200 gigabyte hard drive on your PC is nothing compared to the hundreds of petabytes (a million gigabytes) available on the cloud. You can store whatever you want.

XI. Increased Data Reliability

In contrast to desktop computing, where a hard drive disaster might wipe out all of your important data, a computer crash in the cloud should not affect your data storage. That also implies that even if your personal computer fails, all of your data is still available in the cloud. Cloud computing is the ultimate in data-safe computing in a world where few individual desktop PC users back up their data on a regular basis.

XII. Universal Document Access

Have you ever gotten home from work and realized you left a crucial paper at work? Or did you forget to bring a file with you on your trip? Because you don't take your documents with you when you use cloud computing, this isn't an issue. Instead, they are stored on the cloud and may be accessed from any computer with an Internet connection. There's no need to bring your documents with you because they're instantly accessible from wherever you are.

XIII. *Latest Version Availability*

Another benefit of cloud computing for documents is that when you modify a document at home, the edited version is what you see when you access it at work. The cloud always has the most recent version of your documents; as long as you're connected, you'll never have an outdated copy.

XIV. Easier Group Collaboration

Sharing and collaborating on papers are inextricably linked. One of the most essential advantages of cloud computing, according to many users, is that numerous users may effortlessly collaborate on documents and projects. Because the documents are stored in the cloud rather than on individual computers, all you need is an Internet-connected computer to collaborate.

XV. Device independence

Finally, consider this benefit of cloud computing: You aren't bound to a single machine or network any longer. Your previous applications and documents will follow you across the cloud if you switch computers. Your apps and documents will still work if you switch to a portable device. There's no need to purchase a device-specific version of a program or save your document in a format that's specific to that device. No matter what computer or other device you're using, your documents and programs are the same.

XVI. Better return on investments (ROI)

Assuming that the IT asset returns on Cloud and on-premise IT are equivalent, it makes sense to use the Cloud's pay-as-you-go approach, in which the cost is incurred at the same time as the value is produced (James Staten, 2009).

From the review above, it showed that cloud computing as an ICT advancement is adopted in the agricultural sector can be beneficial to both farmers and the business community within the agricultural value chain.

4. Conclusion

The researcher has presented a desktop review of the state of ICT advancements and the benefits of Cloud Computing as an ICT advancement in the Kenyan agriculture industry in this paper. The study's findings will be added to the body of knowledge on ICT adoption in Kenya. According to the studies reviewed, mobile-based services and platforms are the most often ICT advancement application in Kenya's agriculture industry. Radio and TV are common among the rural population.

From the reviews, the many benefits of cloud computing make farmers and organizations in the agriculture sector adopt it. Farmers can use mobile phone applications and services to get extension-advisory services like weather and market price information. Radios are still commonly utilized in rural areas to disseminate agricultural information. Weak policy environment, insufficient capability, and poor technological infrastructure within the country have all been identified as barriers to Cloud computing and other ICTs adoption

Smallholder farmers should be trained and empowered, according to the study, to improve their ability to deal with new agriculture technologies. In addition, a favorable governmental and economic environment that encourages the use of ICTs and other digital technologies is required. Strong dedication, trust, and teamwork among the various participants in the agriculture value chain are also required.

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Corresponding Author: ***Jeremiah Osida Onunga, Tutorial Fellow, Turkana University College and PhD Candidate, Kibabii University, Kenya.***

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