

**Information Communication Technology as a Tool for Agricultural Transformation and Development in South Africa. A review**

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Research Article

**Information Communication Technology as a Tool for Agricultural Transformation and Development in South Africa. A review**

<sup>1</sup>Nkambule, Tapelo Blessing & <sup>2</sup>Agholor, A. Isaac

**ABSTRACT**

The convergence of IT and ICT has created new ways of communication and information sharing globally, despite the inherent geographical limitations. ICT for development is informed by the belief that development, progress, growth, and globalisation can be achieved using technology for greater advantage. The study addressed the following research questions: *i.* what are the roles ICT in agriculture and rural development in South Africa? *ii.* Are there access and challenges to the use of ICT in South Africa? To answer these research questions, the study adopted a coordinated pattern of reporting approach normally employed in systematic review. Numerous research data bases were explored-ProQuest, Science Direct, Web of science, and Google Scholar to carry out a detailed literature search on information communication technology as a tool for agricultural transformation and development in South Africa. One hundred and fifty-two materials-journals, books, grey literature, conference proceedings, government reports, government gazettes, and university repositories were retrieved, screened for title, abstract, and full text using search terminologies such as: roles of ICT and agriculture, rural development, and challenges of ICT. Furthermore, manual search for published grey literatures were also undertaken. The articles that are in consonant with the authors criteria were shortlisted and independently separated, evaluated, and assessed by each author. The findings indicated inadequate access to ICT as the main challenge for farmers. While still acknowledging the benefits of the adoption of ICT, the task for the agricultural sector is to find an approach that will allow smallholder farmers access to the opportunities provided by digitalisation in agricultural sector.

**Keywords:** Information, communication, technology, agriculture transformation, development, farmers, challenges, data base, adoption

**INTRODUCTION**

The use of Information Technology (IT) dates to the 1970s (Yates 2001). However, the basic concept of IT can be traced back to the World war II with collaboration of the military and IT industry in developing electronics and computer theory (Targowski 2009). In the 1950s, the military was still the biggest source of funding for research and development to improve

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<sup>1</sup>Masters' student: School of Agriculture, Faculty of Agriculture and Natural Sciences, University of Mpumalanga. Private Bag X11283, Nelspruit, 1200

<sup>2</sup>Senior lecturer: School of Agriculture, Faculty of Agriculture and Natural Sciences, University of Mpumalanga. Private Bag X11283, Nelspruit, 1200

automation to replace manpower with technological power. Since then, there has been developments and advancement of information technology to suit the current time. After recognizing the need to collect and distribute relevant, and localised information, the IT industry incorporated communication into its system to allow for access and distribution of information (Liu & Yuan 2015). This led to the use of telecommunications in information distribution, thus introducing Information and Communication Technology (ICT), which is a broader term for Information Technology.

Information and communication technologies are the types of technologies which allows users to access different types of data and information through telecommunications (Qianget *al.* 2004). Information and communication technology (ICT) is closely related to information technology (IT), but ICT focuses mainly on communication technologies. These communication technologies include internet, mobile phones, wireless networks, and other communication tools (Muñozet *al.* 2017). Through these ICT tools, farmers can interact with each other in real time even when they are in different countries. Instant messaging, video or voice conferencing and social networking allows farmers to interact with each other from all over the world without having to travel. ICT is therefore one of the most beneficial ways of spreading knowledge and information through science and technology (Olaniyiet *al.* 2013). It has created new ways of communication and information sharing globally, despite the geographical limitations.

ICT has a positive effect on the growth and development of human civilization. There are many ICT tools used in the collection, storage, analysis, and distribution of information for the benefit of the end user (Rice & Leonardi 2014). These ICT tools include computers, communication networks, databases, artificial intelligence, and knowledge bases. ICT has made an influence in almost all economic sectors and has provided simpler ways to perform tasks that were previously performed manually (Munyua 2007). Through ICTs, information can be stored, analyzed, and distributed electronically without the user having to travel long distances to get to the information source. The concept of libraries was significantly changed after the introduction of ICT. Libraries are now able to provide information to users who are in different geographic locations, which was impossible through traditional methods without extra costs (Berman 2008). Presently, ICT is generally applied as equipment or services that allow for the collection, display, analysis, and distribution of information in different sectors around the world.

Even though they are closely related, IT and ICT should not be confused with each other as they are different fields. The IT industry mostly uses systems such as computers, software networks, servers, and other IT facilities to help collect and analyse information especially in big companies and corporations which are difficult to manage without technology (Vance 2009). Therefore, IT helps in strengthening the performance of a company through IT-skilled individuals who can use servers, database systems and security systems to ensure that the company is operating efficiently, and confidential information is protected from outsiders. The main aims of IT can be summarised as providing tools that improve the company's productivity, automating business processes, communicating with consumers, and generally distributing information (Avgerou & Walsham 2017). ICT on the other hand, focuses more on the education context. In general, ICT can be described as technologies that allow individuals or organisations to handle, use, and share information (Qianget *al.* 2004). ICT is usually used to benefit the individual or organisation which is smaller than the one handled by IT personnel in big corporations. ICT can include simple actions such as using audio and visual equipment for learning, using mobile devices to communicate with each other (Khizbullin 2017). ICT for

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development refers to the utilization of Information and Communication Technologies (ICTs) to achieve social and economic development, with more emphasis on helping rural farmers in isolated areas (Loh 2015). ICT for development is informed by the belief that development, progress, growth, and globalisation can be achieved using technology for a greater good (Rivett 2014).

Many countries in Africa are making efforts to become information societies and knowledgeable countries which will enable them to take part as equal participants in the current global economy that is driven by information (Ponelis & Holmner 2015). To ensure that they can participate in the global economy, some African countries have introduced ICT projects to address the poor network connectivity in the use of internet and other global communication tools (Murphy & Carmody 2015). The World in 2013: ICT facts and Figures indicated that Africa had an estimated mobile phone usage of 63% in 2013. The report further indicated that 16% of Africans are utilising the internet, 7% of households in the continent have access to the internet, and the annual growth in household internet access is 27%. Furthermore, the report indicated that from those using wired broadband subscription, only 10% have a network speed of 2 Mbps or more, and mobile broadband use has increased from 2% in 2010 to 11% in 2013.

In South Africa, the Information and Communication Technology industry continues to show a dynamic growth (Maumbe & Okello 2013). The mobile sector is the leader in use of ICT systems, with most South African citizens owning a mobile device (Herselman 2003). However, the growth of the ICT sector has not achieved the national objective of affordable communication services (Kyobe 2011). The number of farmers who have access to mobile services continues to increase, however, access to broadband, especially fixed broadband remains at very low levels as compared to other developing countries. The cost of communication services, including data, also remains high in comparison with both African and global standards (Chetty *et al.* 2013). In the agricultural sector, Armstrong & Gandhi (2012) noted that ICT tools such as radio, television, visual media, mobile phones, and internet are used for communication and for sharing agricultural information between farmers and other stakeholders. Farmers, especially those who are literate and have adequate resources can use ICT to access important data about market trends, and access new technological innovations which were previously difficult to access due to geographical limitations. Jayathilake *et al.* (2010) argued that Information and communication technologies (ICTs) can be a solution to the challenge of information distribution to farmers. There is only a little reliable information available to the public about the state of the ICT sector in South Africa. Early attempts to fill the information gap on ICT dates to 1996 which resulted in an international publication in 1997. After that, the National Research and Technology Foresight Study and the ICT Working Group's deliberations were structured to extend the previous work on ICT in 1998. The SAITIS project also had commissioned "Baseline Studies" which were published in early 2000. In South Africa, the current literature on IT is not only limited but also points to a narrow perspective, which stems from global view and underpinned by inadequate grey literatures. Against the backdrop, the study aims at exploring in-depth review and documentation of relevant ICT in relation to agricultural transformation.

It is therefore, expected that this study will add to an increasing pool of studies on information communication technology and document evidence on ICT in agricultural development. Against this backdrop, this study addressed the following research questions: i. what are the roles of IT &

ICT in agriculture and rural development in South Africa? ii. Are there access and challenges to the use of IT and ICT in South Africa?

## METHODOLOGY

To answer the research questions, the study partially adopted the reporting approach for systematic review (Moher, et.al, 2009) to review literature in a coordinated pattern to effectively address the research questions. Numerous research data bases were explored-ProQuest, Science Direct, Web of science, Google Scholar to carry out a detailed literature search on the roles of ICT in agriculture and rural development and challenges associated with the use of IT and ICT in South Africa. Papers published in journals, books and conference proceedings were carefully consulted for this review. One hundred and fifty-two materials-journals, books, grey literature, conference proceedings, government reports, government gazettes, and university repositories were retrieved, screened for title, abstract, and full text using search terminologies such as: Roles of ICT and Agriculture, rural development, and challenges of ICT. Furthermore, manual search for published and grey literatures were also undertaken. The articles that are in consonance with the authors criteria were shortlisted and independently separated, evaluated, and assessed by each author.

## CONTEXT AND DISCUSSION

### ICT and Agriculture Development

Information and Communication Technology is one of the tools that play an important role in the growth of developing countries. The use of ICT helps in education and academic development, the management of diseases, reducing unemployment and achieving agricultural development (Kozma & Vota 2014). The agricultural sector is one of the contributors towards the country's GDP and provides employment opportunities. Many countries are gradually adopting the use of advanced technologies such as satellites, mobile phones, social media, and the internet for agricultural development (Aker & Mbiti 2010). The adoption of these technologies can benefit both developing and developed countries by improving their access to agricultural information and improved farming practices.

Agriculture requires continuous application of advanced technology to meet the growing demand for food, reduce poverty and achieve environmental sustainability (Chhachhare *et al.* 2014). Globalisation, urbanisation, and the demand for high quality produce has led to changes in the agricultural sector globally. Due to some of these changes, farming is becoming a challenge for most communities who are still living in poverty (Qiang *et al.* 2012). To cope with these changes and meet global food demands, the Green Revolution took place around the 1960s. The main aims of the Green Revolution were to increase the size of cultivated land, and introduce chemicals, practices, and technologies to increase agricultural production (Pingali 2012). However, farmers still experience huge losses during production and agricultural production has been declining in the past few decades (Bruinsma 2003). Therefore, for agricultural development, farmers must be provided with relevant information and innovative knowledge.

Education is an important part of development; hence, development education uses different education approaches to promote knowledge (Fagerlind & Saha 2016). Therefore, development education is very important to increase agricultural production. ICT allows for the distribution of

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information and knowledge to farmers, in their different locations. Farmers can therefore be able to access information on weather data, fertiliser application practices, land resources, pest management and market prices (Munyua *et al.* 2009). In most countries, state offices are equipped with a computer network, which can enable easier distribution of information to farmers. Through the application of ICT, farmers can have better access to information, and thus promote knowledge sharing. ICTs generally facilitate the generation, management, storage and distribution of any relevant information or knowledge, regardless of whether the information is new or has been previously adapted (Murty & Abhinoy 2012).

ICT has the potential to provide farmers with relevant information to promote better agricultural productivity. Despite this potential, the application of ICT in agriculture is still a relatively new and emerging concept, especially in developing countries (Obiechina 2004). Through collaborations between government and private initiatives, programmes are introduced to promote agricultural development. However, the application of ICT in these programmes is still an emerging trend and some farmers may still be unaware of the benefit of ICTs (Syiem & Raj 2015). Although technological innovation can improve agricultural productivity, many farmers, especially in rural areas still do not have access to adequate information and services due to socio-economic constraints. Others are limited by low levels of literacy, language barriers and the unwillingness to change from traditional methods to new technological ones (Abdullah & Samah 2013).

The way in which ICT projects are designed, with regards to the generation and distribution of information, has an influence on the adoption of ICTs by farmers. This is a crucial factor in the success of ICT-based development projects (Armstrong & Gandhi 2012). To ensure that information needs of farmers are met, relevant and timely information is an important part of ICT projects. The relevance of information usually depends on the extent to which it is designed and localised to fit the farmer's current condition. Therefore, farmers need localised information, which is designed specifically for a local audience considering the geographical location, culture and language, and the economic situation (Labonne & Chase 2009). Thus, localised information extends on the farmer's knowledge, and their current situation. Localised information includes global information that has undergone transformation and adapted into a new knowledge base (Mamba & Isabirye 2015). However, ICT projects may still be irrelevant to farmers and their specific needs due to poor connection between project designers and the intended beneficiaries.

ICT services can be useful in reducing inequality and closing the economic gap between rural and urban areas, thus promoting agricultural development and development of rural areas. The main objectives of ICT application in agriculture are reducing production costs while increasing productivity and efficiency (Musa 2006). ICT and traditional methods can be used simultaneously to improve the relevance of information (Phiriet *et al.* 2019). The main reason for ICT application in agriculture is meeting the farmer's information needs and those of their communities. For some farmers, ICTs have become an important part of their daily activities. These farmers use ICT to keep records, access relevant services, and obtain information on insurance, weather, market prices, diseases and pests, financial assistance and soil testing services (Mwakaje 2018).

### **ICT and Rural Development**

There are various challenges and constraints limiting the effective utilisation of ICTs in rural areas and the agricultural sector. These challenges can be grouped into three main categories, namely, access, quality, and cost (Wolf 2001). Rural areas in general are usually faced with many challenges relating to the lack of infrastructure such as water and electricity, telecommunications, and transport (Phiri *et al.* 2019). Furthermore, low levels of literacy also affect the development of rural people. The quality of mobile network connectivity and the general quality of ICT services is very poor in rural areas as compared to urban areas (Munyua *et al.* 2009). One of the biggest challenges in the effective application of ICT in rural areas is the inadequate supply of electricity, as most ICT tools require electricity to function (Lokeswari 2016). The ICT services are also mostly facilitated in English, which may be a challenge for farmers in rural areas as they are more familiar with their own languages (Best & Maier 2007).

Most development programmes are designed for the situation in urban areas, neglecting the rural communities and in remote areas (Nwagwu 2006). To promote development, it is important to include rural areas in development plans, and design programmes that are focused on rural communities. The lack of basic infrastructure and facilities in rural areas makes life difficult for rural communities as compared to those in urban areas. Most rural communities depend on natural resource based economic activities such as farming for income as they do not have adequate resources to participate in non-farming economic activities (Pateman 2011). Farmers in rural areas are also more vulnerable to external, environmental factors such as droughts, floods, and abnormal temperatures (Fan *et al.* 2005). Farmers need useful information to help them participate in the global food market (Munyua *et al.* 2009) which will assist them become economically independent and reduce their production costs. Although facilities such as roads, dams and irrigation schemes are very important for farmers in rural areas, these are not enough to achieve rural development (Mukherjee 2011). Farmers also need an environment that will allow for growth through interaction with external role players. Therefore, development of the agricultural sector alone is not enough to make adequate impact on rural people's lives. Other investments especially in social services, governance, education, health, and other non-agricultural activities are important in the effort to improve the lives of farmers in rural areas (Hubbard & Gorton 2011).

However, all sectors have their characteristics, challenges, and opportunities. The application and utilisation of ICT in rural development can strengthen the connection between rural and urban areas (Aker *et al.* 2016). Through the application of ICT, rural communities have better access to urban facilities, and they can participate more in the global economy. Other development plans should be addressed through the collaboration of different sectors. For sustainable development, demand, supply, and the environment are the three overlapping areas that should be focused on (Atkinson *et al.* 2014). It is therefore important to understand rural communities before trying to bring any form of development to them. Better understanding of the rural communities will enable programme planners to design programmes that are specifically suited for the needs of the people. ICT can be applied in this regard to strengthen the connection between those designing development programmes and the intended beneficiaries.

### **Impact of ICT on Agriculture Development**

Technological innovations are increasingly becoming more advanced, and at a rapid rate. Therefore, it is important to measure the impact on ICT use in different sectors. This will show which ICTs should be promoted and which ones should not. It is also important to develop an

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enabling environment through the provision of adequate infrastructure, financial support and policies that regulate the use of ICT facilities (Aker *et al.* 2016). ICT facilities can be used by farmers to obtain relevant information on improved farming practices, weather conditions, agronomics, soil management and market trends (Munyua *et al.* 2009). ICT also improves the knowledge of farmers, thus helping them make better informed decisions and ensuring that they are involved in agricultural development. The information and knowledge obtained through ICT helps farmers stay competitive in the global market and helps them cope with changes in the agricultural environment (Jayathilake *et al.* 2010). ICT tools such as the internet enable farmers to communicate with each other and compare prices, to find the best market for their produce (Alia *et al.* 2013). Farmers in rural areas are also able to communicate with each other through ICT, and exchange valuable information that will help solve their problems. This encourages working together within the agricultural sector. Farmers are also able to exchange information and knowledge with experts regarding their farming activities. The application of ICT reduces the gap between innovators, researchers, and farmers (Ugboh & Tibi 2007). ICTs also strengthen the capacity of rural communities and farmers so they can be able to negotiate better pricing, land access, resource rights and infrastructure. This means ICT enables effective communication between rural communities and other external stakeholders (Muñoz *et al.* 2017). If correctly applied, ICT can improve the communication process more efficient and transparent. Through ICT, farmers in rural areas are also able to adequately access to credit and banking facilities which are not readily available to them in their respective communities. In a study by Agholor and Ogujiuba (2021), found that ICT has multiple benefits including timely access to agricultural information and record keeping.

According to Pickernel *et al.* (2004) the utilisation of ICT in horticulture has improved productivity. Farmers can explore new markets and reach distant customers through the internet. The mobile phone is also among the ICT tools mostly used by farmers. Through the mobile phone, farmers can access information about market trends, climate conditions and they are also able to exchange information with other farmers. Alia *et al.* (2013) found that farmers who listened to radio programmes about cassava farming were more likely to adopt new improved varieties than those who did not. After this, the study found that cassava farmers who listened to these programmes experienced a positive impact on their farm productivity. According to Labonne & Chase (2009), the use of the mobile phone as an ICT tool is associated with improvements in the income levels of farmers. Muto & Yamano (2011) also supported this finding, stating that the utilisation of mobile phones by farmers resulted in increased participation in market related activities. In Niger, the use of different ICTs in grain farming resulted in a decrease in grain prices by over 20% and improved allocation of scarce resources, leading to consumers paying over 3% less for grain crops (Aker 2010). Agu (2013) argued that there is a positive correlation between the application of ICT in farming activities and the productivity of the farm. This means that farmers who apply more ICT in their farming are likely to obtain more produce than those who do not. The study also found that ICT application has a significant influence on the type of crop farmers decide to cultivate. The study suggest that most farmers use ICT to access the latest information on market trends and pricing, which helps them make better decisions and ultimately increase their farm income. The application of ICTs has therefore helped farmers in accessing and sharing valuable agricultural information, which in turn helps the farmers make better decision to improve their productivity.

### **Adoption ICT and South African Agriculture**

South Africa has over 35000 registered commercial farms, with 40% being field crop farmers while the other 60% are livestock farmers (Gillwald *et al.* 2019). The agricultural sector in South Africa has shown an annual growth rate of 7.5% since 1994 (DAFF 2018). However, most of the agricultural produce in the country comes from commercial farming. South Africa has a total of around 70000 commercial farming units. According to Naude (2018), only 4% of the commercial units can achieve more than R5 million in annual turnover. Despite the contribution of commercial agriculture towards the country's economy, smallholder farmers are reported to be responsible for 75% of the country's farming activities, with small-scale agriculture being the main source of income for rural communities. The National Development Plan prioritised job creation as a poverty alleviation approach. However, the creation of job opportunities in the agricultural sector requires increments in cultivated land, and area under irrigation. It also requires continuous support for commercial agriculture and skills development through effective collaborations between commercial and small-scale farmers (DAFF 2015).

In South Africa, commercial farmers producing in large-scale are confident and willing to apply ICT in their farming activities because they are aware of the benefits of utilising advanced technologies such as drones and satellite to improve their farm productivity (Tembo & Maumbe 2011). However, the application of ICT should not be perceived to replace farmworkers, but rather a means of supporting the workers to minimise input costs while maximising outputs (Gillwald *et al.* 2019). Agricultural policies and land ownership in South Africa has been greatly affected by the historical racial imbalances. Smallholder and subsistence farmers in rural areas are usually isolated from development plans in urban areas, making them more vulnerable to the effects of the historical racial imbalances. These farmers must therefore receive more support and attention.

### **Accessibility and use of ICT in rural areas**

The digitalisation of economic sectors in South Africa, including the agricultural sector, is primarily based on the affordability of technological devices and data, and adequate access to internet services. According to the 2018 survey by Research ICT Africa (RIA), 53% of South Africans have internet access, which is the highest percentage as compared to other Sub-Saharan African countries. The study also revealed that there is a gap between South African urban and rural areas in terms of internet access. This suggests that there is still a need for ICT infrastructure development to uplift small-scale farmers who operate in rural areas. The survey also found that around 85% of South Africans own a mobile phone. However, only 47% of these are smartphone owners. This is an important factor to address since smartphones are one of the drivers for digitalisation, and they have become an important part of agribusinesses including marketing.

According to the 2018 survey, 47% of South Africans do not have access to internet services mainly because of the high cost of internet-enabled devices and data. Furthermore, limited knowledge, inadequate digital skills, illiteracy, and lack of awareness about the internet are some of the other reasons for the lack of internet access. The RIA and African Mobile Pricing (RAMP) Index of 2020, first quarter, revealed that South Africa was ranked among the countries with the highest data prices. The RAMP Index found that the lowest price for data in South Africa was offered by Telkom and Cell C at R100 per 1GB. The high data prices in the country led to the Competition Commission ordering the dominant mobile network service providers to reduce their data prices by 70%. The dominant mobile network service providers, Vodacom and MTN

have subsequently implemented changes to their data pricing in April 2020. However, when being compared to other countries, data in South Africa is still expensive. The quality of network connections influences the type of online activities farmers engage in, and how frequent they use them. South Africa has been ranked among countries with the highest social network use rate compared to other surveyed countries. This provides an opportunity for South African farmers to utilise these social media platforms to communicate and reach the consumer market. However, the access survey found that only 27% of South Africans use the internet for work purposes. Furthermore, only 10% engage in e-commerce while only 17% have an online bank account. These figures are based on survey data and may be even smaller in rural areas. Even though there are continuous efforts to improve service quality and infrastructure, there is still a gap in internet usage between farmers who have ICT skills and resources to use the internet effectively, and those who barely access the internet. Therefore, these systemic barriers of access must be properly addressed for South African farmers to experience the direct benefits of ICT, especially in the agricultural sector.

### **ICT in commercial agriculture**

Despite the technological challenges mentioned, the use of ICT and digital technology has begun to gain momentum within the agricultural sector in South Africa. There is an increasing use of technologies such as satellite, drones, automatic sensing, wireless communication, and data management (Hanson & Heeks 2020). These advanced technologies are being applied in agriculture to reduce input costs, promote sustainability, and increase farm productivity. The costs involved in advanced digital technology use make it difficult for small-scale farmers to adopt these technologies. However, commercial farmers are likely to adopt most of these technologies that require on-site infrastructure for information collection and processing (Smith 2020). The use of advanced technologies also benefits both commercial and smallholder farmers when applied through extension services and market information systems that can be accessed using mobile devices (Aker 2011).

There is a general understanding and belief that technology could empower small-scale farmers so they can have better access to information and markets. This is because technology can be used to address some major challenges faced by smallholder farmers, and to expose them to more opportunities through direct interaction with suppliers, consumers, and financial service providers. Nonetheless, only some of the potential advanced digital technologies and services have been effectively applied in the South African agricultural sector, and a majority of these are primarily directed towards commercial, large scale farms that can afford them (Antwi & Seahlodi 2011). What remains a challenge for the South African agricultural sector in technology application, is finding an approach that will allow smallholder and subsistence farmers to fully access opportunities provided by digitalisation because these farmers make up most of the agricultural sector. Digital technologies are also being utilised in the agricultural sector to promote transparency in the value chain. This is also fuelled by the increasing number of consumers who demand that food products should be traceable for both ecological and ethical reasons (Gbetibouo & Ringler 2009). Nevertheless, the transparency also has advantages for the agricultural sector. For example, some big international retail companies have adopted the use of block-chain technology to track the sales of their agricultural products. This provides the farmers working with these companies access to important accounting information to promote transparency and accountability (Aguera *et al.* 2020). Furthermore, cloud computing technology

has been adopted in South Africa to allow for easier verification of regulation compliance from distributors within the supply chain.

### **Challenges of ICT adoption**

#### **Cost of technology**

ICT access and utilisation is a generally costly process, especially for advanced digital technologies. Many people, especially in rural areas, struggle to access necessary infrastructure for technology use due to not affording (Chisasa & Makina 2012). Although the government has made efforts by investing in ICT centres for communities in less privileged areas who cannot afford to pay for telecommunications on their own, the implementation of these centres was not properly planned with regards to the basic infrastructure requirements for an ICT centre. This was the main challenge in the implementation of ICT centres in South Africa (Singh 2010).

#### **Unstable policies**

Unstable policies and cultural diversity have also proved to pose a challenge in the adoption of ICT for development because of the historic racial imbalances in South Africa. The uneven distribution of wealth and resources has also played a part in shaping ICT policies (Shachaf 2008). Thus, the selection of appropriate ICTs also depends on the presence of inter-cultural communication and cultural diversity.

#### **Inadequate ICT skill**

The growth and adoption of ICTs in South Africa is also constrained by the lack of necessary skills to develop or utilise ICT tools. This is one of the major challenges faced in using ICTs to promote agricultural development (Chigona *et al.* 2009). A strong relationship between ICT skills and adoption exists because ICT skills and knowledge are some of the determinants of whether a person adopts ICT or not (Hashim 2015).

#### **Security**

Security is an important part of the ICT sector. This includes the development of secured systems for confidentiality, integrity, and availability (Zissis & Lekkas 2012). Most farmers still have concerns about the security of information shared through ICTs. According to Carroll *et al.* (2011), security is very crucial when processing and sharing information through ICTs as modern technologies are vulnerable to unauthorised parties. Therefore, there should be security measures in place to prevent unauthorised access to information shared through ICTs. It must be noted that inadequate security discourages people from adopting ICTs.

#### **Deprived provision of services**

The poor delivery of basic services from the government to citizens has made it difficult for farmers to adopt ICT. Inadequate provision of social amenities like electricity affects the adoption of ICTs by farmers in less developed areas, with those who are willing to adopt having to pay extra costs to have a full experience of ICTs (Schuppan 2009). The poor infrastructure such as roads in rural areas makes it difficult for innovators and development agents to interact with farmers to have specialised strategies aimed specifically at these areas.

#### **Poor approaches to the promotion of ICT adoption**

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Most Sub Saharan countries have little or no investments on the growth and application of ICT. Most of the ICT infrastructure in these countries was donated without proper knowledge on how they can be used effectively. Most of the time, ICT tools such as computers donated end up costing the country even more due to high maintenance costs and the limited number of farmers who are skilled to use them (Datta *et al.* 2005). This is one of the reasons for poor performance of ICT initiatives in Sub Saharan Africa. Government must implement proper approaches that will promote ICT adoption and ensure that they are used to their full potential.

### **Lack of necessary ICT Infrastructure**

The poor network connectivity and inadequate access to broadband technology contributes to unwillingness to adopt ICTs in South Africa. The inadequate ICT infrastructure also affects the achievement of development plans as some development approaches require the application of ICT (Maumbeet *al.* 2008). For example, only the farmers who have access to ICT tools and internet services can access online services such as market information government portals.

### **Climate change and ICT**

Adaptation involves taking the necessary steps to cope with the effects of climate change. For example, remote sensing is used to monitor natural disasters such as earthquakes and other ICTs enable farmers to research out to each other and communicate effectively during times of disaster. ICTs such as radio-based remote sensors are already being used globally to observe the environment, monitor the climate, and make predictions on climate change (Ospina & Heeks 2010). These modern ICTs are necessary for predicting and detecting natural disasters as an effort to save lives and should therefore be given more attention especially in developing countries. Through ICT, farmers can access important information about the changing climate, and they can use this information to find ways to cope with the changes. This information and knowledge also help in ensuring that farmers can sustain necessities such as food and water (Imam *et al.* 2017). This can be achieved through the application of ICTs and the use of environmentally friendly infrastructure.

### **Monitoring climate and ICT**

Dawson *et al.* (2011) predicted that there will be an increase in average temperature during the 21<sup>st</sup> century. This will result in different challenges for many countries with coastal areas facing the risk of rising sea levels while Sub Saharan African countries are faced with the risk of desertification. The environmental challenges will force farmers to move to other places with better conditions, which will put more pressure on water sources and infrastructures. Some ICT systems are used to monitor the environment and distribute important weather information, and give early warnings in case of disaster (Hamdy, 2015). For example, weather satellites are used to monitor hurricanes and typhoons. Other disasters such as tornadoes, major veld fires, and thunderstorms are monitored through weather radars. For climate and weather predictions, radio-based meteorological aid systems are used to gather and evaluate current weather data. Without this system, the weather predictions would be inaccurate (Grunfeld & Houghton 2013). Other ICT systems such as earth observation satellites are used to collect important information about the environment. This includes atmospheric gas compositions, ocean levels, soil moisture and forest control (Imam *et al.* 2017). In case of bad weather events, telecommunications, and satellite broadcasting systems such as radio and television are used to warn farmers in time.

### **Food security and ICT**

The effects of climate change pose a threat to water and food supply. The unfavourable change in climate includes storms, heat waves, floods and droughts that are more severe. These impacts of climate change can be more severe in poor countries who depend mostly on natural resource based for economic activity. Barrios *et al.* (2008) estimated that by 2020, agricultural crop production is expected to drop by 50% in some African countries. This is because of increased water stress and other weather events. To address food security, the global food supply must be systemically monitored, including agricultural production levels and food shortages. Machine-to-machine (M2M) connectivity can be used with remote sensing facilities, high quality radiometers and spectrometers to monitor resources involved in food and water supply (Adeniran & Aristide 2020). Other ICTs such as computers, mobile phones, servers, and databases can be used to collect, store, and analyse information about food security. ICT tools such as the Internet can also be used to disseminate information to farmers and consumers.

Moreover, ICTs can be used to monitor the soil and environment, which can help in increasing farm produce and promote sustainability. Through ICT tools, water use efficiency can be improved through advanced water management systems, providing an opportunity to reduce costs while promoting sustainable water use (Hamdy 2015). Satellite and Global Positioning Systems (GPS) can be used to monitor irrigation and fertiliser application. The use of such systems allows for the crop fields to be split into different sub-fields which can receive different water and fertiliser treatments. This makes it easier to perform crop and spatial analysis and allows the farmers to take soil and climate conditions into considerations to promote more efficient fertiliser application. In agriculture, ICTs such as sensors and telemetry units can be used to monitor climate parameters such as humidity, soil moisture and temperature (Chhachhar *et al.* 2014). This information can be distributed through mobile networks to different global databases.

### **Monitoring deforestation and ICT**

The impact of climate change on forests and forest quality is considered a big challenge. The problem of deforestation has been included in the five main thematic areas of the United Nations (UN), while negotiating for a better achievable climate solution. The untenable land use and destruction of tropical forests release 1.5 billion tonnes of carbon into the atmosphere annually. This contributes more than 17% of the total greenhouse gas emissions (Lawrence & Vandecar 2015). Therefore, the conservation of forests can be an important part of climate change mitigation. ICTs can be used in the efforts to reduce deforestation. For example, the use of advanced technology for collection of data about the current state of forests can be achieved through ICT. Advanced satellite technologies can provide satellite images even in dark and cloudy conditions. These satellite facilities together with remote sensing systems are important in monitoring the condition of trees, and forest degradation (Houghton 2010).

### **Using smart ICT for waste management**

The ICT industry is rapidly advancing with time. There are several transistors which are placed on integrated circuit boards annually which has led to some equipment becoming outdated prematurely, leading to waste. Recycling ICT hardware can result in huge savings in terms of energy use because it reduces the need to extract raw materials, especially ones that will require energy intensive systems (Emmanouilet *et al.* 2013). Therefore, promoting recycling, especially of

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ICT waste can assist in climate change mitigation and reduction of greenhouse gas emissions. The recycling approach helps in ensuring that the materials remain in circulation. Raw materials that have lost quality or outdated can be returned to the factory and be re-used, thus eliminating the need for acquiring additional raw materials. ICTs can also be used to protect and conserve the environment, manage, or recycle waste and promote sustainable supply chain management (Heekset *et al.* 2015). With mobile devices and the internet, people can now search for ICT hardware recycling sites. The International Telecommunication Union (ITU) together with other stakeholders in the ICT sector are developing standards to improve industrial waste recycling, including information about the recycling of rare products and metals.

### **ICT, energy supply, and renewable resources**

ICTs can be used to increase the efficiency of power systems. The computer and communication systems are important in the use of renewable resources for energy. Resources such as solar, geothermal, wind, wave and tidal can be used efficiently in power generation in a smart, sustainable way (Nijhuis *et al.* 2015). The power system requires ICTs to monitor the load on the grid, and to utilise available power from renewable resources. ICTs can also be used to model the status of renewable power facilities, considering local weather stations, so that the shortest route from the source to load can be selected to reduce transmission losses (Ahmed *et al.* 2017).

### **ICT education and climate change**

There are many environmental risks such as floods and droughts, associated with climate change, which results in mass displacement (Grunfeld and Houghton 2013). Farmers in rural have a challenge gaining access to ICT infrastructure such as electricity and internet, which is needed to provide localised information and specialist knowledge that is aimed directly at these areas. With ICT, information and educational content can be distributed to students in their different locations, thus reducing the travelling costs (Aker & Mbiti 2010). ICT tools such as the radio and television have been used to distribute educational information since the 1950s (Munyua *et al.* 2009). Audio and telephone conferencing are among the widely used ICT tools in education (Fu 2013). This includes real time interaction and exchange of voice messages through a network. With the rapid advancement of ICT, text, and graphic visuals such as images or graphs can also be exchanged along with the voice messages. Other ICTs allow for the sharing of moving visuals such as videos or animations (Isaacs 2007). Videoconferencing is also gaining popularity in the education system, allowing for the exchange of live moving visuals. Some ICTs like web-based conferencing allow for the exchange of text, visual and audio content through the internet.

### **ICT and healthcare**

Due to climate change, the global community is experiencing severe changes in the atmosphere, poor soil quality and changes in sea levels (Lawrence & Vandecar 2015). Such changes have a negative impact on economic activities and infrastructure development of any country. The degradation of the environment together with poor economic growth raises a risk to human health (McMichael 2013). It is expected that seasonal death rates due to the unexpected changes in temperature will increase, and the seasonal behaviour of diseases transmitted through a vector will change (Luber & Prudent 2009). ICT facilities and systems can be used to monitor the health effects of local climate changes by generating, analysing and comparing data sets. ICTs allows healthcare workers to process and share data to estimate the impact of future environmental

changes (Ruxwana *et al.* 2010). ICTs also promote independent online education and information distribution. Communities with access to the internet can access information on what can be done to minimise health risks due to climate change. Encyclopaedias and search engines allow communities to find information they are looking for from different sources, including government portals (Zakaria *et al.* 2010). Tools such as remote health monitoring allows farmers to continue living independently in their houses without having to regularly go out to seek healthcare. Broadband network also enables patients to interact with specialists who are far from their geographic location, eliminating the need to travel and thus reducing greenhouse gas emission (Arianiet *al.* 2017).

## CONCLUSION

The study has provided a review of literature about the IT and ICT industries, and their role in transforming agriculture in South Africa. The results show that IT and ICT can be used for agricultural development. The agricultural sector in South Africa is very important as it is a way of life for many people, providing opportunities for entrepreneurship and employment. The adoption and use of technology benefit farmers by providing easier access to relevant agricultural information and new innovations. Findings also showed that majority of farmers does not have access to internet services due to the expensive cost of internet enabled devices and data. Other limitations in the adoption and use of ICT by farmers include lack of skills, political and cultural diversity, security, lack of infrastructure and poor approaches to promote ICT adoption. However, despite these challenges, farmers who produce in a large commercial scale are showing confidence and willingness to use ICT in their agricultural activities. Another challenge is finding an improved approach that will enable small-scale and subsistence farmers to have adequate access to ICT and thus realised the benefits of digitalisation.

ICT and IT application in agriculture allows for the collection, analysis, and distribution of information about the soil and climate. ICT tools such as satellites and sensors can be used to collect and share information about the global climate, including changes in temperature levels and sea levels. With ICT, farmers can be educated about climate change from different locations around the world. The study result show that ICTs can be used to promote agricultural development, sustainability growth and mitigate the effects of climate change.

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