Policy Brief

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Adopting Digital Technologies in Africa's Agricultural Sector

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List of Acronyms and Abbreviations

CSA	Climate Smart Agriculture
DI	Digital Identification
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ICT	Information Communication Technology
ID	Identification
IOT	Internet of Things
R&D	Research and Development
SADC	Southern African Development Community
SME	Small Medium Enterprises
SSA	Sub-Saharan Africa
OECD	Organisation for Economic Co-operation and Development
UNDESA	United Nations Department of Economic and Social Affairs
41R	Fourth Industrial Revolution

Summary

The importance of digital technologies to agriculture is gaining increasing scholarly and policy attention across the globe. The OECD refers to digital agriculture as the use of information communication technologies (ICT) including the internet, mobile technologies and devices as well as data analytics to digitally generate, collect, store, analyze, share and present digital content (OECD,2014a). Agricultural transformation is an urgent priority in Africa, but so far has been difficult to achieve. In this policy brief, we discuss the potential of digital technology in improving development outcomes in Africa's agricultural sector. We also discuss the risks of the adoption of digital tools in exacerbating existing socio- economic and regional inequalities and the penalty for digital exclusion such as gender inequality and youth unemployment. The policy brief suggests technologies and policy directives that could be implemented to address the threats such as food insecurity and climate change using digitisation.

Drawing on some of the general principles of structural transformation, we offer policy recommendations to facilitate a more nuanced approach to identifying steps to enable successful uptake of digital technologies in order to benefit the agricultural sector. These policy recommendations are (i) More collaboration between government and the private sector (ii) Improved regulatory environment (iii) Increase in skills and human development (iv) Increase in research and development (v) improved budget allocations by the government (vi) increased infrastructure provision in rural areas.
This comes against a backdrop of many African countries facing a potential increase in both food insecurity and unemployment. While we are cautious about the hype around the 4IR and digital technology uptakes, governments must create enabling environments with improvements in internet, mobile phone and electricity infrastructure to be economically and socially transformative and avoid the potential threats of 'technological unemployment'. Thousands of villages still lack access to the internet because many are yet to be connected to the electricity grids. Lastly, the policy brief looks at the Kenyan case study as a model for best practice in achieving agrarian gains. Emphasis is put on the need to implement tailor made solutions to fit local contexts and circumstances.

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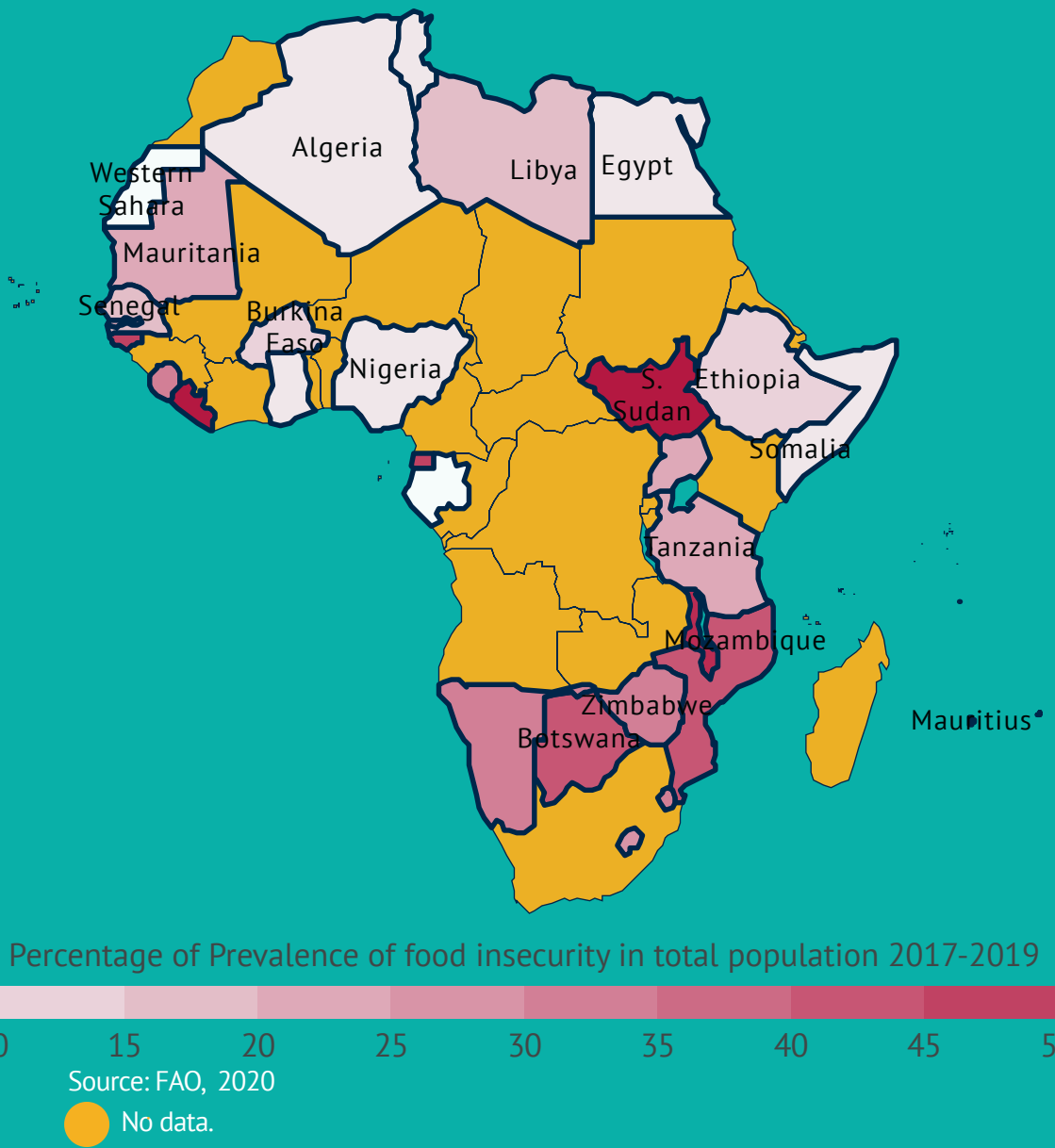
Why Digital Agriculture is important for Africa

Africa's agriculture needs digitalisation to boost the continents Gross Domestic Product through the reduction of food imports and an increase in agricultural exports. Digital agriculture can also increase inter- regional trade, address the gender digital divide, enable the social and economic inclusion of women, improve food security, boost youth employment creation, improve access to networks and data by smallholder farmers and improve resilience to the effects of climate change. This paradigm also serves as an opportunity to engage and empower Africa's women and youth. Macro and micro-level data produced from digital technology uptake can transform and optimise production on fields and enable business efficiency for small holder farmers The data that is produced is critical for public policy design and progamme implementation.

Figure 1.1: The status of food insecurity in Africa 2017-2019



Download data

Figure 1.1 above shows the prevalence of food insecurity in Africa. The worst affected countries on the continent are South Sudan with 63.7percent, followed by Liberia with 60.4 percent. Countries in the sub- Saharan African region were affected by catastrophic weather patterns such as the El- Nino related to climate change. The data also shows that challenges that lie ahead in meeting the SDG indicator 2.1 by 2030 and that policy makers should take swift action. This means that rapid adoption of digital technologies will need to be taken over the next decade to enable countries to overcome the challenges which lie ahead.

Defining Digital Agriculture

Digital agriculture refers to the use of information communication technologies (ICT) including the internet, mobile technologies and devices as well as data analytics to digitally generate, collect, store, analyze, share and present digital content (OECD,2014a). The agricultural value chain starts with research and includes all aspects from before, during and after on-farm production. Agricultural digitalisation can be applied to on-farm production aspects such as crop resilience mechanisms, and postharvest handling activities aimed at income improvement which include supply chain management, market and finance access. The process of digital agriculture includes the use of remote sensors, satellites and robotics, mobile apps and social media (Malabo Montpellier Panel , 2019).

Context

Why Digitisation is important for Africa

The Agrifood sector remains critical not only for ensuring food security but for employment creation. Digitalisation can boost the continent's gross domestic product, address the gender divide, improve food security, reduce the impacts of COVID-19 pandemic, improve access to networks and data by smallholder farmers and improve resilience to the effects of climate change. This paradigm also serves as an opportunity to engage and economically empower Africa's youth. There are different types of digital platforms that provide digital services across the agricultural value chain. These platforms include e-commerce and e-business, and online information services.

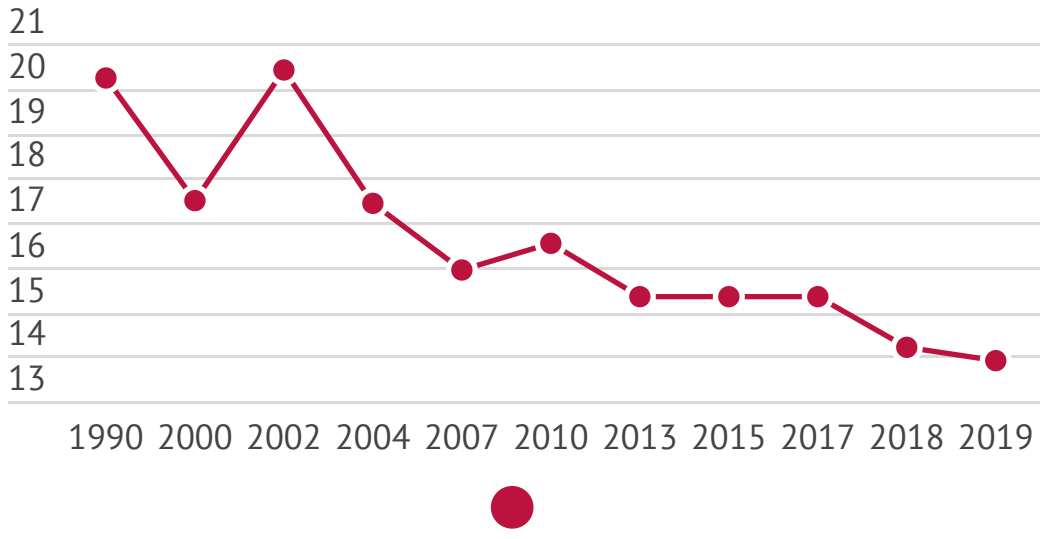


Figure 1.2 Agricultural contribution to Sub-Saharan Africa's GDP
World Bank, 2021

Boost Africa's Gross Domestic Product (GDP)

The agricultural contribution to sub-Saharan Africa's GDP has been on the decline, from 20.2% in 1990 to 13.9% in 2019 (see Figure 1.2). This decline is partly driven by limited national budget allocations resulting in poor financing for the adoption and development of innovative technologies.

The Maputo/Malabo Declaration Commitments required countries to spend at least 10% of their national budget on agriculture. At the end of 2013, 40 countries signed up for the programme, and 9 had attained the 10% target while other countries only allocated 3% (Tafirenyika, 2014). According to the Second Biennial Review report, only four countries attained the 10% target in 2019, indicating that the rate of progress has slowed down (Makombe & Kurtz, 2020).

Address the gender digital divide

While digitisation has the potential to increase access to information and productivity, the use of technology in agriculture also presents significant challenges to those who do not have access to such technologies, particularly women. This significantly raises concerns around food security and the role that women and youth can play in technology-driven food systems. In sub-Saharan Africa 58% of women own a mobile phone as compared to 71% of males (Bill & Melinda Gates Foundation, 2019). Mobile phones are an effective way of accessing real time information on market prices. The capacity building of local rural institutions to provide digital literacy is one effective way of sustaining agribusiness efficiency for women as well as the adaptation of local languages which can encourage the use of ICT among rural women.

Improve food security

Rapid population growth will require improved food security and nutrition. More than a fifth of the population in sub-Saharan Africa experiences chronic undernourishment. Approximately 35% of children under five were stunted as a result of malnutrition in 2016 (Tsan et al., 2019). As a result, innovation from digitalisation is needed to improve productivity and profit so that farmers can produce nutritious food.

Prevalence of Undernourishment (POU) in Africa and other continents 2005-2019

	2005	2010	2015	2016	2017	2018	2019	2030**
North Africa	9.8	8.8	6.2	6.3	6.6	6.3	6.5	7.4
Sub- Saharan Africa	23.9	21.3	21.2	21.4	21.4	21.4	22.0	29.4
Eastern Africa	32.2	28.9	26.9	27.1	26.8	26.7	27.2	33.6
Middle Africa	35.5	30.4	28.2	28.8	28.7	29.0	29.8	38.0
Southern Africa	4.9	5.4	7.0	8.0	7.0	7.9	8.4	14.6
Western Africa	13.8	12.1	14.3	14.2	14.6	14.3	15.2	23.0
Africa	21.0	18.9	18.3	18.5	18.6	18.6	19.1	25.7
Asia	14.4	10.1	8.8	8.5	8.2	8.4	8.3	6.6
Latin America and the Carribean	8.7	6.7	6.2	6.7	6.8	7.3	7.4	9.5
North America and Europe	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Oceania	5.6	5.4	5.5	5.9	6.0	5.7	5.8	7.0
WORLD	12.6	9.6	8.9	8.8	8.7	8.9	8.9	9.8

Table 1.1 Source: FAO, 2020

NOTES :* The projections** do not reflect the potential impact of the COVID -19 pandemic .

Values are in percentages

The outlook for 2030 reflects that the continent is significantly off track from reaching the 2030 SDG goals as seen in Table 1.3. The global average of undernourishment was 8.9percent in 2019. Africa is the most affected continent with 19.1 percent compared to Latin America and the Caribbean which recorded 7.4percent.

Sub- Saharan Africa is the most affected region with a high percentage of undernourishment at 22.0 in 2019 and is projected to increase to 29.4 by 2030, compared to North Africa which recorded only 6.5% in 2019. The situation in Africa has been worsened by catastrophic climate change related events such as the EL-Nino which increased insecurity in some parts of Mozambique, Zimbabwe, Malawi and South Africa. Other catastrophic events such as the locust invasion in Kenya, Ethiopia and some parts of Uganda, violence and conflict in places like South Sudan, Darfur and desertification in the Sahel have been fueled by climate change resulting in increased competition for resources.

Improve access to networks and data by smallholder farmers

Most smallholder farmers in Africa lack access to extension services such as advice on land rights, financial opportunities, and legal support all compounded by high transactional costs due to poor rural infrastructure. Poor digital infrastructure and access to data and networks in turn result in limited access to extension services which affect farmers' operational decisions and production methods. Smallholder farmers also have a low weighting in policy decisions and presence in commercial markets. With a rapidly changing domestic and international market for produce, smaller producers find it increasingly difficult to participate in such markets (Malabo Montpellier Panel , 2019). Also, smallholder farmers in Africa are exposed to higher risks of yield loss due to pests and diseases. In 2017, maize farmers in six African countries experienced a combined annual loss of US$0.9–1.1 billion due to invasive species, which doubled the estimated loss in a span of 10 years (Malabo Montpellier Panel, 2019).

Reduce the impacts of pandemics

COVID-19 has amplified significant economic disruptions in an already fragile global economy. The impact of the pandemic on Africa is expected to result in a reversal of decades of economic progress causing unprecedented challenges for policy makers. The disruptions across the agricultural value chain from extensive lockdowns resulted in the urgent need for inclusive digital and financial technologies as governments battled to contain the effects of the pandemic across all sectors. Among some of the critical concerns was the need to ensure food security and maintain the seamless flow in agricultural value chains. It has become apparent that digitization is a critical aspect in minimizing disruptions. The pandemic has proven that the advanced use of digital connectivity, digital teleworking, broad connectivity and networking can play a transformative role by fostering e-commerce and e-governance of productive resources.

The use of digital financial services provided incentives for transformative growth channels especially for SME and entrepreneurs in ways that has enabled sustained business continuity in the agricultural sector. Agritech start-ups grew significantly in 2020 raising more than 59 million US dollars across the continent in 2020 a 23.7percent increase from more than 48million raised in 2019 (Disrupt Africa, 2020). Agricultural entrepreneurs and SME have been able to secure low cost and contactless financial services for their business continuity. To manage the current and any subsequent impacts of COVID-19, digitalisation can assist with the creation of digital data rooms. These data rooms can be used to track, monitor and forecast trade flows, food pricing and availability, and create e-commerce opportunities for commodity traders (Pais et al, 2020)

Improve resilience to the effects of climate change

Data on climate change variability and long-term changes in rainfall and temperature patterns is mainly sourced from ground-based weather stations in many parts of the continent. However, in recent years the station observations have declined in number and are now sparsely distributed resulting in gaps in true measurements of climate change variability. This is despite their critical role in providing reliable climate information to farmers such as water shortages, higher temperatures, and other extreme weather events. The use of robust climate technology combined with local observations and satellite and global models can improve accuracy and analysis to alert the potential challenges of food security, hydrometeorological disasters and enhanced decision forecasts that empower decision makers. For example, Rwanda and Ethiopia now offer access to credit to farmers and insurance based on climate data such as regional rainfall. It is likely that these events will become more extreme in future decades.

Agricultural digital services and technologies

Digital agriculture has the potential to sustainably bring forth economic, social, environmental and production benefits for Africa. For this to be applied across the agricultural value chain requires a systematic and holistic approach. Outlined below are various agricultural digital services and technologies.

Digital Identification (ID) and Electronic Registration

There are electronic financial, legal and advisory services available for farmers, however, they may be unable to access these services without having an electronically registered profile. A critical barrier to e-registration is the inability to prove one's identity. Figure 2.1 and 2.2 illustrate the higher percentages of low-income countries and women in low-income countries affected by this barrier. Therefore, the World Bank Group's Identification for Development (ID4D) created an initiative to improve access to digital identification. Through the use of these ID systems, farmers can electronically register their profile and access various financial, healthcare and legal services

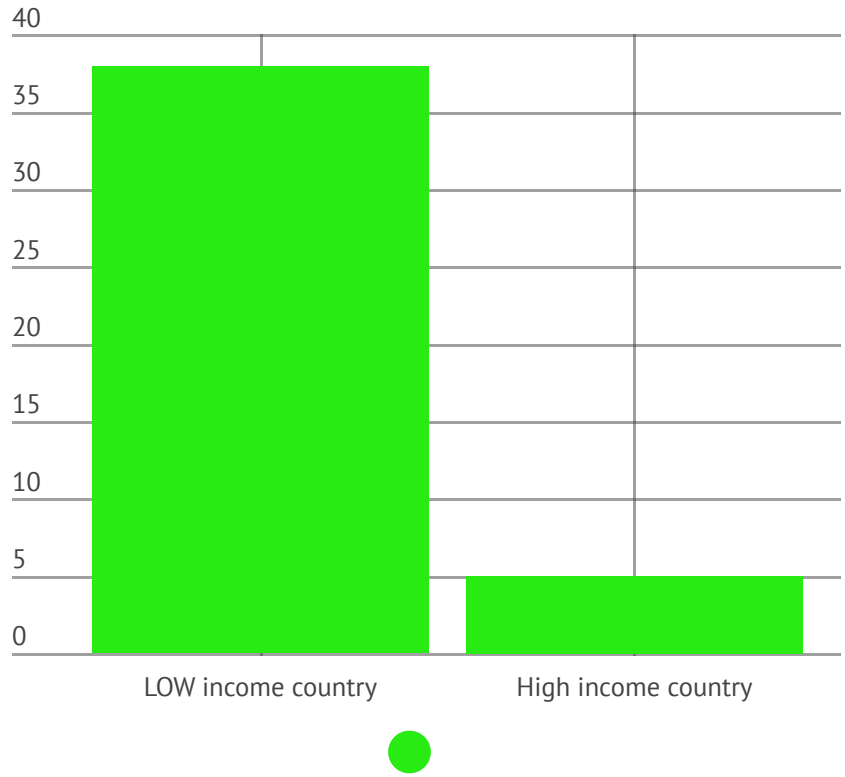
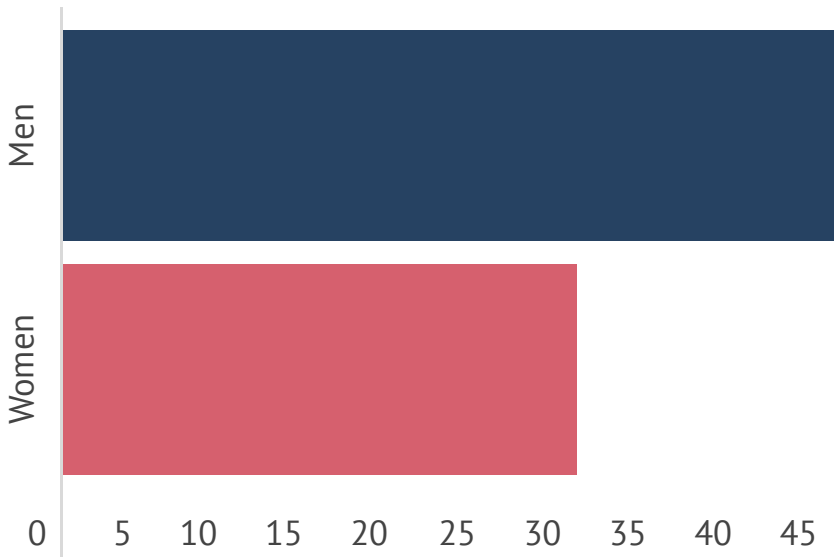


Figure 2.1 above shows % of adult population without an ID; Figure 2.2 below shows % of men and women without an ID in-low income countries.
Source: Bill and Melinda Gates Foundation, 2019



Agricultural digital services and technologies

Land security and ownership

Digitalisation can enforce and secure land rights, which include the right to use, control and transfer land. Farmers with secure land tenure can sometimes find it difficult to prove ownership with the systems currently in place. This leads to reduced investments in land and agricultural production. Also, geospatial data of land location and ownership are not easily accessible in official documents, therefore, the use of Global Positioning Systems and global navigation satellite systems are beneficial in land mapping procedures. The use of drones with sensors acquiring aerial imagery for land tenure systems has been used in 2016, by the Tanzanian Ministry of Lands (Malabo Montpellier Panel , 2019).

Weather forecasting

Currently, many African farmers use outdated and unreliable techniques to gather information about the weather and climate. These techniques include the observation of cloud type and colour, absence or presence of various birds, insects and reptiles, moon phases and wind swirls and direction (Gugulethu, et al., 2013). With reliable forecasts, farmers will have better information to make sowing, ploughing, harvesting and irrigation scheduling decisions. This information can be made available through mobile apps. These mobile apps are likely to be more effective if it is accessible in the farmer's local language. In Ethiopia, a local weather forecast project was initiated by sending an SMS in two local languages to 1500 sesame farmers. In Kenya, the CropMon project provided localised information on production, rainfall and temperature to 150000 farmers (Malabo Montpellier Panel , 2019).

Agricultural digital services and technologies

Finance

Financial digitalisation will allow farmers access to banking facilities, loans, pensions, investors and hiring and repayment services. FarmDrive uses a farm's data to assess the creditworthiness and solvency of a farm. This initiative is scalable to ensure that loans can be developed according to the needs of smallholder farmers. Upon approval, loans and repayments are made easily accessible by using mobile money. The 2016 Nigerian initiative, Farmcrowdy, uses a sponsorship model to connect farmers to potential investors. Investors fund higher yields for a portion of the profit. Since 2016, there have been more than 35000 farm sponsorships (Malabo Montpellier Panel , 2019).

Machine Hiring Services

The limited access that farmers have to tools and machinery have lowered efficiency along the agricultural value chain. Hiring services like TROTRO Tractor Limited enable farmers to digitally connect to tractor operators. Through SMS, farmers are able to request, schedule and pay for tractor services which allows farmers to experience the benefits of using the machine without the challenge of low asset and collateral for ownership (Malabo Montpellier Panel , 2019).

E-governance and the Seed Value Chain

E-governance in agriculture refers to the use of information and communication technologies (ICTs) to deliver governance products and services across the agricultural value chain. E-governance can also be used in the seed value chain for research and development (R&D), production, processing, tracking, distribution and sales of seeds (Bossuet, et al., 2019). Seed R&D allows for the collection and analysis of large datasets that can be used to create smart evaluation models to determine the seed quality, links the different role players in the seed industry and allows for seed traceability.

Legal Services

Lawyers 4 Farmers (L4F), a 2017 initiative in Uganda, provides legal advice to female farmers using an SMS service. This initiative assists farmers in their local language and educates them on responses to any legal issue they may encounter. With the aid of this easily accessible resource, women are able to protect their land rights, fight gender biases and increase their access to legal advice (Bafana, 2019).

Use of ICTs in climate-smart agriculture (CSA)

The Technical Centre for Agricultural and Rural Cooperation (CTA) is using ICTs in a Southern African project that aims to benefit small-scale farmers that are at risk from climate change. The programme adopts four CSA solutions to help farmers increase food security, nutrition and income while overcoming the challenges created by climate change. The solutions include drought-tolerant germplasm, ICT-enabled climate information services, diversification of options for livestock farmers and innovative weather-based insurance (CTA, 2019).

Exploring barriers and risks of a digitalised agricultural economy

Despite the advantages of establishing a digitised agrifood system in Africa, there are growing concerns about the potential of inequality which could pose significant challenges in the effective implementation of transformative farming systems across the continent.

Access to digital devices

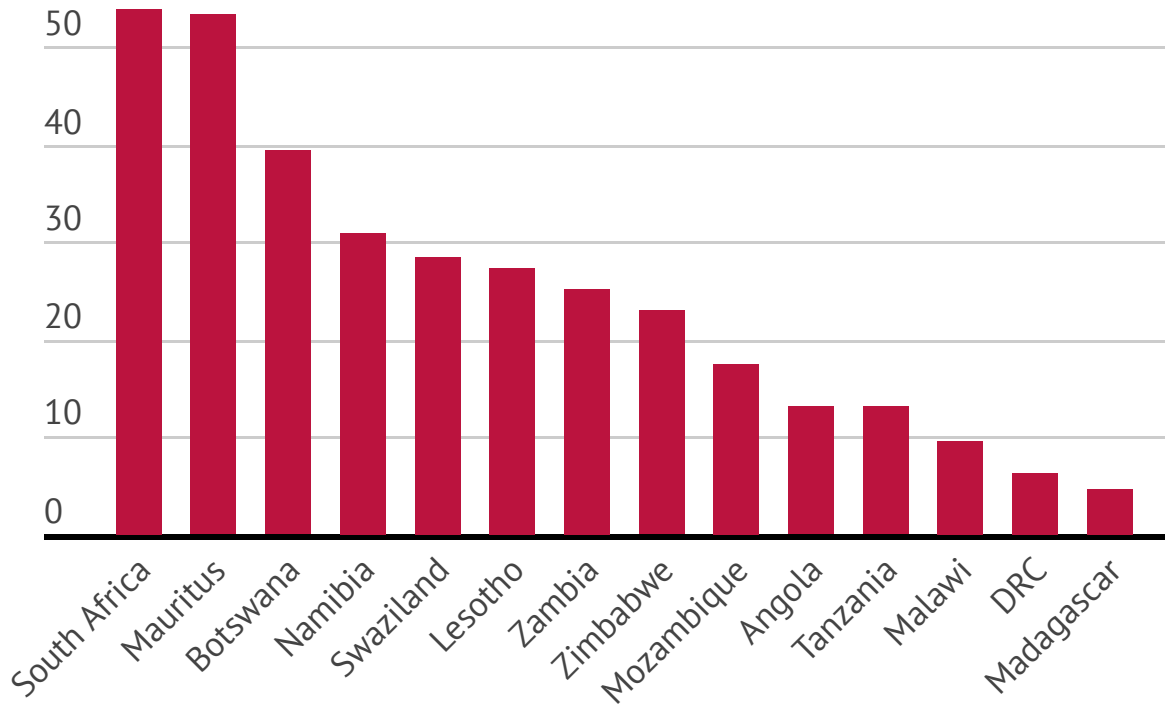
The rolling out of new digital technologies particularly the penetration of smartphones by farmers has increased in some parts of the world such as India. In Africa, smartphones have created new business models for the youth who have maximised technology for the development of agricultural value chains. However, for many rural farmers in Africa, the affordability and knowledge of a smartphone remains a major constraint. While the concentration of the digital ecosystems mainly in urban areas presents more obvious benefits to consumers, supply side constraints remain for small scale producers without access to such technology. The unequal distribution across groups such as youth, women and small-scale farmers could widen the digital divide between rural and urban communities. There is also another risk of a regional divide. Farmers in western countries have more advantages with access to technologies compared to small scale rural farmers in least developed economies. To bridge the divide, R&D is needed to establish how digitalisation will reach the poorer and marginalised regions. R&D will also need to target specific constraints that affect the youth and women, such as cultural barriers, and create digital services that promote gender responsiveness (Malabo Montpellier Panel , 2019).

Low levels of Internet penetration in Africa

Digital infrastructure includes the development of internet connectivity which can enable access to the use of bandwidth, mobile-network coverage and internet and mobile phone penetration offering significant advantages to small scale farmers (Malabo Montpellier Panel, 2019). For example, SADC countries are faced by a challenging environment with low levels of internet penetration. The sub-regional average of internet access in 2018 stood at 26 percent. According to Mothobi,Chair and Rodeman more than 80 percent of internet users in the region access the internet through mobile phones.

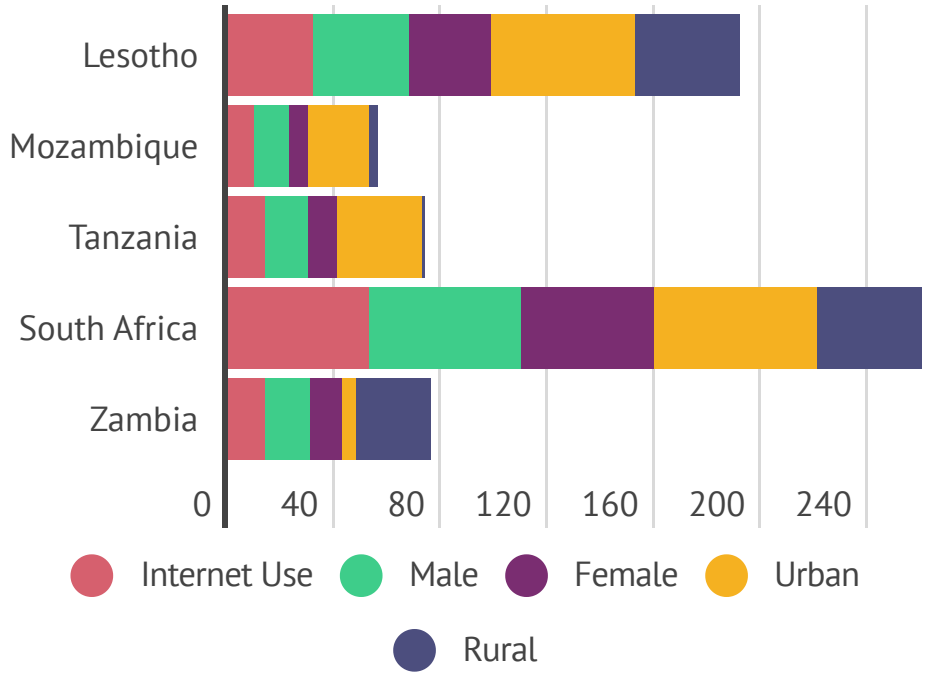
> *ICT has been identified by the SADC as a critical enabler of development with the ability to build an inclusive ,equal and economically empowered society*

Figure 3.1 Percentage of individuals with access to internet in SADC countries 2018



Source: RIA 2018 After Access Survey and ZICTA Household Survey for Zambia

Figure 3.2 Internet use in 5 countries 2017
Source After Access Surveys ,2018



The SADC Declaration on Information and Communication Technologies (2001) invokes member states to prioritise rural and remote areas, underprivileged urban areas, among others yet there remains a notable rural- urban divide in African countries. One of the key factors is how to adopt pro-farmer policies and come up with effective solutions to bring technology to the mass market across multiple villages and greater populations. It is also important to note that not every single small holder farmer needs to be digitally connected. Agri- entrepreneurs can become information agents who will be used to apply digital technological techniques on behalf of rural farmers, mainly because of their knowledge of local contexts.

In order to achieve this, introducing innovation in the digital space and technologies ranging from ICT, Cloud and drone technologies can effectively boost agricultural performance and efficiency and attract Africa's youth to the sector. However, the absence of affordable and supportive infrastructure often means that youth groups remain underserved. Relevant reforms are needed for visible changes in the agricultural sector to occur. Therefore, creating a blend of technologies which includes mobile phones and radios can effectively encourage the uptake of digital technologies by the youth and agribusinesses.

Data affordability

The affordability of data is one major challenge in many African countries, which leads to the monopolization of services. The extension of affordable services in rural areas to ensure inclusive digital growth remains urgent. Rural areas ordinarily only have a single mobile operator available, with poor service and uncompetitive pricing (Chair, 2017). For example, compared to other African countries, SADC countries especially, Botswana, Namibia, Swaziland, Zimbabwe have the most expensive data packages in Africa. The high data cost in the SADC region is attributed to inefficient regulatory policies, lack of competition in both retail and wholesale markets and market entry problems.

Infrastructure Development in Rural Areas

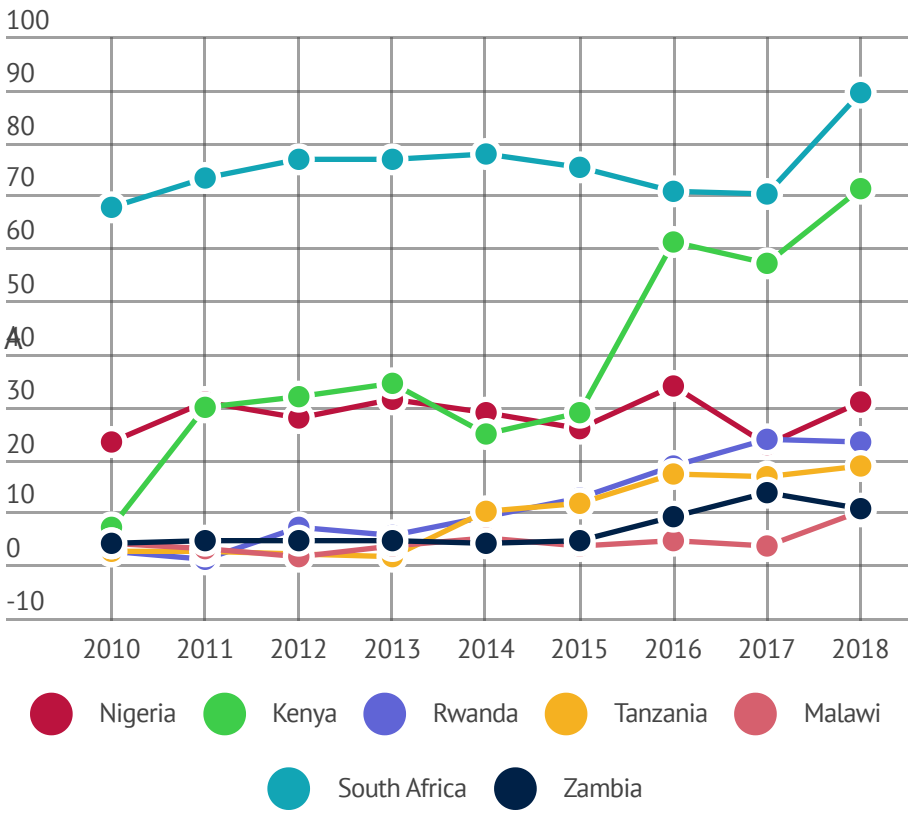


Figure 3.3 % of Rural population with access to electricity Source: World Bank 2018

A World bank study, *Electricity Access in Sub Saharan Africa (2019)* found that in some cases where electricity is actually available, only 57 percent of households chose to connect whilst others preferred to remain unconnected due to the high costs. Rural electrification can act as an enabler, facilitator and driver of digitisation and agricultural growth and rural transformation. For example, China's rural electrification programme in 2018, is considered the leading factor in the increase of farmers income.

Kenya is leading in rural electrification programmes from an initial percentage of 7.1 in 2010 to 71.4 percent in 2018 . It is also leading in electricity production from renewable resources as seen in table 2.0 Agricultural sector growth has also benefited from an increase in agricultural budget sector allocations of 21 percent in 2019/20 financial year.

Boosting rural electrification programmes

Africa is prone to power cuts which limit the use of digital technology and result in poor network coverage. This reduces productivity levels and access to internet-based services. Internet infrastructure requires electricity, presenting a particular challenge for rural dwellers. Modern farming technologies also require electricity which makes digital integration capabilities such as data output, traceability and internet of things (IOT) possible.

The majority of SSA countries are still lagging behind with rural electrification programmes as seen in figure 3.3. For example Tanzania, Malawi and Nigeria are making progress but at a very slow pace. It is critical that governments prioritise both access and affordability of rural electrification, not only to create equal opportunities for growth, but also to enable sustainable production and value addition opportunities in rural areas.

Electricity Production from Renewable sources %	
Kenya	48.2
Austria	16.5
Belgium	20.3
Brazil	12.1
Costa Rica	24.4
Denmark	65.4
Germany	26.3
World	6.8
SSA	2.3

Table 2: %Electricity production from renewable resources Source: World

Low agricultural spending by governments

Agriculture spending in SSA is low compared to other developed regions and is mainly through subsidy programs which often have minimal gains for small scale farmers. However, government investments in public goods such as irrigation have been impactful in increasing productivity. Agricultural R&D is essential but compared to other regions, governments in SSA tend to underinvest with averages of 0.4 of agricultural GDP compared to 1.3percent in Latin America and 0.9percent in South Asia. SSA needs to increase its investments in technological R&D in order to avoid 'playing catch up' in the agricultural revolution.

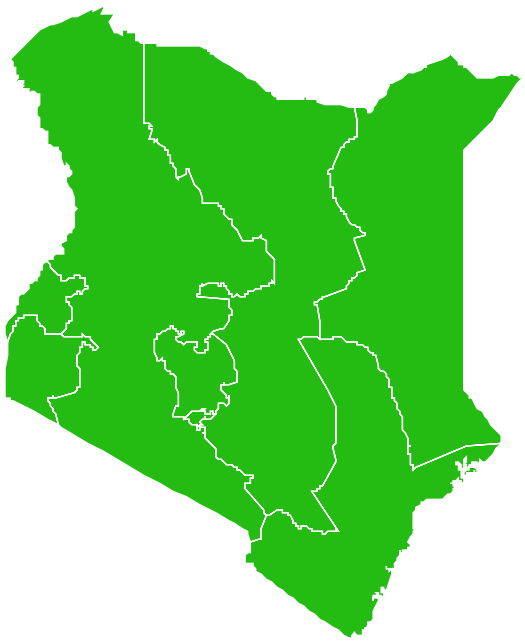
The technological unemployment barrier

The introduction of digital technology might reignite the debate of unintended outcomes like 'technological unemployment' due to economizing labour, which sometimes is inevitable. This outcome is commonly visible in labour absorbing sectors such as agriculture where it is widely anticipated that youth participation could reduce the continent's current high unemployment rate. To create employment opportunities, the majority of the SSA population will require skills redevelopment courses in the ICT sector. Therefore, strong leadership will be required to enable a steady transition for rural communities.

Financing Agricultural Digitalisation

Finance and investment is an example of a digital agricultural enabler, however, high levels of regional variations in investment may result in uneven growth and development. According to the 2017 World Investment Report, five African countries received 57% of the total Foreign Direct Investment in 2016. The level of variation across African countries indicates that investors are still risk-averse and prefer to invest in regions with existing providers and a strong digital ecosystem. As a result, hard-to-reach markets remain underdeveloped, while easy-to-reach markets continue to grow, increasing the digital divide (Tsan, et al., 2019).

To overcome this challenge, investments should be geographically inclusive by developing digital infrastructure in these regions and ensuring its access to smallholder farmers. A major challenge faced with any paradigm shift is the resistance to change. Some farmers may choose to not use digital technologies and be unlikely to pay for digital advisory services raising issues around affordability. Another factor that decelerates the digital process is that most companies are still working on viable business models (Trendov, et al., 2019).



Case Study: Lessons from Kenya agriculture growth success

The agricultural sector in Kenya remains a major player in its economy and a dominant source of employment. The agricultural sector employs 56% of the total population and 70% of Kenya's rural population. Agriculture is also responsible for 65% of merchandise exports in 2017 (World Bank Group, 2019). The data from figure 4.1 below has been adapted from (The World Bank , 2020). The figure illustrates the increasing value that Agriculture, forestry and fishing has added to Kenya's GDP since 2010.

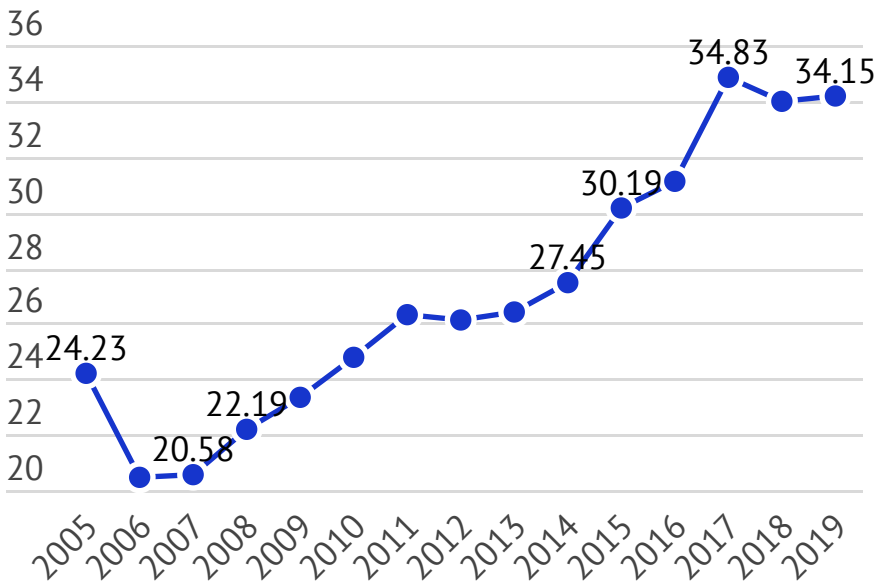


Figure 4.1 Agriculture ,forestry and fishing value adde...

Kenya's agriculture and Digitalisation success

During a time of crisis, the Kenyan government recognizes that an important response for planning and resource allocation is a substantial budget allocation. (Attelah, 2020). Ksh. 8 Billion has been allocated to agricultural projects, as improving food security is one of the big four agendas of the government. The government allocated additional funding in the agricultural and food sector, of Ksh.3 Billion to subsidize farm inputs for 200 000 small-scale farmers through the e-voucher system. The total budget allocation for the Agriculture and Food sector for 2020/2021 is Ksh. 60.7 Billion, which is a 21% increase from the 2019/2020 financial year (Attelah, 2020).

Examples of digital initiatives adopted and developed in Kenya, which can be adapted to support the agricultural sector, are outlined below.

- One Acre Fund (OAF): A flexible loan fund for the procurement and distribution of high-quality farm inputs. The service also offers training on the use of the inputs and assists with market facilitation. The OAF recognizes smallholder farmers' unseasonal and uneven income and therefore allows flexible repayments of as little or as much as they want at any time. Prior to 2014, repayments were made in cash. With the development of M-Pesa, a mobile money transfer platform, loan repayments can be made electronically (Ndung'u, 2018a).
- Water vending machines: Water storage units that release water when users load points onto their smart cards and thereafter swipe their cards to gain access to the machine. Credit can be purchased on-site or using their mobile phones on the M-Pesa platform (Ndung'u, 2018a)
- Mkopa Solar: An affordable solar power programme that assists low-income households to purchase and own their energy system using a one year payment plan (Ndung'u, 2018a).

- Twiga Foods: A program that uses mobile money and logistics to improve food supply chains. It consolidates informal market supply and demand by creating a link between smallholder farmers and informal vendors. As a result of the programme's efficiency, food prices and spoilages are reduced (World Bank Group, 2019)
- Agricultural Sector Transformation and Growth Strategy 2019–2029: One of the nine strategies focuses on digitizing the national subsidy system. It aims to register 1.4 million farming households to allow them access to inputs using an e-voucher system (Malabo Montpellier Panel , 2019).
- Epod: A tool for the agribusiness sector for contract farming, a traceable value chain, payment systems and production technologies to monitor feed activities and record data (Akuku, 2019).

Policy Recommendations

- It is a generally accepted fact that returns on agricultural produce can be increased through agro-processing. For example, agro-processing in Kenya has been limited due to the type of crops produced. Traditionally, most of its exports such as coffee, tea and flowers were not exposed to value addition in the name of 'comparative advantage'. However, Kenya's processed exports, like for the rest of the continent, can be expanded in fruit purees and processed vegetables (World Bank Group, 2019).
- Kenya's GDP, as well as other African countries, can also benefit from improved budget allocations within the agricultural and food sector. Increased investment should be made in agricultural research and development, infrastructure and climate proof strategies. The agricultural sector should increase the adoption of drought-tolerant varieties and increase the efficiency of water management systems by adopting climate smart agriculture.
- Across Africa, researchers and developers should combine farmers' traditional methods and knowledge with scientific knowledge. This will allow for an easier adoption of scientific methods. Small-scale farmers should receive financing to enable participation in digital platforms. Funding should also be made available to encourage the diversification of farming activities. Adoption of digital agriculture will go a long way in transforming the sector and deepening its role in the development of the continent.
- Despite the optimism around the 4IR, Africa like the rest of the world, digital agriculture is still in the initial stages of a productive digital outcome and is arguably yet to experience the digital productivity explosion. In some places, the concept is even yet to be introduced. Therefore, now is the time for governments and the private sector to lay the foundations which will enable productivity and growth in the agricultural sector through the creation of collaborative opportunities.
- The public sector has a huge role to play in ensuring that farmers do not end up on the wrong side of the rural divide by ensuring an inclusive and competitive market. This involves creating a regulatory environment which ensures the reduction in costs of the internet, reduces the import costs of smartphones, enables a competitive market environment against big data tech monopolies, and safeguards farmers data and ownership. Public private partnerships can balance the risk of digital technologies and introduce lower costs in infrastructural acquisitions.
- Government and private funding should prioritise human development and investment towards developing ICT skills and employee training, developing human capital through digital literacy programmes, encouraging youth and women participation through campaigns and university programmes. Private investors and companies will need to code and programme software for mobile apps and create linkages for local and global networking.

Policy Recommendations

- R&D will also be essential to produce, accumulate and analyse large datasets to develop adaptable and sustainable technological solutions. These are key factors which facilitate the effective adoption and use of digital technologies in the communities.
- Equally, basic services need to be created to facilitate a more inclusive digital infrastructure particularly for the rural population and ensure access to reliable sources of electricity and internet connection. Government ministries of Agriculture should also have data officer centres to assist with the registration and networking of farmers for subsidy programmes and access to finance packages.
- Data cooperatives should be encouraged to ensure that farmers have additional power and access over their data. For an accelerated transformation, investors should also incentivise product designing and prototyping, sharing lessons learned including success and failed practices, and support policies with strong data protection measures that prioritise privacy and consumer protection such as digital identity.

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