AFRICAN DEVELOPMENT BANK GROUP
GROUPE DE LA BANQUE AFRICAINE DE DÉVELOPPEMENT

Food and Agriculture Organization of the United Nations

Alliance
Bioversity International
CIAT
International Center for Tropical Agriculture

CGIAR
Platform for Big Data in Agriculture

Digital Agriculture Profile
• South Africa

HIGHLIGHTS

South African agriculture is a highly profitable and dominated by exports, which accounted for R104 million in 2017/2018.

There are several opportunities for digital agricultural solutions to substantially increase resource use efficiency, profitability, transparency, market participation, and environmental sustainability.

The three major bottlenecks to scaling digital agricultural solutions in South Africa are limited network coverage, exorbitant data costs, and low digital literacy. Additionally, there is a notable digital divide between wealthy large-scale farmers and smallholders.

Mobile platforms, vehicle tracking, database technology, and blockchain technology **are the most promising technologies** for creating digital solutions in South Africa.

The private industry, non-profit organizations, public sector, and international community all have important and distinct roles to play in creating sustainable digital agricultural solutions in South Africa.

67%
OF RURAL INHABITANTS HAVE ELECTRICITY

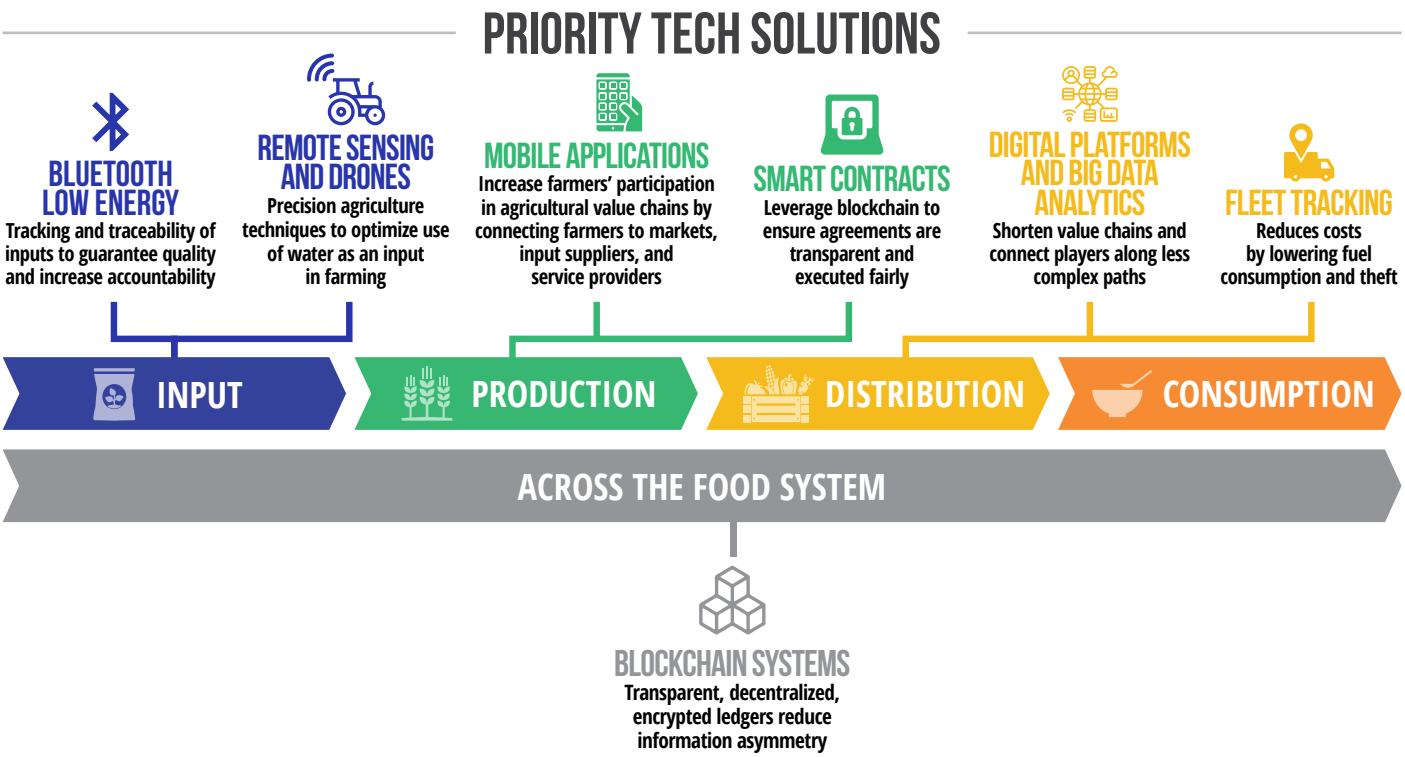
SOUTH AFRICA RANKS **46TH** IN THE WORLD ON THE INFORMATION COMMUNICATION TECHNOLOGIES DEVELOPMENT INDEX

56% OF SOUTH AFRICAN RESIDENTS USE THE INTERNET

MOBILE PHONE SUBSCRIPTION PENETRATION RATES ARE OVER **100%** MEANING ABOUT HALF THE POPULATION HAS MORE THAN ONE SUBSCRIPTION

SMARTPHONE PENETRATION RATES ARE **80%**

AT **US$10.40/GB** SOUTH AFRICAN DATA COSTS ARE SOME OF THE HIGHEST IN AFRICA



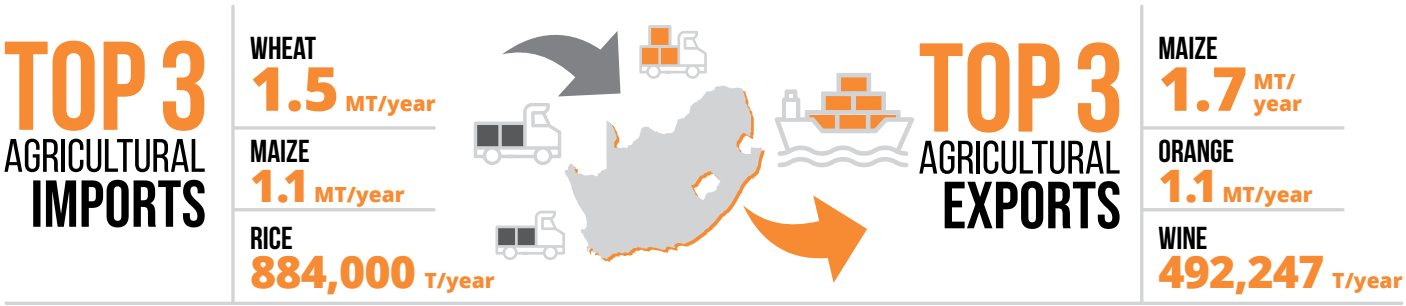
Introduction

South Africa has the second largest economy on the continent. The 2018 GDP was US$366 billion, to which the agriculture sector contributed approximately US$2.1 billion. The portion of the GDP coming from agriculture has been steadily decreasing as other sectors have emerged and diversified over the years. However, the total value of the sector has increased six-fold from 1970 to 2018. South Africa's numerous regional exports have earned it the reputation of being the bread basket of the region.

There are approximately 2.5 million smallholder farming households in South Africa and 35,000 commercial farming units (Aliber et al., 2013). South Africa's agri-food system is sophisticated, yet nearly 11% of the population experienced hunger in 2018 (Department of Statistics 2019). There are major inefficiencies and inadequacies in the agricultural value chain, particularly for smallholder farmers. Near-universal smallholder issues include low access to basic services, reliance on rainfed crops, inconsistent policy enforcement, low capacity and knowledge-sharing, and climate variability and change. Additionally, producers face challenges specific to their particular crops, livestock, and region. Other value chain actors, such as distributors, retailers, processors, packaging plants, and consumers, also grapple with common problems; some of these include quality and safety of products, traceability of produce, cost of transport and cold chains, and matching supply with demand.

Digital solutions have shown potential, both in the region and in comparable agri-food systems, for addressing similar issues by aggregating access to services, inputs, information, and markets. Digital agriculture includes the use of digital technologies, big data, and business model innovations to transform practices across the agricultural value chain with the ultimate goal of improving agricultural productivity, market access, financial management, supply chain management, and post-harvest handling (Tsan et al., 2019). Digital solutions have the potential to create more efficient agricultural value chains by decreasing costs, increasing decision support, reducing loss, and improving sustainable resource use efficiency. While digital technologies are not applicable to every challenge faced by agricultural stakeholders, there is considerable scope for spurring sustainable economic growth and inclusion in the sector via digital agriculture.

The Digital Agriculture Profiles are knowledge and policy advisory products of the African Development Bank's Digital Agriculture Flagship. The profiles for Côte d'Ivoire, South Africa and Rwanda join a series of similar inter-organizational guides, first conceived by the World Bank which also include countries such as Argentina, Grenada,

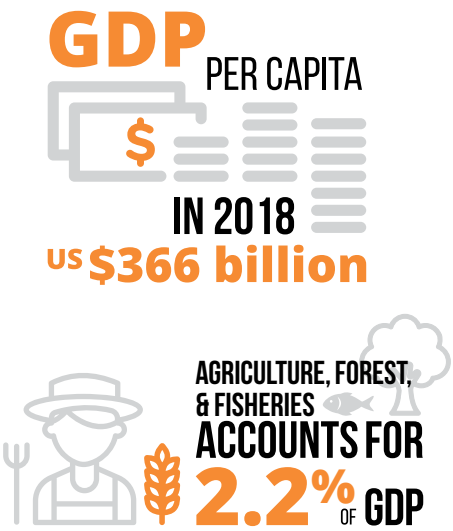


Turkey, Kenya and Vietnam. This Digital Agriculture Profile for South Africa leverages the expertise of stakeholders to evaluate the current landscape of digital agriculture in the country, including key players across the value chains, the main barriers they face, and the potential to overcome those barriers through the adoption of innovative technologies. In identifying and prioritizing these technologies, we aim to support investors and implementers in maximizing their impact by focusing on the opportunities of highest potential.

National Context

Economic relevance of agriculture

South Africa's economy is largely based on manufacturing, services, and mining. The national GDP of US$366 billion (World Bank 2018) makes South Africa the second largest economy on the continent. The portion of the GDP coming from the Agriculture, Forest, & Fisheries sector has been steadily decreasing, from 11% in the 1960s to a current 2.2%, as other sectors have emerged and diversified. Nevertheless, the total value of the sector has increased six-fold from 1970 to 2018. Furthermore, when taking the entire value chain into account, the contribution of Agriculture, Forest, & Fisheries to GDP rises to 12% (FAO, 2016). South Africa's agriculture sector was liberalized as part of national democratization in 1994. The deregulation of prices, import controls, and market controls left the agricultural economy largely influenced by international markets and exchange rates, local production and consumption, production in the South African Development Community, and local and international stock levels (DAFF, 2017).



Export accounts for a large portion of agricultural GDP, and South Africa's numerous exports have earned it the reputation of being the bread basket of the region. In 2013, South Africa was a net exporter of primary agricultural products and a net importer of processed agricultural products (FAO, 2016). The top three destinations for agricultural exports were the Netherlands, the United Kingdom, and Zimbabwe; imports primarily originated in China, Brazil, and Argentina. Based on 2014-2017 averages, the top three agricultural exports by volume were maize (1.7 million tonnes), oranges (1.1 million tonnes), and wine (half a million tonnes). The top three exports by value were wine (US$740 million), oranges (US$630 million), and grapes (US$497 million) (FAO 2016). The citrus sector alone exported approximately 2 million tonnes of produce valued at US$1.4 billion in 2017. South Africa was the seventh largest producer of wine in the world in 2016 (DAFF, 2017), and the wine industry employs approximately 270,000 people either directly or indirectly.

As a whole, around 5% of the South African population is employed in agriculture; this is less than half the percentage in 2002 (World Bank 2018). An estimated 8.5 million people directly or indirectly rely on the sector for income. The Department of Agriculture, Forestry and Fisheries of South Africa has long recognized the potential for the agricultural sector to

contribute to job creation, improve food security and economic growth.

Agricultural production systems

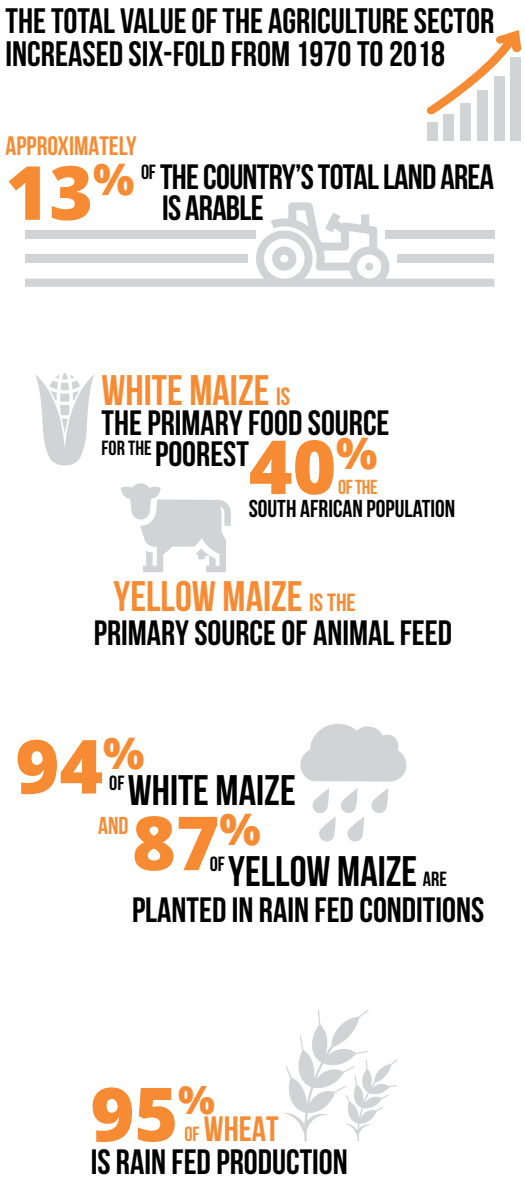
South Africa's 122 million hectares feature a range of agro-ecological zones, including Fynbos, Savanna, Grassland, Nama Karoo, Succulent Karoo, Forest, and Albany Thicket. Each of these has unique rainfall patterns, and consequently specific rainfed agricultural seasons. Such diversity allows for the production of a number of different agricultural commodities. Agricultural and pastoral activity occur across all of these zones. Winter and high summer rainfall regions are used for intensive crop production, while arid regions are preferred for sheep and cattle. Approximately 13% of the country's total land area is arable (World Bank 2018). The primary crops by volume per year include sugarcane (17 million tonnes), maize (12 million tonnes), potatoes (2.3 million tonnes), grapes (1.9 million tonnes), and wheat (1.7 million tonnes).

Maize is vital not only as an export, but also as a staple food crop and as livestock feed. White maize is primarily used for human consumption, and is the primary source of nutrition for the poorest 40% of the South African population (Kirsten 2012), while yellow maize is generally for animal feed. 94% of white maize and 87% of yellow maize are planted in rain fed conditions. Every province produces maize. The Mpumalanga, North West, and Free states are particularly prominent producers, and collectively account for 1.7 million ha of rainfed maize and 147,000 ha of irrigated maize annually.

Wheat is also an important crop, and is primarily produced in the Western Cape of the Free state. Approximately 420,000 ha of wheat are under rain fed production, and 29,000 ha are irrigated. KwaZulu-Natal is the dominant sugar-producing state with approximately 200,000 ha of rainfed sugarcane annually. The *Aspalathus linearis* plant, from which rooibos tea is produced, is endemic to the Fynbos agro-ecological zone in the Western Cape. The Western Cape and Northern Cape feature just under 100,000 ha of wine vineyards.

People, livelihoods, and agriculture

The current population of South Africa is approximately 55 million, with 19.4 million people (~35%) living in rural areas and the remaining 35.5 million in urban areas (World Bank 2018). By 2050, as much as 80% of the population will be urbanized (Mlambo, 2018). Gauteng province is the national economic hub, and receives high numbers of both international and internal migrants seeking employment.



South Africa scores relatively well on development indicators. Nevertheless, these scores are the average of remarkable disparities. South Africa ranks 1 out of 149 countries in terms of overall inequality (NPR.org 2018). High income inequality is part of this metric; the country scores 0.63 on the Gini coefficient scale (a value of 1.0 represents absolute equality). This places the country as the 113th most equal worldwide in terms of income. Within the South African Development Community it is outranked only by Botswana, the 101st most equal. In 2017 the top 10% of earners in South Africa received about 65% of total income, while the lowest 50% of earners accounted for just 6.3% of total income (World Inequality Database 2017). Approximately 19% of the population falls below the international poverty line of US$1.90/day; this represents an increase in poverty rates from 2010, when 16.5% were below the international poverty line (World Bank 2018).

Life expectancy at birth is 63.5 years, second in the region only to Botswana (68.8 years). South Africa experiences

relatively high incidences of communicable diseases like HIV and Tuberculosis. The public healthcare system is a focus of government, which spent 11% (R157 billion) of the national budget on healthcare in 2014/2015. Only 17 in every 100 South-Africans have medical insurance. There are several challenges faced by the public heath care sector in South Africa, including under-staffing and poor maintenance.

Urban electricity access has been steadily increasing since the 1990s and is now at 93%. Electricity access in rural areas has declined by nearly 10% from 2014-2019, and now stands at approximately 67% (World Bank 2018). As of 2015, 85% of the population had access to basic drinking water services, and 73% had access to basic sanitation services.

The 2015 literacy rate was 99% for youth aged 15-24. Only 82% of the population aged 25+ had obtained a primary education as of 2016 (World Bank 2018). Education in South Africa has made strides in recent years. Pre-school attendance has increased from one in ten in 2002, to one in three in 2018 (Stats SA, 2019). Secondary school attendance comes in at 90%. However, matriculation of high school remains a challenge, largely due to barriers associated with poverty. Approximately 25% of the high school cohort will drop out before matriculation.

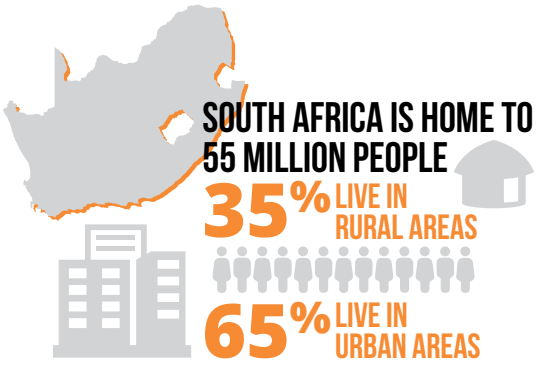
There are tangible links between agricultural activity and vulnerability to insecurity as a result of climate variability and change. Gauteng and the Western Cape are the two most developed and urbanized provinces, and are the least vulnerable to climate change. On the other hand, Limpopo and the Eastern Cape are the most climate-vulnerable. These two provinces have the lowest literacy rates, the highest unemployment rates (Gbetibouo et al. 2010), and the greatest numbers of smallholder farmers. Large-scale South African producers are extremely powerful; 35,000 commercial farming units occupy 14 million hectares (Aliber et al., 2013).

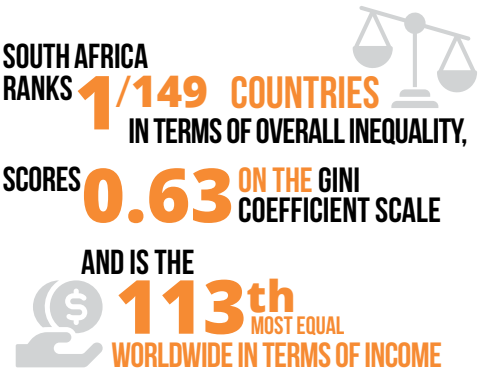
Challenges in the agricultural sector

Challenges for South African agricultural producers vary greatly across crops, livestock and regions. However, there are several outstanding cross-cutting issues, including:

Aging farmer population

The average South African farmer is over 60 years old. Rapid youth urbanization has occurred as young people disengage from family farms to seek out viable careers and opportunities for personal growth. Farming is largely seen as a survival profession rather than a family business that requires knowledge and expertise





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in agronomy, finance, marketing, and risk management. Nevertheless, nationally, 55% of youth and 27% of the potential labor force were unemployed in 2018. This massive unemployment gap represents a great opportunity for transforming the agricultural sector to one that offers career and growth opportunities that young South Africans desire.

Lack of access to finance

Farming is a business of high initial investment with the expectation of a single large return at the end of the growing season. As such, access to financial services to support the up-front cost is a prerequisite to successful farming, and operating without financial services is a formidable barrier to upscaling (Strategy for Agrarian Transformation, 2015). Often smallholder and emerging farmers do not have the title deeds to the land that they cultivate. This makes accessing financial services difficult, and makes it unlikely that farmers will invest in the land. Low value chain access and poor record keeping further reduce smallholders' access to financial services.

Overstretched and under-resourced extension staff

The Department of Agriculture, Forestry, and Fisheries of South Africa extension agents are often said to be overcommitted, as anecdotally reinforced during the workshops in the country. New agricultural census results are set to be released in 2020. In the meantime, the 2007 statistics report 2,210 extension officers in the whole country (DAFF, 2009). This implies a ratio of 1,147 farmers per extension agent, versus the recommended ratio of 800:1 (Feder, Ganguly, and Anderson 2006). As a result of this understaffing, farmers experience difficulties in accessing information on e.g. best farming practices, inputs, markets, weather, seasonal calendars, and adapting to climate change. Such basic information is imperative to the success of farm management, and may be a major barrier to emerging farmers scaling up their operations.

Lack of access to knowledge and training

Related to the limited access to extension services is low farmer access to knowledge sharing platforms and initiatives. Commercial farms can generally afford premium services beyond those offered by the government, and have liquidity to invest in recommended innovations aimed at increasing yield and profit, such as precision agriculture and sensors. Smallholder farmers, on the other hand, are often geographically remote, with little network coverage, and with very limited funds to invest in services or innovations. As such, they rely on understaffed extension services provided by the government, and consequently face a dearth of accessible, relevant, practical information to share, as well as few or no opportunities for expanding their capacities.

Drought and scarcity of water resources

South Africa is a water-scarce country with unpredictable and unevenly distributed rainfall (Goldin, 2010). Some regions receive less than 100 mm of rain annually (FAO, 2016). The agricultural sector consumes 60% of all available water (von Bormann and Gulati, 2014). In addition, the country has been enduring droughts since 2014, most notably in the Western Cape, which contributes about 22% of the national agricultural GDP. Over US$338 million has been lost in the Western Cape agricultural economy due to drought (Kalaba 2019). This decreased food production threatens not only livelihoods but also the nutritional security of smallholders. The parched rangelands have forced livestock owners to purchase feed, leaving them heavily in debt. Cape Town narrowly escaped being the world's first major city to run out of water. The Northern Cape has also been experiencing droughts, with the worst in a century currently devastating the province.

Climate variability and change

Climate change is expected to reduce overall precipitation in western South Africa and increase the incidence of severe weather events—both floods and droughts—throughout the southwest (Niang et al., 2014). The hot desert zone is projected to expand into the Northern Cape, in part due to drastic temperature increases in the western interior of the country (Engelbrecht and Engelbrecht, 2016). Because the vast majority of agriculture is rainfed, farmers have long relied on rainfall to mark the beginning of the growing season. Recent increased variability and shifts in precipitation patterns make the already volatile rainfall of South Africa more difficult to predict with accuracy, even for farmers who are aware of climate change impacts. As the probability and predictability of certain weather patterns decreases it will become increasingly difficult to maintain livelihoods that depend on natural systems.

Lack of participation in the value chain

South Africa's agricultural value chain tends to favor large commercial farmers with access to sophisticated technology (Aliber et al., 2013). Poor infrastructure makes it difficult for smallholders to transport their produce to marketplaces and retailers. Farmers might also be geographically far from transport networks or unable to afford the cost of transport. A dearth of market information is another obstacle to farmers entering the value chain (Khapayi and Celliers, 2016). The limited size of smallholders' plots preclude them from benefitting from economies of scale. Meanwhile, large-scale value chain participants (e.g. retailers, insurance companies, banks, traders, millers) control most of the flow of funds (von Loeper et al., 2016). Aggregation of services and inputs would enable more smallholder and emerging farmers to leverage economies of scale to enter the value chain.

Postharvest food waste

Of all the food intended for human consumption in South Africa, approximately 34% is wasted (von Bormann and Gulati, 2014). The majority of this waste occurs between the farm gate and the consumer-- during handling, storage, processing, and distribution. At the same time, the percentage of undernourished people in the country has been steadily rising since 2011, and reached 6% in 2017 (World Bank 2018). In addition to human food insecurity, food waste is also a loss in terms of economic growth; productive alternative uses such as animal feed; and the money, water, and energy resources used to dispose of food waste. Preventing postharvest losses is thus a remarkable opportunity to increase national food security, expand the agricultural economy, and maximize resource use efficiency.

Current landscape of digital tools and policies

End-user diversity and demand

Digital agriculture end users may be grouped into four hubs. Each hub has unique challenges for which digital agriculture could offer solutions, and each has a unique set of resource and needs in terms of digital agriculture. The hubs are not mutually exclusive; any given individual may function within multiple end user hubs.

The **Input Hub** includes all actors providing agricultural inputs, such as seeds, feed, agrochemicals, machinery, and finance. Challenges facing this hub in South Africa include a lack of relevant decision support tools and poor monitoring and traceability of inputs.

The **Production Hub** includes crop farmers and livestock keepers. Producers face a lack of decision support tools, financial services, and market access, as well as high initial investment risks compounded by climate change.

The **Distribution Hub** consists of all actors in the value chain between the producer and the consumer, including traders, transporters, processors, and retailers. Frequent challenges in this hub include poor market access, minimal value-addition, high costs, high inefficiencies, and high postharvest waste.

The **Consumer Hub** includes consumers of both raw and processed agricultural products—in effect, the entire population. The primary challenges faced in this hub are a lack of purchase decision support tools, food waste, poor market access, and food quality and safety.

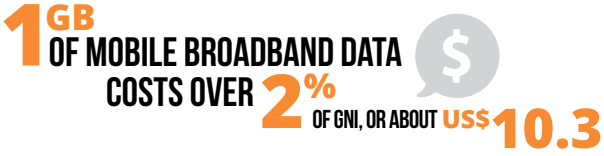
Digital infrastructure, availability and access

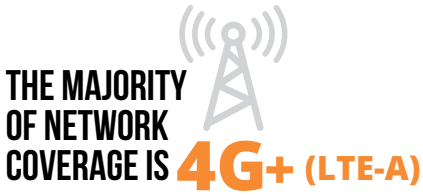
South Africa's supply-side strengths in terms of digital infrastructure, availability, and access include favorable policies, strong investment, and good Internet bandwidth and connectivity provision. The Global Connectivity Index ranked South Africa 46 out of 79 countries in 2018.

Opportunities for improvement include improved 4G coverage and investment in IoT and fiber optic infrastructure (Huawei, 2018). The cost of Internet data is also a major opportunity for improvement. It is prohibitively expensive for most individuals to operate a smartphone in South Africa. The Competition Commission describes South Africa's data costs as "anti-poor". 1GB of data costs approximately US$10.37, which amounts to 2.2% of Gross National Income. (Alliance for Affordable Internet 2018). This puts even minimal data usage out of economic reach for a large portion of the population.

The high cost of mobile data is primarily due to the governmental restriction of radio frequency spectrum. Delays by the government in releasing new spectrum have been a challenge for several years. In addition to driving up costs, spectrum restrictions have significantly hindered growth. An additional source of cost is the growing trend in the theft of high-value cellular tower batteries and, and presented barriers to implementing Internet of Things standards in the country.

While fiber optic capability is available, there is a gap between urban and rural Internet access. Network coverage maps show good coverage around cities and towns, and large swathes of rural areas without cellular data networks. The primary network providers in South Africa include MTN, Vodacom, Cell C, Rain, and Telkom.





The majority of network coverage is 4G+ (LTE-A), but there are also areas of 2G, 3G, and 4G (LTE) coverage. LTE offers average download speeds of 10-25Mbps. LTE-A, sometimes called 4.5G, offers average download speeds of 20-40Mbps but cannot be received on a normal LTE router. 2G coverage is low cost, and the cost of devices that connect to 2G networks are concomitantly low. Many people rely on 2G services to communicate due to the low cost. However, some providers, including Vodacom, have plans to phase out 2G and redistribute the spectrum to improve 4G coverage over a period of several years, providing users time to upgrade their devices.

Demand-side strengths include mobile broadband subscriptions, smartphone penetration, and cloud migration. 56% of South African inhabitants used the Internet in 2017 (World Bank 2018). Smartphone penetration is over 80%, and mobile phone subscription penetration is in excess of 100%; there were 153 active mobile subscriptions per 100 people in 2018 (Independent Communications Authority of South Africa, 2019).

Demand-side opportunities include fixed broadband subscriptions, eCommerce transactions, and analytics data creation. There is particularly high potential for big data and data analytics to deliver both economic gains and market development. South Africa lags behind the rest of the world with regard to numbers of software developers, ICT patents, and R&D investment (Huawei, 2018).

Institutions and policies for Digital Agriculture

There are many organizations engaged in digital agriculture in South Africa, including corporations, government agencies, start-ups, universities, and research institutes. In many cases digital services are created through partnerships between research, public, and/or private organizations. Digital solutions for smallholder and emerging farmers are most often led by government, non-profit organizations, or research institutions. While the private sector tends to spearhead solutions for commercial farmers who have the capacity to compete internationally in terms of yield, quality, and profitability. In this regard there is opportunity for a more coordinated effort that would leverage shared resources and reduce duplication of efforts.

Institutions

Several South African universities are engaged in developing digital agricultural solutions with stakeholders across all four hubs. The University of Stellenbosch's Faculty of AgriSciences collaborates with AgriColleges to provide services. The University of Johannesburg Technology Lab and the Elsenburg Agricultural Training Institute at the Western Cape Department of Agriculture have developed service platforms, and The University of the Free State conducts research on the feasibility of digital field management solutions in South Africa. The Agricultural Research Council, a state-owned research institution, also provides digital service platforms. Various other institutions are involved in developing and scaling digital solutions, such as the non-profit organization AgriSA, the Grain SA producers' organisation, and the South African Organic Sector Organisation.

The buying power of commercial farmers has encouraged several companies to offer or endorse digital agricultural solutions. For example, the citrus industry is largely export driven and is highly engaged in digital agriculture to maximize production and adhere to international export standards. Monsanto is scouting areas of South Africa in which to roll out a subscription-based software platform. Cutting-edge equipment, such as John Deere and Massey Ferguson precision tractors, are readily available in the country.

Government policies

While buying power has been the primary driver of digital agriculture in South Africa, policy has also driven digital innovation. For example, farmers must be registered for VAT and the Customs and Excise Act and prove their lawful consumption of diesel fuel in order to receive the 80% diesel fuel rebate. Smart tractors can automatically track diesel use and record it directly in the rebate application documents. Such integration between digital solutions and policies both encourages farmers to advance towards technology adoption and enables them to fully leverage policy benefits.

The Department of Agriculture, Forestry, and Fisheries Strategic Plan for 2015-2020 aims to increase employment, achieve food security for all, and protect and enhance environmental assets. Recent efforts to tackle the high cost of data have included amendments to the End-User and Subscriber Service Charter Regulations that prohibit mobile operators billing subscribers for out-of-bundle services once a data bundle is depleted. The amendments also make depletion notifications and unused data roll-over mandatory. These policies were an important step towards increasing the accessibility of data, particularly for users with less buying power.

The Department of Agriculture, Forestry, and Fisheries offers multiple higher education grants, internships, and scholarships. There is significant opportunity for government to partner with institutions to promote the engagement of youth in digital agriculture topics, such as programming, remote sensing, and GIS, among others. The department also offers emerging farmers the resources needed to enter commercial farming through the governmental land redistribution scheme (MacLeod, McDonald, and Oudtshoorn 2008).

Local agricultural entrepreneurship networks in South Africa are well supported by incubators, allowing for partnership formation and successful and impactful engagement along the agricultural value chain. Small- and medium-sized agricultural enterprises have several agriculture-based incubators at their disposal, including Mobile Agri Skills Development and Training Incubator (MASDT), Timbali Technology Incubator, SEDA Agricultural and Mining Tooling Incubator, and BioPark Business Incubator, among others. International incubators operating in South Africa include the Google Launchpad Accelerator Africa and the Global Cleantech Innovation Programme for SMEs. These incubators offer agricultural entrepreneurs advice and the network and access to resources imperative to maintaining a business.

Some policy distortions have limited the growth of the agricultural sector and, consequently, the feasibility and uptake of digital agricultural solutions. For example, subsidized inputs to smallholder and emerging farmers may be provided too late in the season to be effectively used to increase yields or improve practices. When producers are unable to take advantage of the full growing season, their livelihoods are put at risk, and the Distributor and Consumer Hubs are also compromised.

Digital agricultural services and applications available

There is a wide array of digital services and technologies available to farmers in South Africa. The most common digital solutions address credit applications, instructional resources, market and inputs access, decision support, field management, and data management. In many cases, multiple services are integrated into a single platform. The following are some prominent examples among the many current digital agriculture initiatives in South Africa.

Agronomy instruction

- The University of Stellenbosch's Faculty of AgriSciences collaborates with AgriColleges to provide online short courses.
- The Agricultural Research Council provides agricultural and livestock training through their website.

Precision field management

Precision agriculture uses satellite and/or drone imagery to analyze crops and optimize inputs. Precision agriculture is offered by many companies in South Africa, and is a topic undergoing much research at universities and institutions. Its popularity is due primarily to the potential to dramatically reduce costs and increase resource use efficiency. For example, remote sensing could save nearly US$ 9 million per season for citrus, macadamias, wine, stone fruit, table grapes, and pome fruit alone (GreenCape 2018). Precision agriculture can directly inform digitized farm records via Internet of Things (IoT) integration. Digitized records, in turn, open up the possibility of using big data analytics and leveraging farm operations to establish credit.

- Aerobotics, a South African ag-tech company, has received investment from one of the country's largest commercial banks, Nedbank, to develop a precision pesticide application product to ensure compliance with export standards.
- The University of the Free State is conducting research on the feasibility of precision agriculture solutions for the South African context.
- Monsanto is scouting areas in the country in which to roll out Climate Field View, a software platform for digital farming that offers data-informed precision

farming decision support for a monthly subscription fee.

- John Deere and Massey Ferguson precision tractors are readily available in South Africa, and crop-spraying drones have recently become legal.
- Much of the agricultural equipment in the field is analogue. Partial digitalization is a cost-effective way to enable farmers who own legacy machinery to leverage the advantages of digitization. Agricultural equipment can be retrofitted with Bluetooth transmitters and GPS systems that gather and transmit data to a mobile phone or computer.
- Aerobotics uses drone and satellite imagery, along with artificial intelligence, to monitor the health of orchards, detect disease, and provide advisory services on managing potential issues.

Crowd farming

- Many people recognize the value of agricultural business, but lack the land, skills, capital, time, or desire to fully invest themselves in farming. Crowd farming allows anyone to invest any amount in an agricultural venture and reap the profits, much in the same way stockholders invest in companies.
- Impact Farming, created by Fedgroup, offers crowd farming in blueberries, apiaries, and urban solar farms.
- Livestock Wealth is a platform that allows investment in cattle managed by professional farmers. Livestock Wealth has partnered with retail giant Woolworths to supply free-range beef.

Input and services aggregation

Aggregated input purchasing and product supply allows smallholders to benefit from economies of scale.

- Khula is a mobile app that connects smallholder and emerging farmers with the formal marketplace. The app allows farmers to list their produce, track real time inventory, and satisfy market demand.

Extension services

- The Agricultural Research Council aims to bridge the information gap between researchers, extension workers, and farmers. To this end, they provide agricultural and livestock training through their website, as well as the ARC Hub app, which provides early warnings and daily operations management information for smallholder and commercial producers.
- Connected Farmer is a cloud-based service developed by Vodacom wherein farmers can access extension services, market prices, and weather forecasts, as well as purchase inputs with SMS vouchers.
- Monsanto's platform for smallholder and emerging farmers, FarmRise, has yet to be introduced in South Africa. There is a possibility that it will follow the implementation of Climate View Field, Monsanto's precision agriculture product that is being piloted in South Africa.
- The National Emergent Red Meat Producers' Organization (NERPO) aims to improve emerging farmers' access to information, finance, and technical support, and to commercialize the sector to ensure meaningful participation of black individuals in agribusiness. NERPO, Vodacom, and the German Development Cooperation are partnering to create market linkages for smallholder farmers using an innovative ICT solutions project. The mobile platform will provide digital advisory services on inputs, logistics, operations, climate variability, and breeding stock. The app also aims to move farmers to digital record keeping. The platform pilot will initially be licensed to 200 farmers for 12 months, and there are plans to scale out in 2020. Such digital operation records can also help farmers access financial services.

Market and input value chains

- The Farmer2Market project prepares smallholder and emerging farmers to access high-value markets by offering training on food safety standards and good agricultural practices. The project is funded by the EU in partnership with the Department of Environmental Affairs and the international NGO Solidaridad.
- AgriProtein recycles organic food waste as part of insect-based feed for aquaculture and similar industries.

Tracing and certification

- The South African Organic Sector Organization is working to create blockchain solutions to enable digital certification of organic produce, formalized land tenure, smart contracting, digital farmer profiles, and produce source traceability.

Challenges for digital agriculture

The three major bottlenecks to scalable digital agricultural solutions in South Africa are network coverage, data cost, and digital literacy. The cost of data is consistently one of the highest in the region. Many rural areas do not have network coverage. These two factors limit adoption of mobile technologies, thus perpetuating low digital literacy. For example, many proposed digital extension services rely on video, which is inaccessible to rural areas in terms of both connectivity and digital literacy. Expansion of 4G and 4G+, along with opportunities for

stakeholders across all hubs to develop digital literacy through public education and extension programs, would significantly reduce these limitations and pave the way for profitable digital solutions in agriculture.

Once these barriers are removed, secondary issues will begin to arise as digital agricultural solutions proliferate. The technical capacity to design, develop, and manage digital services will be increasingly in demand. Educational institutions will have the opportunity to expand their offerings of courses and training that focus on skills such as programming, data analysis, blockchain, and entrepreneurship. Similarly, increasingly high processing power and server storage will be needed as vast amounts of data are produced by digital agriculture.

Data ownership and protection laws will also be necessary to ensure trust and transparency across the value chain. Stakeholders are often wary about how their information might be used, and yet this data is irreplaceable in terms of value chain integration and the development of tailored solutions to agricultural challenges. Some services, like Monsanto's Climate View Field, address farmers' concerns directly by guaranteeing that farmers retain ownership of their data. However, this may not apply to data that does not have copyright protection (Wiseman et al. 2019).

Enabling Digital Agriculture

Technologies with greatest potential

A group of in-country representatives across all four hubs participated in several workshops as part of the development of this Digital Agriculture Profile. The workshop participants identified the following as the most promising technologies for addressing solutions to the problems currently faced by South Africa's agricultural sector.

For the **Input Hub**, tracking, traceability, remote sensing, and online platforms are the most promising technologies:

- Bluetooth Low Energy (BLE), also known as Bluetooth Smart, is a type of wireless communication with a range of more than 100 m that is particularly useful for input asset tracking. The technology has the potential to increase traceability of inputs, which will allow farmers to ensure the quality of inputs such as seed, fertilizer, and pesticides. BLE is set to overtake radio frequency identification (RFID) as the most used technology for tracing inputs.
- Remote sensing, drone imagery, and artificial intelligence as part of precision agriculture make for a more efficient use of field inputs.
- Online platforms created in collaboration with the government offer an opportunity for better coordination between agricultural departments and farmers. The government already offers the delivery of inputs to smallholder and emerging farmers but at times, poor timing of input supply can lead to farmers failing to plant at the start of the season. An online platform could solve the problem of coordinating input supply with farmers.

For the **Production Hub**, mobile platforms and accessible networks are most promising:

- Mobile platforms that connect farmers to markets, input suppliers, and service providers—particularly advisory and finance services
- Integrated climate and weather forecasting, particularly in terms of South Africa's propensity toward drought
- Online training in agribusiness, agri-processing, and farm management targeting youth seeking viable career opportunities
- Low power, wide area network solutions are needed to allow farmers to collect data from IoT[1] sensors, such as those for weather, soil, and livestock. For example, LoRa[2] can be used under low network coverage, without the prohibitive cost of mobile data, and without high energy input.

In the **Distribution Hub**, technologies that enable tracking are key:

- Vehicle tracking has been highlighted as a technology that could mitigate theft of agricultural goods and fuel in transport, as well as decrease the cost of transport by identifying the most efficient routes and driving styles. Lowering the cost of transportation, in turn, increases accessibility to markets for smallholder and emerging producers. Vehicle tracking uses GNSS[3] for geo-location and GSM[4] or satellite for real-time communication. Several IoT[5] systems are also available for functions such as temperature sensing in vehicle fleets. This technology is highly profitable and is already being brought to scale; uptake in the next decade is expected to be near 100%.

1 Internet of Things
2 low-power wide-area network technology
3 global navigation satellite system
4 global system for mobile communications
5 Internet of Things

- Similarly, database technologies, barcoding, and IoT solutions would enable tracking and traceability of agricultural products. This allows for more efficient value chains that can move produce more quickly from farm to consumer, offer information transparency to all stakeholder hubs, and minimize barriers to farmers engaging in the value chain.

For the **Consumer Hub**, blockchain technologies would transform the supply chain through simplification and accurate traceability of products:

- South African consumers are wary of low-quality inputs resulting in low-quality products. Traceability offers consumers product transparency, and offers producers the opportunity to charge premium prices for the additional cost of high-quality products in niche markets. In addition, product recall of poor quality or contaminated food would be near instant, and consumers could rely on players in the value chain to supply safe food. Current blockchain pilots have begun to scale, and the technology is expected to reach most target users in the next 10 years.

Potential enabling policies for digital agriculture

Two of the three bottlenecks currently limiting digital agriculture solutions in South Africa—data costs and network availability—are best resolved through policy approaches. New spectrum sales, in coordination with telecommunications regulations, would largely remove these barriers. Migrating from analogue to digital broadcasting would free up significant spectrum. The emergence of digital agriculture has brought accelerated data generation, thus creating a need for comprehensive legislation that protects all key stakeholders, particularly the generally vulnerable smallholder farmers. Both central and local government have a unique role to play in ensuring fair regulations on data ownership, privacy, and dissemination.

Advances in digital technologies typically have applications across multiple sectors; for example, there is significant opportunity to prioritize digitalization in national agricultural policy and strategic plans with an emphasis on cross-cutting impacts. Additionally, South Africa's current drone policy requires lengthy and expensive licensing processes, resulting in 99% of drones users operating without a license. Streamlining this process would improve the efficiency and scalability of precision agriculture technologies, as well as increase government licensing profits.

Finally, there should be more initiatives from the government to make data findable, accessible, interoperable and reusable (the FAIR principles of data). Much governmental data is in PDF form and is not available online or is not well archived.

Potential avenues for the public sector

The scarcity of natural resources in South Africa, particularly water and arable land, has resulted in a push from policy makers, producers, and consumers for agricultural systems that are more sustainable. Retailers are pushing suppliers to adhere to strict standards of health, safety, and sustainability. While this has created additional challenges for resource-constrained smallholders, it also represents a well-supported opportunity to prioritize public capital for establishing sustainable systems.

There are significant untapped synergies across national and regional information sources. Most state agricultural websites are highly informative in terms of agronomic practices. These websites could be further leveraged to (1) raise awareness and realistic expectations of what digital solutions offer agriculture—both in terms of potential and limitations, (2) offer digital literacy training, and (3) themselves serve as a digital extension and training tool. Fostering interconnectivity between state departments will capitalize on these efforts to maximize the number of beneficiaries, raise awareness of the available services, and reduce work duplication.

Integrated climate and weather forecasting do not offer robust profitability potential, but rather strong gains in terms of food systems efficiency, safety, socio-economic equity and, consequently, national prosperity. This information can be further utilized by academic, research, and private sector organizations, ultimately enabling improved services to farmers. This makes climate information services a public good that is best provided by the public sector.

Collaboration and partnerships are vital for achieving the Department of Agriculture, Forestry, and Fisheries Strategic Plan goals for 2020. Several public-private partnerships between government, research organizations, and international companies have achieved scale, including FruitLook and ConnectedFarmer. This paves the way for further collaborative efforts. The strong presence of incubators in the country suggests a strong enabling environment and a space that allows creative entrepreneurships to flourish. Nevertheless, there are several opportunities for further bolstering this area of strength. For example, the country ranks just 84 out of 190 countries in terms of business regulations and their enforcement (World Bank Group 2019).

Potential avenues for the private sector

The South African private sector has been at the forefront of digital agriculture. Private sector actors have on several occasions partnered with research institutions to scale out technologies. Several international companies have also invested in digital agriculture in South Africa, almost exclusively targeting large-scale commercial farmers. There remain numerous opportunities for the private sector to fill technology gaps in the market and cater to digital agriculture users with specific needs.

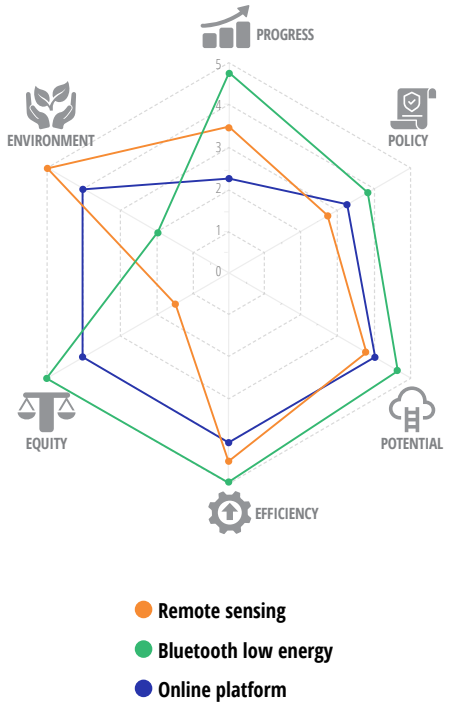
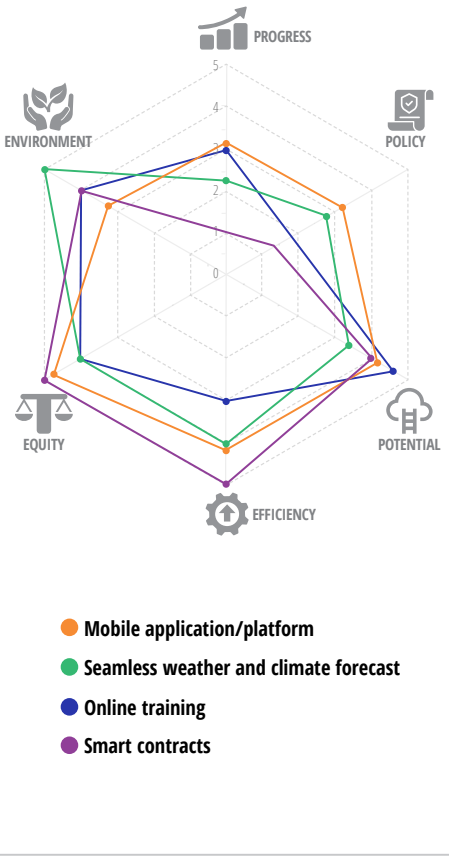
The strength of private sector actors is in developing and/or scaling new technologies that require high up-front investments and offer strong potential in terms of profitability and scalability. Start-up organizations, which have low running costs, can efficiently bring novel services or products to market. Once the technology is mainstreamed, it becomes profitable for large companies with vested interests in the efficiency and sustainability of the sector to engage smallholder and emerging farmers in scaling out the technology. For example, precision agriculture, including remote sensing, satellite, drone imagery, vehicle tracking, and blockchain technology, are excellent opportunities for private sector engagement.

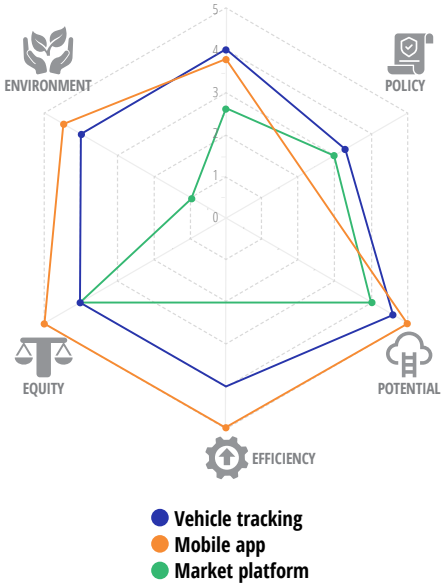
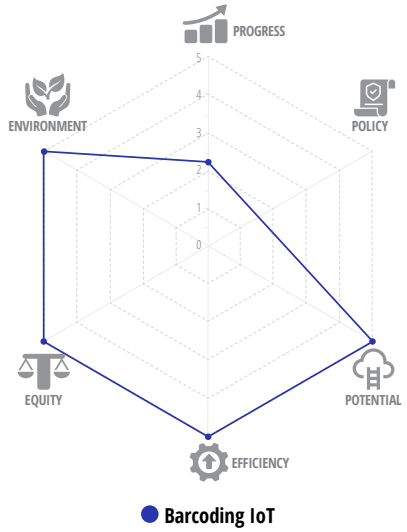
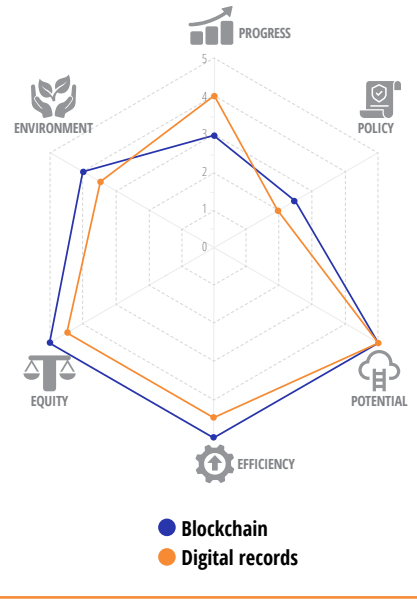
Going forward, private sector partnerships with the government, international companies, NGOs, and research institutions will support continued innovation and scaling. Potential obstacles include the country's slow economic growth rates, and a recently downgraded credit rating from the three major rating agencies. Investing is thus risky, although payoff can be high. The country is particularly strong in terms of protecting minority investors and in streamlining the process of paying business taxes (World Bank Group 2019).

Outlook

The South African agricultural sector has made great progress in digital agriculture, in particular regarding precision agriculture technologies. There are several outstanding opportunities to address some of the key challenges facing the agricultural sector with digital solutions. The country's policy, infrastructure, and funding environments are relatively conducive to digital solutions, although some bottlenecks persist. Our findings suggest that the most promising digital agriculture solutions in the coming years will leverage remote sensing, drone imagery, mobile platforms, vehicle tracking, database technology, blockchain technology, Bluetooth Low Energy, artificial intelligence, and weather forecasting, often combining these technologies. Solutions must be tailored to the unique needs and priorities of the communities they are intended to serve. A strong understanding of the diverse stakeholders involved is crucial to any digital agricultural solution. In particular, digital solutions appropriate for smallholders will differ significantly from those suited for medium and large-scale commercial farmers. The continued development of sustainable digital solutions in South Africa requires input and coordination across all value-chain actors and stakeholders, including NGOs, the private and public sectors, and the international community.

Table 1: Prioritized technologies

	Challenge	Technology	Outcome	Analysis
INPUT HUB	Quality of inputs including agri-chemicals, fertilizers, and seeds is not guaranteed	**Bluetooth Low Energy tracking**	Inputs are tracked throughout the value chain	
	Water scarcity	**Remote sensing and drones for precision agriculture**	Water is used sparingly and precisely via irrigated systems when rainfall is insufficient	
	Poor timing of government supplied inputs (seeds, fertilizer, pesticides)	**Online platform**	Better coordination between government and farmers for improved livelihoods	
PRODUCER HUB	Low farmer participation in the value chain	**Mobile apps to connect farmers to markets, input suppliers, and service providers**	Improved access to markets and opportunities for economies of scale	
	Lack of information on climate and weather that pose risks to farming	**Seamless weather and climate forecasting paired with advisory apps**	Farmers can make climate-informed decisions	
	Youth perceive agriculture as a low-potential career option	**Online training in agri-business, farm management and agri-processing**	Youth are able to realize their career potential in agriculture	
	Informal, inconsistent, or unenforceable agreements enable corruption and increase risk	**Smart contracts**	Contracts terms are automatically executed based on encrypted code, enabling transparent agreements and fair execution of terms	

	Challenge	Technology	Outcome	Analysis
DISTRIBUTION HUB	Cost of transport and theft of goods in transport	**Vehicle tracking units**	The most efficient routes and driving styles are identified, theft is detected and reported	
	Food waste	**Platforms to aggregate production, big data analytics to predict trends in consumption**	Food waste is curbed because production is better coordinated with demand	
	Long value chains with many middle men	**Mobile app to connect stakeholders more directly**	Reduced middle men and associated costs	
CONSUMER HUB	Food safety and source transparency	**Barcoding and IoT**	Food is traceable all along the value chain	
CROSS-CUTTING HUB	Market information asymmetry	**Decentralized, encrypted blockchain ledger**	Transparent, data-informed decision-making at all stages of the agricultural sector	
	Lack of tracking and tracing			
	Lack of data collection	**Digitization of farm records and other essential data**	Farmers can use digital records to apply for credit, analyze decision-making, and optimize operations	

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Annex

Selected examples of digital agricultural solutions provided by different institutions in South Africa

Institution and Intervention Name	Digital agricultural solution	Technology used
Aerobotics / Several on-farm decision support tools	Precision Agriculture. Exports standards compliance, monitoring orchard health factors	Drones, remote imagery, artificial intelligence; Mobile app, web-based platform
John Deere / Several on-farm decision support tools	Precision agriculture	Smart tractors equipped with sensors; crop-spraying drones
Massey Ferguson / Several on-farm decision support tools	Precision agriculture	Smart tractors equipped with sensors; crop-spraying drones
Livestock Wealth	Crowdfunding for livestock investments	Mobile app and web-based platform
University of Stellenbosch	Capacity building	Internet (online course)
Agriculture Research Council	Capacity building	Internet (web-based training)
University of the Free State, Faculty of Natural and Agricultural Sciences	Research	Sensors
Monsanto/Climate View Field	Precision agriculture	Software platform
Impact Farming by Fedgroup	Crowd sourcing investments	Web platform
Khula	Better value-chain integration, market access, logistics	Mobile app and web-based platform
Agricultural Research Council / ARC Hub APP	Early warning information on extreme weather, diseases, and other events	Mobile app and web-based platform
Vodacom Connected Farmer	Extension services, market prices, weather forecasts, input purchasing	cloud-based service
National Emergent Red Meat Producers' Organization (NERPO)	Access to information, advisory services, finance, and technical support	Mobile platform
EU, Department of Environmental Affairs and Solidaridad / Farmer2Market	Access to high-value markets through training on food safety standards and good agricultural practices	Online farmers market
AgriProtein	Recycles organic food waste and monitors traceability	Supplier control software
South African Organic Sector Organization	Certification, formalized land tenure, smart contracting, digital farmer profiles, and produce source traceability	Blockchain solutions

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1 The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)

2 The African Development Bank

3 FAO, Food and Agriculture Organization of the United Nations