Contribution of Digitalisation for Agriculture (D4Ag) in Food Security Information System to Enhance Public Participation

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Abstract: This paper is based on the context of food security governance in the digital age. The paper forms part of the study (thesis) conducted by the author which evaluated the "impact of public participation of community food security projects" in Sedibeng District Municipality (SDM). The goal was to understand the level in which the public access information for food security programmes. It examines the pace of digital transformation in African agriculture and its value in food security information system to enhance public participation. An empirical approach is applied to attain the set objectives. A theoretical approach from recent research activities and Gauteng Provincial Government website is considered. The underlying development assumption is that the availability and use of reliable digital resources can enhance food security information system and influence for dissemination of information about food security programmes. The study concludes with a set of recommendations for managing food security information system for improved pro-poor.

Keywords: Digitalisation for agriculture, Digital technologies, Food security governance, Food Security Information System, Public participation

1. Introduction

Agriculture is currently undergoing a digital revolution and its advances have been taken up in various fields including agriculture. The agricultural sector faces major challenges to feed a growing world population in a sustainable way, whilst dealing with major crises such as climate change and resource depletion. The advances made in the IT industry have been taken up in various fields of activity and agriculture is no exception. This paper explores the level in which the public access information for food security programmes. Further the paper examines the pace of digital transformation in African agriculture and its value in food security information system to enhance public participation. A literature review was observed to comprehend the writings on digital agriculture and food security information system. The paper provides results of the community knowledge on tools used to access food security. An outline of the context of digital agriculture is presented. Influential factors for disseminating information on food security are discussed. Desktop results are offered on the institutional arrangements of the Gauteng Provincial Government e-Services. A discussion and suggestions on how to further harness the implementation of digital agriculture.

2. The Context of Digital Agriculture

Historically, agriculture has undergone a series of revolutions that have driven efficiency, yield and profitability to previously unattainable levels (Trendov, Varas & Zeng, 2019:1). Each previous agricultural revolution was radical at the time. The:

- first (Agriculture 1.0) represented a "transition from hunting and gathering to settled agriculture";
- second (Agriculture 2.0) is characterised by "innovation as part of the British Agricultural Revolution which saw new machines such as Jethro Tull's seed drill";
- third involved "production changes in the developing world with the Green Revolution" (Agriculture 3.0);
- fourth ('fourth agricultural revolution', or 'Agriculture 4.0') is acknowledged for "its rapid transformation in several sectors especially for agriculture to improve food security" (Rose & Chilvers, 2018:87).

Market forecasts for the next decade suggested a 'digital agricultural revolution' will be the newest

shift which could help ensure agriculture meets the needs of the global population into the future (Trendov *et al*., 2019:1). The expansion of the fourth industrial revolution is marked by spectacular technological advances (Bojang & Bwando, 2018:93). This fourth agricultural revolution is based on both human-machine communication and machine-machine communication (Bojang & Bwando, 2018:93). Agricultural transformation is a priority in the policy agenda of African governments in their quest to meet the challenges of food and nutrition insecurity, climate change, youth unemployment and overall economic growth (Tsan, Totapally, Hailu & Addom, 2019:10).

Digital agriculture refers to a range of different concepts and technologies, and connected to ideas on the Fourth Industrial Revolution or Industry 4.0 (Zambon *et al.*, 2019). Digital agriculture reflects a shift from generalized management of farm resources towards highly optimized, individualized, real time, hyper-connected and data driven management (Van Es & Woodard, 2017:97). It comprises the use of digital technologies, innovations, and data to transform business models and practices across the agricultural value chain (Tsan *et al*., 2019:5). It has a machine learning, which may have pervasive effects on future agriculture and food systems and major transformative potential (Klerkx & Rose, 2020:100347). Digitization involves the use of storage, processing and retrieval technologies among online users (Simion, Popa & Albu, 2018:96). It also has multiple and varied tools and cross-cutting technologies such as computational decision and analytics tools, the cloud, sensors, robots, and digital communication tools (Van Es & Woodard, 2017:98). It also includes existing telecommunication infrastructures, such as fixed telephones, televisions, radio, and satellite (Hung, 2019:1).

3. The Pace of Food Security Information System Transformation in African Agriculture

Food security is a state "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (FAO, 2007). A Food Security Information System (FSIS) comprises a succession of related food security information activities involving data collection; data management techniques and software; data analysis and communication of information through appropriate channels (Economic Commission for Africa (ECA), 2011:10). The objective of FSIS is to provide well-analysed food security information in order to support decision-making processes (FAO, 2007).

Integrated food security information systems have been developed as a means of giving a universal and coordinated approach to the issue of food insecurity (ECA, 2011:28). Agricultural transformation is a priority in the policy agenda of African governments in their quest to meet the challenges of food and nutrition insecurity, climate change, youth unemployment and overall economic growth (Tsan *et al*., 2019:10). It is indicated that Africa needs an inclusive and environmentally sustainable agricultural transformation to build greater food security, improve nutrition, and expand economic opportunity (Tsan *et al*., 2019:26). Thus far, significant amounts of money are being spent in the design and application of Agriculture 4.0 technologies worldwide (Klerkx *et al*., 2019). Government policies and frameworks are one of the driving forces behind digitalization to create an enabling environment for competitive digital markets and e-services (Trendov *et al*., 2019:4).

There has been significant growth in digitalisation for agriculture (D4Ag) over the years. The 1974 World Food Conference concluded that the existing monitoring and information systems for food security were inadequate (The Regional Food Security Analysis Network (RFSAN), 2016:12). Food Security Information System (FSIS) comprises a succession of related food security information activities involving data collection; data management techniques and software; data analysis and communication of information through appropriate channels (FAO, 2007). The World Summit on the Information Society (WSIS), organized by the ITU, recognized the importance of ICTs for agriculture and adopted an Action Line on e-agriculture in the Tunis Agenda (Romero & Adolph, 2009:5). There has been significant growth in digitalisation for agriculture (D4Ag) over the years. A Regional Information Systems and National Food Security Information Systems were developed to improve communication in the agricultural sector.

3.1 Regional Information Systems

SADC has long recognized the importance of information systems in the spheres of agriculture, food security and disaster preparedness and response. A Regional Information Systems is aimed at understanding the gaps, as well as the strengths in systems

that collect, analyse, manage and disseminate food security and nutrition information (RFSAN, 2016:6). Since 1980s, the region emphasized on the creation of a Regional Early Warning System (REWS) to provide sufficiently-reliable crop production forecasts several months in advance of the harvest. The early warning system was instrumental in supporting major relief interventions in response to severe region-wide droughts, which affected southern Africa, especially during the 1980s and 1990s (ECA, 2011:11).

3.1.1 EMA-I (EMA-i) App Animal Health System Support

FAO also developed the EMA-I (EMA-i) App Animal Health System Support to facilitate quality and real time livestock disease reporting captured by animal health workers in the field and it is easily adaptable to countries existing livestock disease reporting system (Trendov *et al*., 2019:11). EMA-i is currently used in six countries in Africa (Cote d'Ivoire, Ghana, Guinea, Lesotho, Tanzania and Zimbabwe) (Trendov *et al*., 2019:11).

3.2 National Food Security Information Systems

Food security analysis require data that support the measurement of each of the four dimensions of food security (availability, access, utilization, stability) and related vulnerabilities (ECA, 2011:11). Member State has several types of information systems that are relevant for understanding vulnerability to food insecurity. In 2006, FAO and others launched "www.e-agriculture.org" to guide efforts in this area, and to enhance sustainable agricultural development and food security by promoting the use of ICTs and associated technologies to support rural development (Romero & Adolph, 2009:5). Two other leading initiatives: Bridging the Rural Digital Divide (BRDD) and First Mile Project (FMP) organized by the International Fund for Agricultural Development (IFAD) in Tanzania.

- The BRDD is a FAO Programme for worldwide implementation aimed to establish networks for exchange of information and communication on agriculture and rural development at a global scale (Romero & Adolph, 2009:5).

- The FMP seeks to "connect the rural poor at a regional scale to relevant information, knowledge and key people in the market chain (including processors, traders and consumers) by making use of mobile phones, the Internet and e-mail" (Romero & Adolph, 2009:5).

3.3 Agricultural Robots ('agrobots')

Agricultural robots ('agrobots') are seen as a key trend that will deeply influence agriculture in the future. For example, a Dino weeding robot was created to allow vegetable farmers to manage crop weeding with a high level of precision, while helping them save time all through the season (Trendov *et al*., 2019:11).

The Ethiopia's Agricultural Transformation Agency introduced two development for agricultural transformation, namely agricultural hot line and the Ethiopian Soil Information System (EthioSIS) (Annan & Dryden, 2016:vi). The Ethiopia's Agricultural Transformation Agency was launched in 2014 with the aim to send text messages and automated calls containing up-to-date agronomic information. The hotline reached almost 500,000 users. The EthioSIS was developed for soil map analysing the country's soils. In 2019, both the European Union-African Union Task Force Rural Africa Report (TFRA) and the Communiqué from the Global Forum for Food and Agriculture (GFFA) highlighted the power of digitalisation in transforming agriculture (Tsan *et al*., 2019:11). Examples of current farmer information system solutions include a few different models such as large-scale government-run farmer information services (Tsan *et al*., 2019:26). Examples of such solutions include the 80-28 Farmer Hotline in Ethiopia that is managed by the country's Agriculture Transformation Agency (ATA), ZIAMIS in Zambia, Kenya's Agriculture and Livestock Research Organisation's (KARLO's) suite of farmer applications, Smart Nkunganire System (SNS) in Rwanda (Tsan *et al*., 2019:26). Some big players in the agricultural sector with their headquarters in Singapore are investing heavily in Africa (Veras, 2017).

4. The Context of Agriculture 4.0

Research is now beginning to explore what Agriculture 4.0 means for farmers with issues relating to where data ownership lies (Wiseman *et al*., 2019). As in other areas and in developments, there have been a number of published research that have set out to discover "how the changes brought by the emerging technologies of the Agriculture 4.0 will be manifested" (Simion, Popa & Albu, 2018:94).

Some studies have been carried out in relation to the role of ICTs in improving the food security of rural households. For instance, Lashgarara, Mirdamadi & Hosseini (2010) reported that "ICTs have the potential to improve the ability of individuals to acquire information needed for promoting food security".

4.1 Communication Tools

The study conducted by Olaniyi & Ismaila (2016:15) assessed the use of ICT for accessing food security information among maize crop farmers in Ondo State, Nigeria. Their study used a multi-stage sampling technique to a sample of 212 selected maize farmers who were household heads. Their findings concluded that cell phone, radio and television were the major ICT tools used by the respondents in accessing food security information in the study area.

FAO, WFP and FEWS NET's FSIS are acknowledged for their role in supporting regional and national information systems. FAO has established itself as the leading source of information on food production and food security throughout the world (ECA, 2011:11). FAO also plays a significant role in "capacity development support to member States, in such areas as methods for crop yield forecasts, market information systems, food security monitoring and early warning systems, emergency needs assessments, response analysis and integrated analysis of food security, vulnerability and resilience" (ECA, 2011:11).

New developments are also noted in the regime. Moturi and Otieno (2013:40) developed a framework for food emergency response and design a prototype system that would be used in planning for and managing food emergencies using Geographical Information System (GIS). Geographical Information Systems is deemed critical in countries such Kenya where there is no unified communication framework to facilitate the management of food emergencies (Moturi & Otieno, 2013:40).

The International Telecommunication Union (ITU) is also recognised for playing a key role in promoting the use of technology to address emergencies and food security. It also has a role in the development of Agriculture 4.0. The ITU released a *Technology Watch Report* in July 2009 which examined ways in which information and communication technologies (ICT) can be used locally and globally to address this problem (International Telecommunication Union (ITU), 2009:25). In 2003 and 2005 the ITU organized the World Summit on the Information Society (WSIS) to recognize the importance of ICT in food security and decided that e-agriculture should be a priority. Two leading initiatives were launched, namely: Bridging the Rural Digital Divide (BRDD) and the First Mile Project (FMP) organized by the International Fund for Agricultural Development (IFAD) in Tanzania. The FMP seeks to connect the rural poor on a regional scale to relevant information and key people in the market chain by making use of mobile phones, the Internet and e-mail (ITU, 2009:25). In 2006, FAO and others launched the web portal www.e-agriculture.org to guide efforts in enhancing sustainable agricultural development and food security, by promoting the use of ICT to support rural development (ITU, 2009:25).

4.2 Critique

Development in any sphere may result to critiques which can never be ignored. It is indicated that high-tech solutions to our food system might have potential inclusion and exclusion effects. Hickey *et al*. (2019) reported that the "discourse surrounding food security is currently dominated by neo-Malthusian justifications which see a rapidly growing population as the central problem and technology as the solution". Hung (2019:1) illustrated the impacts of IT on agricultural development, online agricultural marketing, climate change adaptation, food security, and food safety in Vietnam. Klerkx & Rose (2020:100347*)* argued that the dominance of emergent innovations associated with Agriculture 4.0 could divert money and attention away from currently implementable technologies that could make a difference now". Another critique indicated that "responsible innovation has not been widely considered". Rose and Chilvers (2018:87) further argued that "key dimensions of responsible innovation-anticipation, inclusion, reflexivity, and responsiveness should be applied to this fourth agricultural revolution".

5. Results and Discussion

Digital information exchange through various modes has become one of the main priorities of national and local governments all over the world (Bojang & Bwando, 2018:94). In this section, two sets of results are presented in this section. The first results present the results obtained from the interviews conducted on the level in which selected community members

in Sedibeng District Municipality source food security information. The second results provide a desktop review about the institutional arrangements towards digitalisation for agriculture.

5.1 Interview Results: The Level of Public Participation for Community Food Security Information in SDM

Two questions were asked which aimed to ascertain whether community members have access to food security programme information and the enabling factors which influence food security information. A sample of 112(*n*) community members were selected to determine the manner in which they receive food security information for participating in food garden projects. The food garden projects are established through the Provincial Department of Agriculture in various provinces in Gauteng Province. The respondents were selected on the basis of equal representation. The sample comprised of 57(51%) males and 55(49%) females who reside in low income households in selected townships in SDM. The research also considered different age groups to acquire information. The study was represented by youth 24 (21%), Elderly 20 (18%) and disabled 21 (20%). Most of the participants were unemployed of which 41% relied on state social grants. 98% of the respondents have identity documents (ID) whereas 2% of the female respondents did not have IDs.

The rationale to obtain data on ID possession results from the requirements of public participation in government poverty alleviation programmes. An ID is crucial for all citizens to access government services. For example, individuals require an ID to *vote*, to affiliate for CFGs, to sit for Grade 12 examinations, apply for a grant (for the child or disability) and to open bank account. In this regard it is crucial for citizens to own an ID. Currently, the South African government introduced the smart ID, which is readable from various systems in different sectors.

5.2 Access to Food Security Programme Information

Respondents were asked if they have access to food security programme information. The results showed that 64 (57%) of the respondents had access, while 48 (43%) did not have access to food security information. Some of the respondents participate in food gardens which are not linked to government programmes. For example, the residents of Sebokeng-Hostel grow their crops on their own, their crop field was green during the interview (November 2009). They have also vacated the open area near the railway station. It is evident that some community members participate voluntarily in these activities, but they are not recognised by the authority in their respective locations.

5.3 Enabling Factors which Influence Food Security Information

The respondents were asked to indicate their source of influence for dissemination of food security information. There are important enablers that facilitate digital agricultural transformation. Three key enablers are: the use of internet and mobile and social networks among farmers and agricultural extension officers, digital skills among the rural population and a culture which encourages digital agripreneurship and innovation (Trendov *et al.,* 2019:7).

Table 1: Enabling Factors which Influence CFGs

Value Lable	Frequency (*V*)	Percentage (%)
Church	0	0%
Clinic	6	5%
Community	30	26%
Employer	1	1%
Family	10	10%
Government	13	12%
Media (Radio, television, newspaper, cell phone)	50	43%
Private	0	0%
School	2	2%
Total	112	100%

Source: Author

41% of the respondents fall in the working class group. 26% of the respondents received information from their surrounding communities. The community comprises the disability groups, old age centre and stokvels. Access to information from government is insufficient; there are only 12% of the respondents who obtained information from government. Family members play an important role in development, as shown by the 10% rating obtained. The schools, media and clinics could play a major role in information dissemination. It is assumed that these institutions may empower communities if the responsible persons are flexible and responsive to the current challenges of poverty.

6. Desktop Results on Gauteng Provincial Government E-Services

Adoption of digital technologies varies significantly across countries, with lower current adoption rates in low-income countries. Integrated food security information systems have been developed as a means of giving a universal and coordinated approach to the issue of food insecurity (ECA, 2011:28). The researcher reviewed the Gauteng Provincial Government (GPG) website and found that there is a Gauteng digital platform created to service the citizens online. The GPG websites has diverse offering of services, including agricultural, housing, health, safety and security and education. There is also a dedicated service delivery towards agricultural development. The researcher came across the online site which presents the Agriculture and Animals services to the community. Important services for digitisation are presented in Table 2. Some service requires community to present themselves in government offices, while some services can be offered by means of telephone services.

The services available to community members comprise in-person, phone and online services. Provision of agricultural support is aimed to mitigate food insecurity at community and household level. The service is provided by the Gauteng Department

Table 2: Agriculture and Animals

Online Service	Description	Service Availability	
		In Person	Phone
Apply for AgriBEE Fund	This service is aimed at assisting farmers and farmworkers to access enterprise development and equity acquisition.	x	
Apply for Agro-processing services	These services are aimed at supporting smallholder farmers as well as township enterprises who are either operating in the agro-processing space or on a small scale or would like to add value to their produce.	x	x
Apply to donate plants	Individuals, businesses and municipalities can apply for a permit to donate plants.	x	x
Apply to sell plants	Individuals, businesses and municipalities can apply for a permit to sell plants.	x	x
Request Agriculture related feasibility study and business support	This service is aimed at supporting emerging entrepreneurs on feasibility study business plan compilation to access finance, markets and compliance with the regulatory measures of Agricultural Products.	x	x
Request for information on farm biosecurity	Biosecurity is the practice of good farming principles to prevent entering of a disease onto a farm as well as spread to other premises. They should form part of any farmer's Good Farming Practice.		
Request for support to a backyard food garden	Provision of agricultural support to mitigate food insecurity at community and household level.	x	
Request for support to a community food project	Provision of agricultural support to mitigate food insecurity at community and household level.	x	
Request for support to a school food garden	Provision of agricultural support in order to supplement the school nutrition feeding programme.	x	

Source: Gauteng Provincial Government (2020)

of Agriculture and Rural Development to encourage communities to produce their own vegetables in their backyard.

The website provides the criteria and process for applications. Project information is also provided which indicates the package provisions for participating communities. The link also guides on how to apply for food security programmes. The contact details are also included on website which includes the email address and the address of the office. The website provides an address where to community members can apply. The information about the address and the telephone details of the Gauteng Department of Agriculture and Rural Development (GDARD) is displayed on the website. The vicinity of the GDARD is accessible as it within the central business district in Johannesburg, whereby communities may travel by taxi, private car, bus or train. The website also provides the address of the municipalities in Gauteng Province., including the Ekurhuleni Metropolitan Municipality and Sedibeng District Municipality, Randfontein Local Municipality (Westrand District Municipality), and Tshwane Metropolitan Municipality.

The study conducted by Nally (2016) showed that technology is important to boost productivity and has indeed contributed to enhancing food security and prosperity. D4Ag has significant potential to act as a driving force behind Africa's agricultural transformation in the coming decades (Tsan *et al*., 2019:26). Coetzee (2018) indicated that "technology is being touted as the enabler of a new era of African agricultural prosperity". The article titled "How we made it in Africa" by Veras (2017) indicates that "Africa's economy is inherently dependent on agriculture". In digital technology, today's African leaders have a powerful tool they can deploy to help clear away the primary obstacle to progress: the profound isolation of the vast majority of smallholder farmers (Annan & Dryden, 2016:iii). In Africa, agriculture accounts for two thirds of livelihoods and food accounts for two thirds of the household budgets of poor people (Veras, 2017). In Africa with more than 60% of its 1.166 billion people living in rural areas, more than 32% of the continent's gross domestic product comes from the agricultural sector (Veras, 2017).

6.1 Radio

Digital technologies are already improving smallholders' access to information, inputs, market, finance and training (Trendov *et al.,* 2019:1). Digital agriculture can potentially accumulate large amounts of data, and analytical capabilities that facilitate the effective employment of these data are key implementation factors (Van Es & Woodard, 2017:98). Radio broadcasting was found to be a key medium for information, it is relatively inexpensive and has wide coverage in the developing world (Romero & Adolph, 2009:5). National Radio stations such as Lesedi Stereo, Motsweding and Umhlobo Wenene have a programme slot which provides information about food security matters. In such programmes host specialist from the department of agriculture who speaks about agricultural economy and farmers who share experiences on their success and challenges experienced in farming. The results also show that there is a FAO Rural Radio in Africa (ITU, 2009:26) which provide service directed at developing countries and also features a special Food Security Channel with programmes giving advice on how to improve productivity (ITU, 2009:26). The FAO Rural Radio has a food security channel with programmes giving advice on how to improve productivity (Romero & Adolph, 2009:5).

6.2 Mobile Cellular

It is used to achieve greater income for smallholder farmers, improve food and nutrition security, build climate resilience and expand inclusion of youth and women (Tsan *et al*., 2019:5). Globally, mobile cellular subscriptions have been growing over recent years (Trendov *et al*., 2019:3). The rapid increase for the use of mobile phones in developing countries has become another major means of disseminating information (ITU, 2009:26). Between 2013 and 2018 there were 1 billion new mobile subscribers and 67% of the world population is now subscribed to mobile services. Much of this recent growth has been driven by countries in Africa and Asia and the Pacific (Trendov *et al*., 2019:3). Cell phone usage and perception towards contribution of ICT usage were found to have significant effect on household food security status (Olaniyi *et al*., 2016:1). The use of mobile applications allowed Kenya to develop *Kenya* M-Farm: and it led Kenyan farmers to change their cropping patterns and some reported receiving higher prices at market as a result (Baumüller, 2015). It is evident that the usage of mobile phones enables farmers to respond quickly to market demand and prevent wastage caused by over-fishing. Farmers are able to use short message service (SMS), to receive information directly on their phones, and

in their local language (ITU, 2009:26). For example, TradeNet, based in Accra, Ghana has created a platform where farmers and traders across the world can share market information via mobile networks and the Internet (ITU, 2009:26).

6.3 SMS

It can be said that the use of mobile phones to distribute food market information offers great advantages for consumers and food producers (Romero & Adolph, 2009:4). It is observed that farmers can use mobile phones to receive text messages with market information on commodities. The study also identified the development of Tradenet31 which is used in Ghana to help farmers receive accurate weather forecasts and local price information direct to their mobile phones, and in their local language (Romero & Adolph, 2009:5).

6.4 Telecentres

Telecentres were also found to benefit rural area and underserved communities. These centres provide the rural population with access to the internet, to telephone, fax services connection and communication with potential buyers and to access information on improved farming techniques (ITU, 2009:26). The desired outcomes of digital agriculture are more productive, profitable, and sustainable systems (Van Es & Woodard, 2017:97). Digital agriculture offers new opportunities through the ubiquitous availability of highly interconnected and data intensive computational technologies (Schwab, 2016). The exciting world of possibilities offered have made companies, governments and policy makers sit up and take notice of how such technologies can be applied to foster greater innovation, efficiency and economic and social progress (Coetzee, 2018). Adopting key technologies to enhance agricultural production and sustainably intensify food production (Coetzee, 2018). Digital agriculture can leverage the smart use of data and communication to achieve system optimization (Van Es & Woodard, 2017:98). Mobile communications can shatter this isolation and enable the creation of a new food system suited to contemporary needs (Annan & Dryden, 2016:iii). It is evident that the emerging technologies of Agriculture 4.0 have enabled organizations to use equipment that can communicate with each other over the Internet. Agriculture 4.0 encompass a wide variety of potential 'future agricultures' or 'future food systems' which are characterized by high-tech, radical, and potentially game-changing technologies (Rose & Chilvers, 2018).

Farmers are regarded as the most important people in the world. Digital technologies enable increased transparency by improving product traceability, and better informing consumer choice as to price, nutrition, production practices, and environmental and biodiversity impacts (Townsend *et al*., 2019:12). The use of Information and Communication Technologies (ICTs) therefore takes the lead of all the strategies for ensuring household food security among rural populace through the dissemination of relevant information (Batchelor *et al*., 2005). Farmers can easily access valuable information through databases established by government or farming organisations, which facilitate an exchange of interaction between researchers, extension workers, traders, and farmers (Hung, 2019:1).

E-AGRIC is developed and in use today in rural areas, and provides solutions to many challenges faced while working to enhance agricultural development (Hung, 2019:1). Smarter farms are seen as a contributor to *empower smallholder family farmers.* Smarter farms include e-extension, precision agriculture (remote sensing), matching markets for mechanisation services and other inputs, improved access to market price information and finance, and improved certification for export markets. Smarter farms also bring reduction of cost to government institutions, whereby extension officers can receive report from farmers while doing other errands in their respective office (Deichmann, Goyal & Mishra, 2016; Nakasone & Torero, 2016). Smarter farms came into place during the COVID-19 outbreak where we witnessed the global arena lockdown regulations which restrict mobility of government officials and community members.

Digital technologies have significant potential to improve efficiency, equity, and environmental sustainability in the food system (Townsend *et al*., 2019:4). Improved public service is witnessed by social grants transfer developed in South Africa for safety net among low income households. Another example is showcased by government online services developed to communicate with community member by means of phones and SMS. In Nigeria, the government reached a higher number of recipients with lower cost and lower leakage through an e-wallet programme for subsidized fertilizers (Townsend *et al*., 2019:15). It can also contribute to greater

transparency and accountability in public decisions, stimulate the emergence of local e-cultures, and strengthen democracy (Fakhoury, 2018).

Digital technologies are also used to enhance monitoring and evaluation of outcomes in agriculture (Townsend *et al*., 2019:15). The contribution benefits the international organisation to map and monitor world food supplies, early warning systems, and to respond when disasters strike (Moturi & Otieno, 2013:40). Digital technologies also expand rural network coverage for people residing in rural areas (Townsend *et al*., 2019:15). Digital technologies are creating new opportunities to integrate smallholders in a digitally-driven agrifood system (USAID, 2018). It has an ability to foster digital entrepreneurship, whereby farmers get the opportunity to access financial services to help finance agricultural inputs and for savings mobilization (Townsend *et al*., 2019:9).

Agricultural transformation also facilitates demand for digital technologies in the food system. It is a fact that no state can remain underdeveloped forever. The transformation enforces the state to provide e-learning programmes to educate rural farmers on the use of technology as new developments surface. Through, telecentres several partnership initiatives have offered online toolkits to train individuals and support institutions and networks world-wide in the effective management of agricultural information (Romero & Adolph, 2009:5). Investment in skills and knowledge are crucial to improve farming practices in general, but also to improve digital literacy and enable farmers to better take advantage of digital technologies (Townsend *et al*., 2019:9).

Digital transformation has the potential to deliver significant economic, social and environmental benefits. Some appropriate digital applications are already in use, and more are in development. It can be concluded that the capacities of ICTs on food security are related to improving communication in the agricultural sector. Digital technology can help advance all these principles simultaneously. It has an ability to make connections possible, transfer's information instantaneously, and can help build virtual communities even among widely separated and remotely located individuals and communities. Digital agriculture has an ability to create systems that are highly productive, anticipatory and adaptable to changes such as those caused by climate change and lead to greater food security, profitability and sustainability (Trendov *et al*., 2019:2). Digital technology can also revolutionize farmer organizations whereby farmers affiliate to respective farmers' union (Annan & Dryden, 2016:vi). Finally, by participating in e-commerce, the rural farmer can have a direct link to producers, traders, retailers, and suppliers (Hung, 2019:1). Technologies can also support farmers to anticipate and respond to pest attacks, crop failures and climatic changes through timely weather-based agro-advisory messages (Trendov *et al*., 2019:12).

7. What Can be Done to Speed it up and Why is it Important that we Do?

The digital transformation has become a critical management issue and requires new ways of managerial thinking (Tsan *et al*., 2019:10). Membership in agricultural cooperatives has always lagged in Africa, because smallholders are too spread out (Annan & Dryden, 2016:vi). It is argued that ideas of responsible innovation should be further developed in order to make them relevant and robust for emergent agri-tech (Rose & Chilvers, 2018:87). D4Ag may eventually lead to Agriculture 5.0. The following are conditions that may shape the digital transformation of agriculture in different contexts:

- The use of internet and mobile and social networks among farmers and agricultural extension officers.
- Digital skills among the rural population.
- A culture which encourages digital agripreneurship and innovation (Trendov, Varas & Zeng, 2019:8).
- Develop human capital.
- Drive greater business model sustainability.
- Invest in the missing middleware infrastructure.

A sustainable digital agripreneurial culture is a long-term political and practical process, starting with appropriate education in schools (Trendov *et al*., 2019:8). The culture requires early learning foundations whereby agricultural learning should be taught in primary schools to allow transition of knowledge. Early teaching of agriculture will allow farmers to design business plans and seek funding in the right channels without being rejected.

Youth farmers will also be able to manage risks in their farm management. In Italy, almost 12 000 agricultural start-ups were created in 2013 by men and women aged 25 to 30. In rural areas, a lack of infrastructure and resources often limits the quality of education Digitalization creates demand for digital skills. Fundamental digital government reform demands sustained effort, commitment and leadership over many generations (Fakhoury, 2018). Literacy and digital skills and the availability of technologies all affect the use of digital innovations. Digital agricultural applications need to be run on neutral digital platforms to which any farmer can connect, rather than proprietary platforms for a select few (Tsan *et al*., 2019:10). Governments can offer In-house training to provide farmers with basic literacy and numeracy to be able to handle data.

Access to the internet is regarded as the critical component for unlocking the possibilities of digital technologies. The study conducted by Olaniyi, Akin and Ismaila (2016:1) recommended that "extension institutions should concentrate on the identified ICT tools especially cell phones in disseminating relevant and timely information to farming households for sustainable food security". The next period of growth in mobile connections is expected to come mainly from rural communities (World Bank, 2016). This means making sure that all farmers are included from the start, especially the poorest and most remote. The design and management of a digital government programme also require government to increase the capacity of government workers to undertake and implement the agricultural mandate. Right policy, innovation and investment could also transform the continent's agriculture into a powerhouse not only to feed a growing population but to create decent employment for millions of young people (Tsan *et al*., 2019:10). Africa also needs to prove that D4Ag deployments can be sustainable in order to drive greater investment.

8. Conclusion and Recommendations

The agricultural sector remains a major source of livelihoods in rural areas. The surge in digital technologies available over the past few decades has transformed virtually every sector of the global economy, and agriculture is no exception. The digital transformation of society has brought many immediate benefits of job creation and boosting efficiency and promoted innovation. Literature proves that E-agriculture services are fundamental in providing farmers with useful information. Various modes of communication are acknowledged whereby mobile phones and SMS messaging have changed the way farmer's access market information. It has also improved the interaction government agencies efficient. Digital literacy will be a requirement in agrifood jobs and suitable education and training will be required. It can be said that the transformation must be done carefully to circumvent an increase of a digital divide.

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