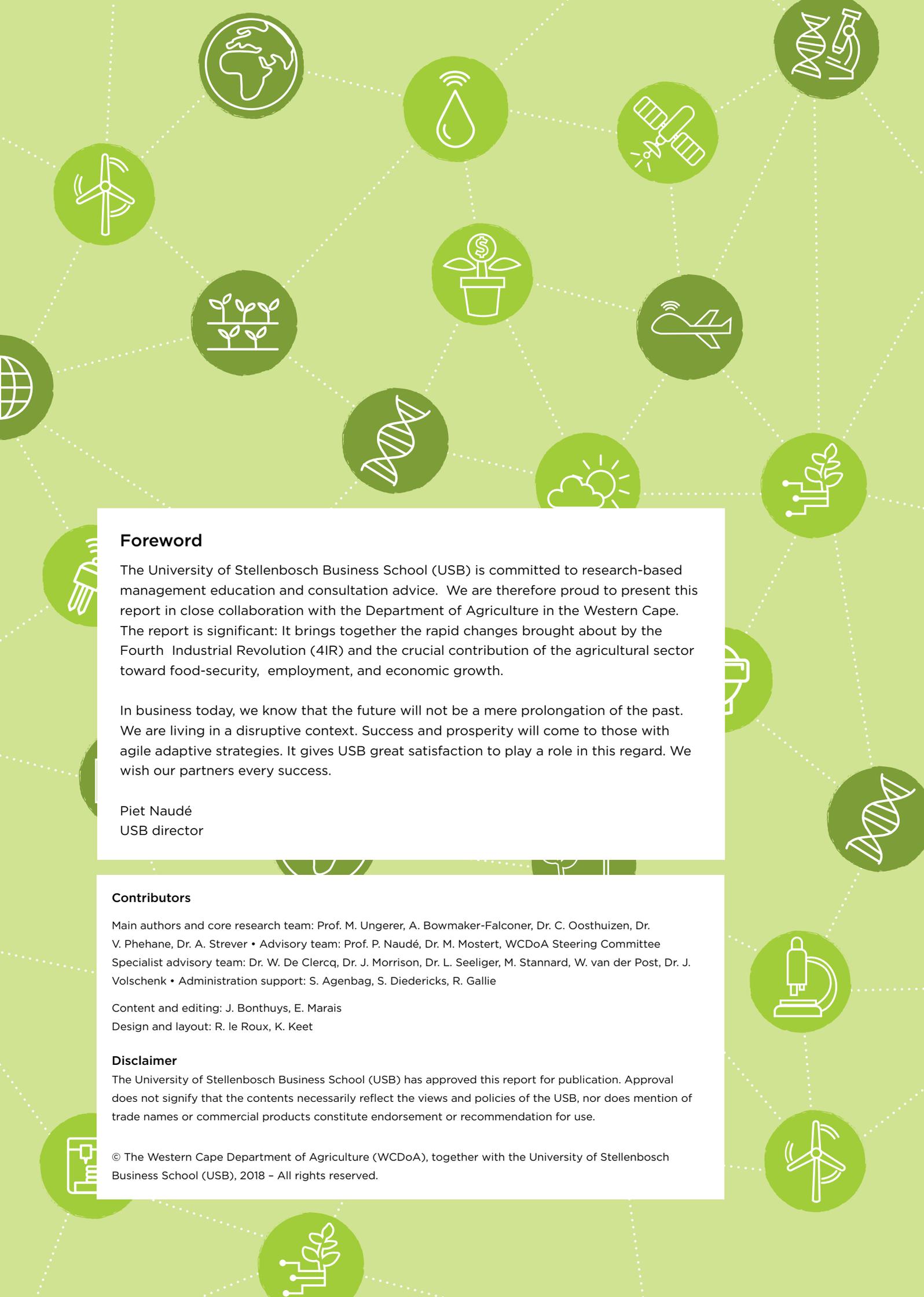




**The future of the Western Cape agricultural sector  
in the context of the Fourth Industrial Revolution**

*Synthesis report*



## Foreword

The University of Stellenbosch Business School (USB) is committed to research-based management education and consultation advice. We are therefore proud to present this report in close collaboration with the Department of Agriculture in the Western Cape. The report is significant: It brings together the rapid changes brought about by the Fourth Industrial Revolution (4IR) and the crucial contribution of the agricultural sector toward food-security, employment, and economic growth.

In business today, we know that the future will not be a mere prolongation of the past. We are living in a disruptive context. Success and prosperity will come to those with agile adaptive strategies. It gives USB great satisfaction to play a role in this regard. We wish our partners every success.

Piet Naudé  
USB director

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# Overview

## The Fourth Industrial Revolution (4IR)

Industrial revolutions occur when new technologies and world views introduce significant shifts in economic systems and social structures.<sup>1</sup> The Fourth Industrial Revolution (4IR), currently under way, differs fundamentally from its predecessors – its scope is much broader than mere smart and connected machines and systems. We are pivoting towards a fusion of the physical and the virtual world. Interoperability, advanced artificial intelligence and autonomy are becoming integral parts of a new industrial era<sup>2</sup> (see Figure 1).

Interconnected technologies in the context of the 4IR are now an inescapable reality – it is monitoring our cities, our factories and even our homes, and promises to benefit us all. This report indicates how the Western Cape agricultural sector can harvest the benefits of this ongoing change. The 4IR will directly affect the agricultural industry. Technology is a critical part of the 4IR, but aspects like energy and the environment, economics and policy, the consumer and social change are also integral drivers of future change (see Figures 4 and 8).

## Key messages

**The 4IR creates an opportunity for the agricultural sector to evolve into an ‘Agri Renaissance’ desired end state,**

wherein role players embrace technology through the adoption of, amongst others, farm-management software, precision agriculture, predictive data analytics and genetics. This enables producers to monitor crop health, the weather and soil quality by using robotics and drones. Together with smart irrigation, this results in higher yields, cost reductions and improvement of food’s nutritional value. The accelerated adoption of agricultural technology (AgTech) offers new, efficient and sustainable ways of farming and is leading to increased competition amongst producers in a new, AgTech-enabled normal.

**Increased access to information about farming practices allows consumers to be better-informed than ever.** This information is available throughout the entire agricultural value chain. Informed consumers are changing the demand for products due to concerns about food quality and nutrition, its traceability to origin, and the use of herbicides, pesticides, fungicides (crops) and antibiotics (livestock) in production and processing. Meeting these demands requires investing in new technologies.

**It is imperative to create conducive conditions for smallholder farmers to become commercially sustainable.** Such conditions include: (1) an incubation period focused on developing new entrants and creating a productive mindset; (2) education on technology, farming practices, and biology; (3) mentorships to

support skills development; (4) business education to develop commercial acumen; and (5) financial assistance through rent or buy options and other funding alternatives. Smallholder farmers and government must work together to unlock the sector’s full potential.

### **The agricultural ‘brand’ needs repositioning in the context of the 4IR.**

Currently, this sector is not well branded as a prime career destination. The formulation of a narrative and strategy to attract young talent to the sector is required. The core message could centre on rapid evolution in agriculture in the context of the 4IR. Tertiary education institutions engaged in agricultural education, training and development should strengthen their curricula by including theory, skills and technologies related to the 4IR. This differentiation would create competitive advantages for the first adopters. President Cyril Ramaphosa illustrated the importance of the latter when he introduced the Digital Industrial Revolution Commission in his first State of the Nation Address in 2018. He stated, “Our prosperity as a nation depends on our ability to take full advantage of rapid technological change. This means that we urgently need to develop our capabilities in the areas of science, technology and innovation.”<sup>3</sup>

The gains of the 4IR in the Western Cape will be realised through leadership. We must shape the future we want to live in.

# Executive summary

## About this report

This document reflects the content of a study commissioned by the Western Cape Department of Agriculture (WCDoA). The brief was to develop a view on agriculture in the province in the context of the 4IR.

## Structure of this report

This report comprises four main sections. The 'context' section provides an overview of the 4IR, the evolution of agriculture, the key drivers and trends to disrupt farming, and future scenarios. The 'rise of agricultural technologies' section provides an overview of AgTech and its applications. The 'findings' section explores trends shaping the farming future, emerging technologies and innovations that could change farming, and opportunities and challenges associated with the sector. 'Conclusions and recommendations' covers five key themes.

## Methodology

This study provides a strategic outlook on the future of agriculture in the context of the 4IR. It does not develop new theory. Its underpinning research focused on the construction of possibilities that could be argued on the ground of current trends and future perspectives. The study consists of an extensive literature review on the 4IR and its impact on agriculture. Opinions of experts, practitioners and key stakeholders were elicited through interviews and focus group dialogues. The study deployed a qualitative research approach as detailed in Annexure D.

## Overall findings

### Key trends reshaping the farming future

#### Climate change and water

The effects of climate change on water and water-management practices will continue to shape global agriculture across the value chain and particularly at the production stage where the quantity and quality of water will influence cultivar and technology selection. Given the envisaged higher temperature conditions, new varieties and practices will be required in future.

#### Global agricultural technologies

Big data, artificial intelligence (AI), machine learning, automation, and precision farming will become prominent technologies. Data collection and analysis will drive optimisation. Automation and mechanisation will add efficiency with precision farming delivering higher yields, superior quality products and production sustainability. Genetic technologies will continue to produce more resilient varieties that deliver better yields and more nutritious food.

#### The consumer

Consumers will increasingly demand knowledge on production, the nutritional value of agricultural products and its traceability to origin. Farming will require a balance between ethical and environmental sustainability practices, and economically viable production.

#### Change accelerators for innovation

Innovation in the global agricultural sector will be driven by the need to increase

output with fewer resources. Digital communication will facilitate innovations in market structures. Successful pilot studies will promote technology adoption. The consumer will continue to influence ongoing innovation in farming practices.

#### Seven key technologies for agriculture in the Western Cape

Emerging technologies that will transform agricultural practices will be related to water-management and related technologies, automation, the Internet of Things and sensor technology, remote sensing, precision agriculture and smart farming, genetics, AI and machine learning. Collectively, these technologies will catalyse Western Cape agriculture.

#### Technology, skills and future talent

The concern that technology will result in job losses is possibly valid for semi-skilled and unskilled labour categories. Yet, technology itself enables new types of jobs, resulting in the potential to retrain and reskill the labour force. Farming as a career needs rebranding to attract future talent.

#### Other contextual issues

**Cost:** The cost of technology is decreasing worldwide, yet South Africa remains a net importer of most technologies. Cultivars and seed are often protected by patents and plant breeders' rights owned by large global companies, making local access more expensive.

#### Research and information issues:

To facilitate technology adoption, the scientific community, together with agribusiness and the WCDoA, should provide and disseminate validated

information about the availability, benefits and integration of different technologies. Research efforts should not only focus on single technologies and their uses but the integration of technologies.

**The adoption of technologies:** The identified obstacles to technology adoption must be overcome to optimise opportunities.

## Recommendations

The recommendations are grouped into five themes with each recommendation aimed at a stakeholder to facilitate action. Here, an abbreviated version of these recommendations follows. More detail is included elsewhere in the report.

### No. 1 'Agri Renaissance' as the desired end-state

#### For government

1.1 The WCDa's strategic positioning should align with and support the 'Agri Renaissance' desired end-state, i.e. the department's vision should reflect this scenario with strategic initiatives to accelerate growth in agri-economic outputs.

1.2 The department should cooperate with tertiary institutions and the Department of Telecommunications to develop digital skills and capability for the agricultural sector. Tertiary institutions should make digital quotient and digital license courses and certification available to the sector. Reskilling and retraining opportunities are vital to growing the number of employed workers in the sector.

#### For academic institutions

1.3 Tertiary education institutions should strengthen their current curricula by including theory, skills and technologies related to the 4IR.

### No. 2 Engage with the rising influence of consumers

#### For producers

2.1 Producers in the supply chain should

list products on the blockchain as an opportunity that will allow the tracking of food origins for complete transparency.

#### For producers • processors

2.2 Agri-producers and processors should use innovations in packaging (biopackaging and recycled materials) that are environmentally centric and reduce storage space in logistics and packing. Another opportunity is related to food preservation, namely organically packaged food in the form of bio-derivative packaging. This provides ready-packed produce through automation, with smart indicators towards freshness.

#### For consumers

2.3 Consumers should use current legislation to enforce their right to accurate and truthful information from retailers and producers regarding quality, production practices, health and nutrition.

#### For government • agribusinesses • scientists • producers • retailers

2.4 The WCDa, agribusinesses and the science community must be jointly accountable for responsibly informing consumers about genetic engineering technologies.

### No. 3 Accelerate technology adoption in agriculture

#### For suppliers • scientists • government • producers

3.1 Suppliers, scientists, government and producers should disseminate information about the above-mentioned seven technologies in a transparent, open-source and equitable basis covering all categories of commercial farmers. Relevant forums, interest groups, and tertiary institutions should be leveraged to communicate and inform stakeholders.

#### For government

3.2 The WCDa should lead initiatives for expanding and improving current

databases. The dissemination of information also includes linking data from all parties in the agricultural value chain to expand the variety, denseness and volume to the benefit of stakeholders. Other opportunities include opening up the databases of original equipment manufacturers (e.g. John Deere) for sharing information about local agricultural production (planting and harvesting) and related information with more than just its customers. Original equipment manufacturers could be requested to make this information available. Alternatively, this could be legislated. This and other important agricultural data should become part of a shared information platform.

3.3 The WCDa needs to support the dissemination of information related to agricultural technologies and associated supporting systems, establish technology demonstration farms, run trials on the farms of existing participating farmers across the value chain, and share this information on accessible platforms, which should have maintenance support.

3.4 The department should coordinate the creation of a capacity to develop business cases for investing in technology. This requires independent, verifiable information on return on investment and associated benefits and productivity improvements. This should be independently determined and made public for practitioners to use in the development of their investment business cases.

3.5 Together with technology service providers, the department should investigate options to reduce the cost of acquiring new technology for smallholder farmers. Options include shared platforms, financing schemes, servicing solutions, and subsidised internet services.

#### For government • producers • scientists • agri-suppliers • agri-advisors • industry bodies

3.6 All role players in the value chain can

supply extension services. Extension specialists must be able to demonstrate technologies and communicate its benefits, proper application and system requirements. This should involve the matching of farmer needs and technology products in the market. Agribusiness-based advisors and specialists should strengthen their market intelligence and share this with their clients.

#### **For scientists**

3.7 The agri-science community should stimulate technology adoption. The scientific community should provide inputs on the availability and integration possibilities of technologies. Research efforts should not only focus on single technologies and their uses but more on the integration of technologies into the farming system and value chain.

#### **For investors • For producers**

3.8 Financial institutions should develop financing products suitable not only for large farmers but specifically for new entrants and smallholder farmers. Successful and sustainable farming requires investment on an annualised basis. This is a critical success factor for developing the sector.

#### **For government • businesses • entrepreneurs • investors • industry bodies**

3.9 Agri-entrepreneurs, investors, the department and industry bodies should collaborate to stimulate entrepreneurship across the above-listed technologies. Regional hubs could be commodity-based to be funded from the private sector in partnership with tertiary institutions.

3.10 Business and the WCDoA should initiate competitions, challenges and idea fairs to stimulate the understanding and application of the 4IR technologies in the agricultural sector. Potential partners include academic-based and private sector technology accelerators.

## **No. 4 Smallholder commercial farming development**

### **For government • investors • producers**

4.1 The department should develop an integrated framework for the on-boarding and development of new entrants into the sector. This must include the five enabling conditions described above. Aspects of this framework can also be relevant for the support of existing smallholder farmers.

4.2 The provincial government, together with financial institutions, should develop financing schemes targeting smallholder farmers. The WCDoA, together with the Department of Rural Development and Land Reform, should facilitate the acquisition of title deeds by individuals or entities or explore other forms of collateral. Smallholder farmers should organise collectively to present a bigger business case to gain access to finance.

### **For agribusinesses • smallholder farmers**

4.3 Agribusinesses and smallholder farmers should continue to create partnerships to facilitate access to financing, markets and technology. This should be encouraged through incentives such as increasing dam capacities, greater access to river catchment systems, and infrastructure development (roads, energy and railways) to increase production capacity. Enabling market access and participation in market structures by smallholder farmers through partnerships with large agribusinesses must be accelerated.

4.4 Agri-entrepreneurs should be encouraged and supported to develop crowdfunding platforms and other AgTech-propositions aimed at smallholder commercial farmers.

4.5 Agri-entrepreneurs should invest in collaborating in the value chain through equipment rental services, seeding services as an alternative to owning planting equipment, advisory services,

and data analytic services. To attract agri-entrepreneurs, the WCDoA should establish an annual AgTech innovation competition aimed at supplying services to smallholder farmers.

4.6 The department should stimulate the creation of business cases in the domain of the sharing economy and crowdfunding through innovation challenges, idea fairs and competitions. This should be in collaboration with both academic-based and private sector technology accelerators.

4.7 Smallholder farmers should explore high-value niche market products to be cultivated in smaller quantities. There is also the opportunity to define and supply specific local markets and communities with home-grown commodities.

## **No 5. Reposition the agricultural sector's brand for the 4IR**

### **For government • industry associations • academic institutions**

5.1 Industry associations, academic institutions and the department must formulate a collective narrative and strategy for attracting future talent. The core message could centre on rapid evolution in agriculture in the context of the 4IR and be distributed on social media platforms.

5.2 The department should cooperate with tertiary institutions and industry associations to implement agri-accelerator development programmes through skills exchange programmes to and from countries leading agricultural technology innovation. This initiative can also include study tours focusing on best farming practices and technologies used elsewhere.

5.3 Role players in the value chain should adopt, in their marketing approach to consumers, new brand experiences based on digital marketing, data analytics and social media.

# The context

*Today, we operate in a world of interconnectedness, the dawn of the 'Internet of Everything' and shifting technological frontiers. Exponential technological change and innovation is transforming the way we work, live, travel and communicate.<sup>1</sup> There is a Fourth Industrial Revolution (4IR) under way, and it is likely to be more profound than any previous stages of extreme innovation.*

## The Fourth Industrial Revolution (4IR)

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Humanity has experienced three industrial revolutions. The first took place in the 18th century, as people moved away from relying on the power of animals to mechanised power. The second occurred in the late 19th and early 20th centuries when a host of breakthroughs set in motion systems of mass production and communication. The third happened over the last half century as computers unlocked the digital world. In each stage, new technologies and world views introduced significant shifts in economic systems and social structures.<sup>1</sup>

Now we find ourselves at the genesis of the 4IR.<sup>2</sup> The velocity, breadth and

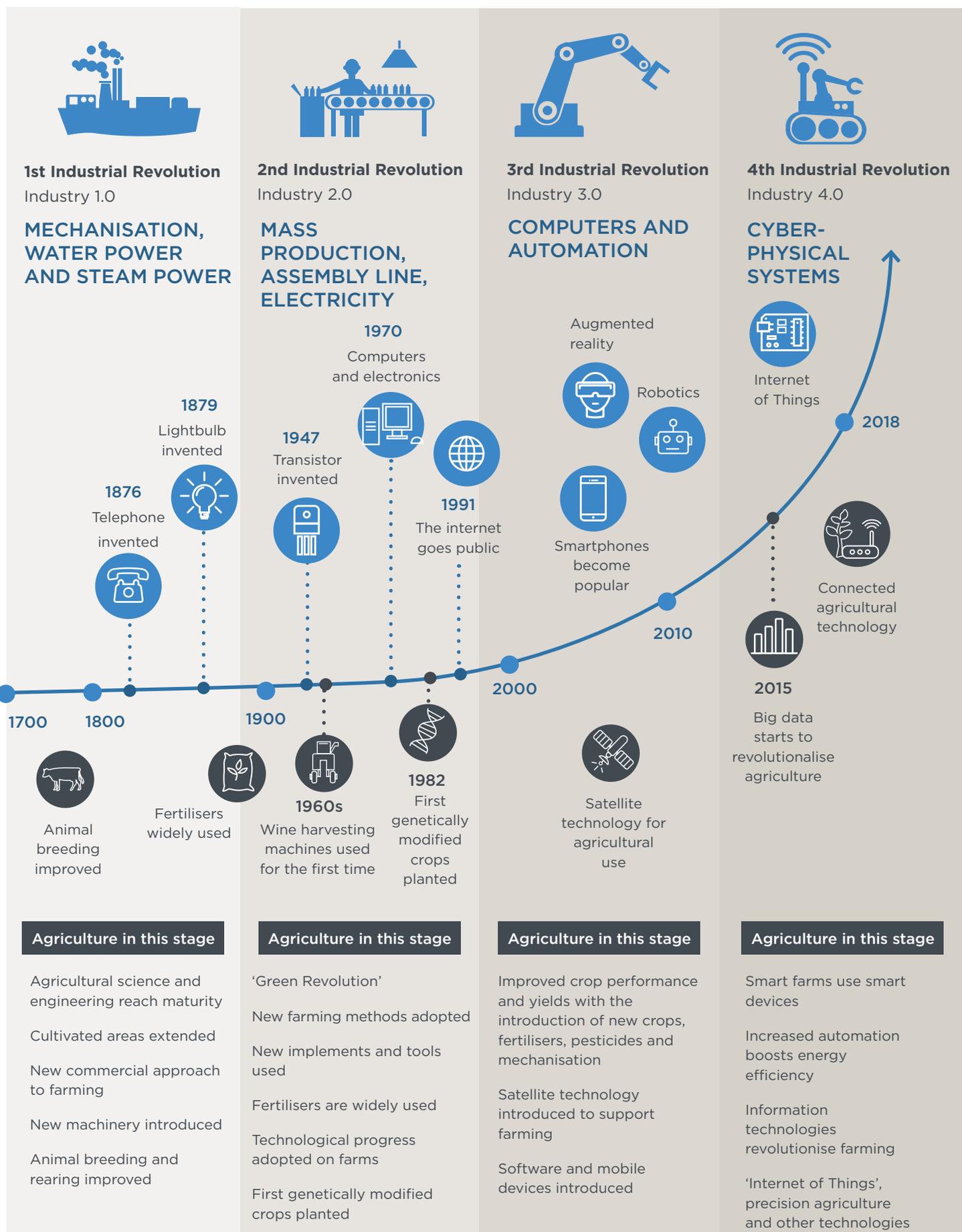
depth, and systems impact of the change support the conviction that a fourth and distinct industrial revolution is under way.<sup>1,2</sup> The 4IR is evolving exponentially rather than linearly. Building on the digital revolution, this stage combines multiple technologies that are leading to unparalleled paradigm shifts in the economy, business, society and individually. Today, technology produces newer and ever more capable technology in our deeply interconnected world.

Waves of technological breakthroughs are happening at the same time in areas ranging from gene sequencing to nanotechnology and quantum computing.

The fusion of these technologies and their interaction across the physical, digital and biological domains is what sets the 4IR apart from its predecessors.<sup>2</sup>

Technological progress is now rapidly spreading via the internet at relatively low costs, and its broad influences reach every aspect of human life. Concepts such as advanced artificial intelligence and autonomy are becoming integral parts of our lives.<sup>4,5</sup> We now live in the age of automation and artificial intelligence - humankind has to adapt to this or perish as the 4IR unfolds.

Figure 1: Evolution from the 1st to the 4th Industrial Revolutions



## The rise of technology in the 4IR

Most technologies that will have a significant impact on the world in five or ten years from now are already in limited use, while those technologies that will reshape the world in less than fifteen years probably exist as laboratory prototypes.<sup>6</sup> Although many of these technologies are still in early stages of development, they are already introducing an inflection point as they build on and amplify each other in a synthesis of technologies across the physical, digital and biological worlds.<sup>2</sup>

Consider the overwhelming convergence of emergent technology like artificial intelligence (AI), robotics, the ‘Internet of Things’, autonomous vehicles, 3D printing, nanotechnology, biotechnology, energy storage and quantum computing, among others. Cyber-physical systems are at the core of ‘Industry 4.0’ – the convergence of hardware, software, and people to get work done, and, adding AI as well as machine learning to this fusion.<sup>7</sup>

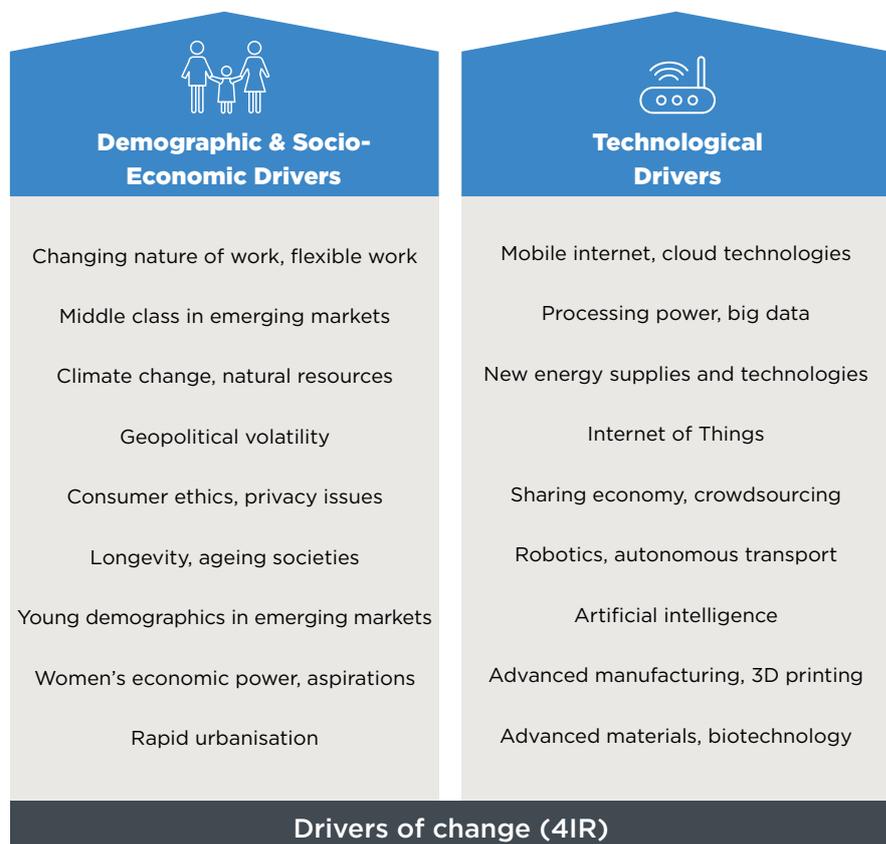
The 4IR is epitomising a ‘gravitational pull’ set by multiple and complex drivers and crosscurrents, such as expanded globalisation, technological explosion, digital tools, internet-centric data flow, and global competitiveness (see Figure 2).<sup>4</sup> Klaus Schwab, well-known economist, clustered these technological megatrends into physical (for example autonomous vehicles, 3D printing, and advanced robotics), digital (for example the Internet of Things, radio frequency identification and Bitcoin), and biological trends (for example genetic sequencing, synthetic biology, genetic engineering and editing). The seemingly abstractness of these megatrends are obvious, but it nevertheless gives rise to practical applications and developments. This is demonstrated by the discernment of the

technological shifts that are becoming mainstream and will shape the future digital world.<sup>2</sup>

Figure 2: Megatrends<sup>4</sup>

Implantable technologies	Big data for decisions
Digital presence	Driverless cars
Vision as the new interface	Artificial intelligence and robotics
Wearable internet	Blockchain
Ubiquitous computing	The sharing economy
A supercomputer in one’s pocket	3D printing and manufacturing
Storage for all	3D printing and human health
The internet of and for things	3D printing and consumer products
The connected home	Designer beings
Smart cities	Neurotechnologies

Figure 3: Drivers of change (4IR)<sup>9</sup>



Although the 4IR is regarded as being driven by extreme automation and extreme connectivity<sup>8</sup>, it is increasingly evident that disruption (resultant from the 4IR) does not stem solely from technology, but is also influenced by demographic shifts, globalisation, macroeconomic trends and more (see Figure 4).<sup>8</sup> It is important to note that parallel to the current technology revolution is also a set of broader socio-economic, geopolitical and demographic developments, each interacting in many directions and intensifying one another.<sup>9</sup>

In today's world, there is a multitude of connected devices, from thermostats in homes to cars and other items that can communicate and react with one another without the need for human intervention. Machine learning is, for instance, helping to analyse ever-growing data sets to find opportunities for optimisation in everyday life. While these technological and other drivers (see Figure 3)<sup>9</sup> are

transforming society, the question beckons: "how will the future of agriculture, and specifically agriculture in the Western Cape, be impacted?"

### Evolution of agriculture in the 4IR

Despite significant growth in food production over the past half-century, one of the most critical challenges facing society today is how to feed an expected population of some nine billion by the middle of the 21st century.

It is estimated that 70% to 100% more food needs to be produced to meet the growing demand for food without significant price hikes. This must happen within the context of climate change and take into account concerns over energy security and regional dietary changes.

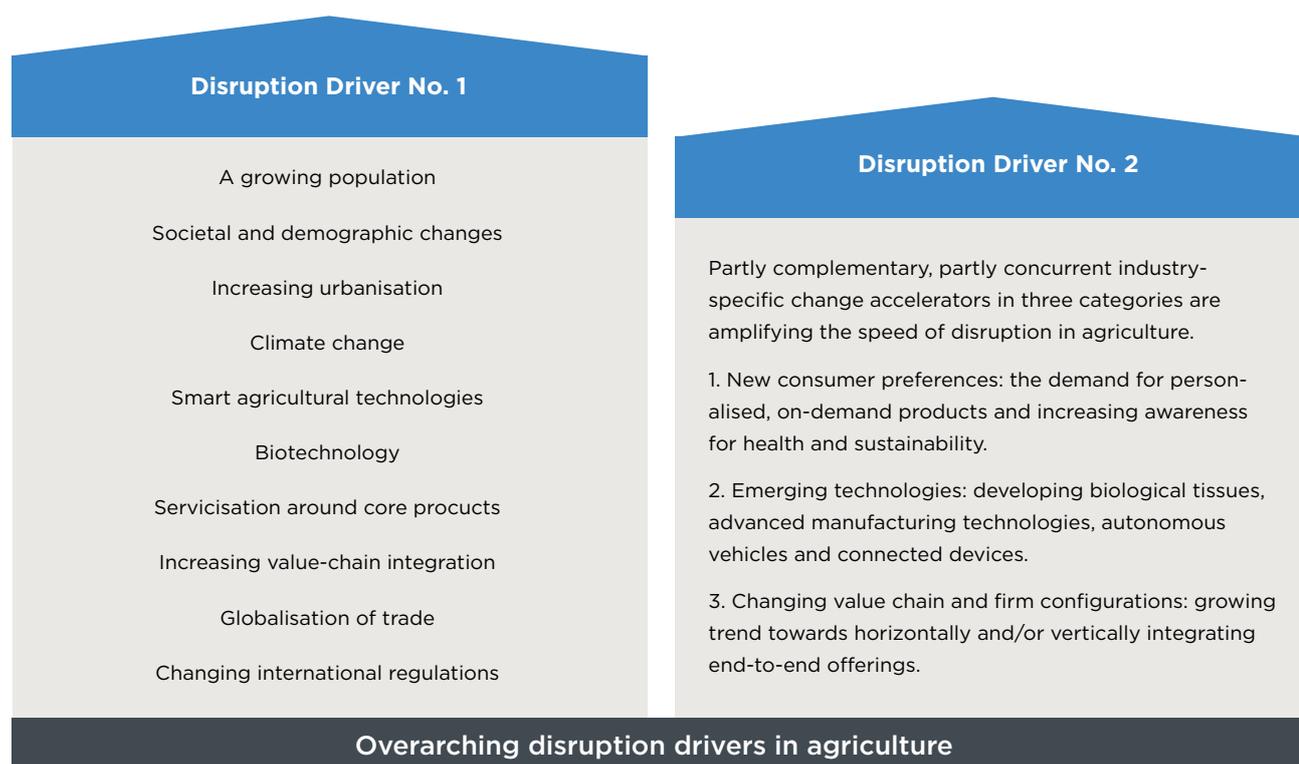
With the dramatic advancements in technology, a tipping point is fast

approaching for the dawn of a new era in agriculture. In agriculture, information and communication technologies (ICTs) have grown significantly in recent times in both scale and scope. The use of the Internet of Things, cloud computing, enhanced analytics, precision agriculture in convergence with other advancements such as AI, robotic technologies, and 'big data' analysis have revolutionised agriculture.<sup>10</sup>

Today, the use of digital technologies – including smartphones, tablets, in-field sensors, drones and satellites – are widespread in agriculture, providing a range of farming solutions such as remote measurement of soil conditions, better water management and livestock and crop monitoring.

Enhanced analytics, affordable devices and innovative applications are further contributing to the digitalisation of farming. Research in 'precision agriculture'

Figure 4: Overarching disruption drivers in agriculture<sup>8</sup>



has, for instance, provided producers with many types of sensors for recording agronomically relevant parameters, as well as numerous farm-management systems. Digitalisation moreover helps improve working conditions for farmers and reduce the environmental impacts of agriculture.<sup>11</sup> Electronically controlled machines are becoming state of the art; in fact, technology is now capable of automating cyber-physical systems by networking between different machines.<sup>12</sup> This allows farmers to plan more effectively and be more efficient, enabling them to improve crop yields as well as optimising process inputs and labour reduction. Also, inherent to the 4IR, developments in communication technologies such as cloud computing and the Internet of Things are converging with other advancements such as AI, robotic technologies, and big data analysis, which are further driving digital agriculture, or, 'Agriculture 4.0'.<sup>12</sup>

It is conceivable that the agricultural industry is about to be disrupted and transformed into a high-tech industry. There are numerous innovators spearheading attempts to tap into the growth opportunities embedded in improving yield efficiency, increasing supply chain efficiency, and decreasing complexity along farming's value chain. Although traditional investor companies are only slowly getting involved, large agrochemical incumbents are already investing heavily in agricultural technology, or as is referred to, 'AgTech' (see The rise of agricultural technologies, page 18). It is believed that this investment focus will transition from the mature food e-commerce sector to a more diversified portfolio of innovation fields and targeted value zones.<sup>13</sup>

Agriculture 4.0 is particularly noticeable in countries such as the USA, Israel, China and India that are pushing the innovation boundaries. Another country embracing technology and innovation is the

Netherlands, who, amidst having limited arable land compared with most other developed countries, is the second largest food exporter in the world, after the USA.<sup>14</sup> AgTech holds significant promise to make the farms of the future more productive and efficient, with advancements in specific categories, namely:<sup>15</sup>

- Farm-management software;
- Precision agriculture and predictive data analytics;
- Sensors that help farmers to collect data and to monitor crop health, weather and soil quality;
- Animal data (software and hardware aimed at better understanding livestock, from breeding patterns to genomics);
- Robotics and drones;
- Smart irrigation;
- Next-generation farms, where technology is used to provide alternative farming methods to enable farming in locations that previously couldn't support traditional agriculture; and
- Marketplaces (technological platforms that connect farmers directly to suppliers or consumers)

Although AgTech has been implemented in some respects (e.g. biotech), it is considered still in the hype stage and mostly hasn't delivered on its promise yet. There is enthusiasm about numerous technologies, however only at the first iterations. Although real adoption is still to come, it is envisaged that once it does, it will be transformational. Until then AgTech will continue to attract attention driven by the macro drivers (consumer trends, environmental and resource challenges, increasing populations), demanding technological advancement of agriculture.<sup>16</sup>

Although agriculture still needs to catch up with the other industries, AgTech adoption will inevitably thrive in the 4IR as the global demand for agricultural products is rising. At the same time,

consumers, retailers and participants in the value chains are also increasingly demanding product quality and transparency of production.<sup>17</sup> Developing and transferring technology alone will not tackle yield gaps or reduce wastage or post-harvest losses.<sup>17</sup>

Significant challenges remain to develop policies that support the widespread emergence of more sustainable forms of land use and efficient agricultural production. An enabling investment environment should also be established. Farmers are likely to adopt technologies only if there are sound incentives to do so: this calls for well-functioning input and output markets, improved infrastructure, and better finance and risk-management tools.

The challenges posed by current and future global food supply will continue to thrust agriculture towards technological innovations, but at the same time, new developments also create further questions. Not everything that is technologically feasible will become a reality, hence the importance to assess it in the context of social, economic and political developments around the globe.<sup>18</sup>

Also, the food systems of the various countries are intertwined in numerous ways, from the trade in raw materials to final products. This is a highly complex system with many uncertainties and factors influencing it.

## Agriculture in the Western Cape in the 4IR

Food systems are constrained by existing and new pressures emanating from global megatrends including climate change, the growing population, limited natural resources, urban migration, and trade systems.

South Africa's average annual GDP has slowed to 1,8% since 2008. Its employment

rate has remained at 25%, with youth unemployment at 52%<sup>19</sup>. An opportunity to reverse this trend lies in a focused process to transform the agricultural value chain by expanding agricultural exports. This presents many opportunities for agriculture in the Western Cape.

The Western Cape, with 6,2 million residents, accounts for 11% of South Africa's population and contributes 14% to the country's GDP. In 2014 (latest available data), the real economy (agriculture, mining, manufacturing and construction) made up 22% of the province's

output, with agriculture's contribution at 4% (22% of national agriculture). Although growth in the province overall has generally been slightly above that of the rest of the country, it also saw decelerating growth from 2011.<sup>20</sup>

The agricultural and agri-processing sectors added R21 billion and R33 billion respectively to the value added in the Western Cape in 2016, contributing to more than 10% of the entire regional economy and mainly driven by the labour-intensive cultivation of fruits for export.<sup>21</sup> In fact, 52% of the Western Cape's exported

goods were from these two sectors, with exports valued at R121 billion in 2016.<sup>22</sup>

Faced with population growth, declining household sizes, increasing household numbers, high levels of migration, urbanisation and escalating development pressures, the province has experienced changes in land use and land cover. These factors have also encouraged issues such as urban spread, marginalisation of the poor, limited public access to resources, land degradation and climate change.<sup>22,23</sup> Ecosystem goods and services (i.e.

**Table 1: Alignment of Western Cape Department of Agriculture's strategy to the National Development Plan (NDP)**

Alignment on jobs	
PSG 1	Create opportunities for growth and jobs
DSG 1	Support the provincial agricultural sector to at least maintain its export position in the next five years
NO 4	Decent employment through inclusive growth
Alignment on land reform	
PSG 1	Create opportunities for growth and jobs
DSG 2	Ensure that at least 70% of agricultural land reform projects are successful over the next five years
NO 7	Vibrant, equitable, sustainable rural communities contributing towards food security
Alignment on environmental sustainability	
PSG 1	Create opportunities for growth and jobs
PSG 4	Enable a resilient, sustainable, quality and inclusive living environment
DSG 4	Optimise the sustainable use of water and land to increase climate-smart production
NO 10	Protect and enhance natural assets
Alignment on economic opportunity	
PSG 1	Create opportunities for growth and jobs
PSG 2	Improve education outcomes and opportunities for youth development
PSG 3	Increase wellness and safety and tackle social ills
PSG 4	Enable a resilient, quality, sustainable and inclusive living environment
PSG 5	Embed good governance and integrated service delivery through partnerships and spatial alignments
DSG 5	Increase agriculture and related economic opportunities in selected rural areas based on socio-economic needs over a decade. Strengthen interface with local authorities.
NO 7	Vibrant, equitable, sustainable rural communities contributing towards food security
Alignment on human capital	
PSG 1	Create opportunities for growth and jobs
PSG 2	Improve education outcomes and opportunities for youth development
DSG 7	Facilitate a 20% increase in relevant skills development at different levels in the organisation and the sector over the next ten years
NO 4	Decent employment through inclusive growth
NO 5	A skilled and capable workforce to support an inclusive growth path
NO 7	Vibrant, equitable, sustainable rural communities contributing towards food security

KEY	
PSG	Provincial strategic goal
DSG	Departmental strategic goal
NO	National outcomes

products derived from healthy ecosystems, including fresh, clean and potable water, flood attenuation by wetlands, and pollination services) underpinning the agricultural economy are also in decline in many areas. Research shows that natural thresholds are already exceeded in many of the Western Cape's key water catchment areas, which could have a direct impact on water security in the region in the medium- to long-term. Simultaneously, the ecological infrastructure in the province is experiencing mounting pressures that could affect how well the ecosystems supporting the agricultural sector will function in the future.<sup>24,25</sup>

Considering the severe continuous drought situation in the province and farmers prioritising high-income fruit over vegetables and crops, the estimated losses in agriculture range between R4,9 billion<sup>26</sup> and R6 billion, with anticipated job losses of 30 000<sup>27</sup> (with more recent estimates in March 2018 estimating job losses as high as 57 000).

Many challenges and opportunities exist to improve and secure agricultural production

in the province and align it with provincial and national development, economic and other strategies. Alignment of the WCDoA strategy to the national policy mandates of South Africa is an important consideration.<sup>28</sup>

The strategic goals and objectives of the Department of Agriculture, Forestry and Fisheries (DAFF) are a response to achieve the National Development Plan's (NDP) objectives and targets. The New Growth Path (NGP) is a national policy broadly aimed at unblocking private investment and job creation to address systematic blockages to employment-creating growth. The Agricultural Policy Action Plan (APAP) aligns itself with the NGP, the NDP, as well as the Medium Term Strategic Framework (MTSF) in respect of the desired outcomes 4, 7 and 10 of government.

The Western Cape Government has identified five provincial strategic goals to deliver on its vision and contribute to the objectives of the NDP. Agriculture and agri-processing are strategic sectors embedded therein, in terms of

their contribution to economic growth, employment absorption, and foreign earnings. Yet, its relative importance for exports from the Western Cape creates volatility in the provincial economy, especially given the uncertainty brought about by climatic changes and the prevailing water crisis.<sup>23</sup>

The situation in the Western Cape remains ominous with major long-term impacts due to restrictions on the availability of water for irrigation of high-value agricultural export industries. The continuation of severe droughts in these areas places serious pressure on grain, livestock, fruit, vegetable and dairy producers, who face the risk of significant production failures.<sup>29</sup>

Along with the provincial strategic goals, the WCDoA has determined seven departmental strategic goals.<sup>28</sup> These goals are aligned with the provincial strategic goals and overall planning (Strategic Plan 2015 - 2021), as well as to the NDP, APAP and NGP, through its detailed programmes and sub-programmes.

**Figure 5: Agriculture in the Western Cape<sup>22,30</sup>**

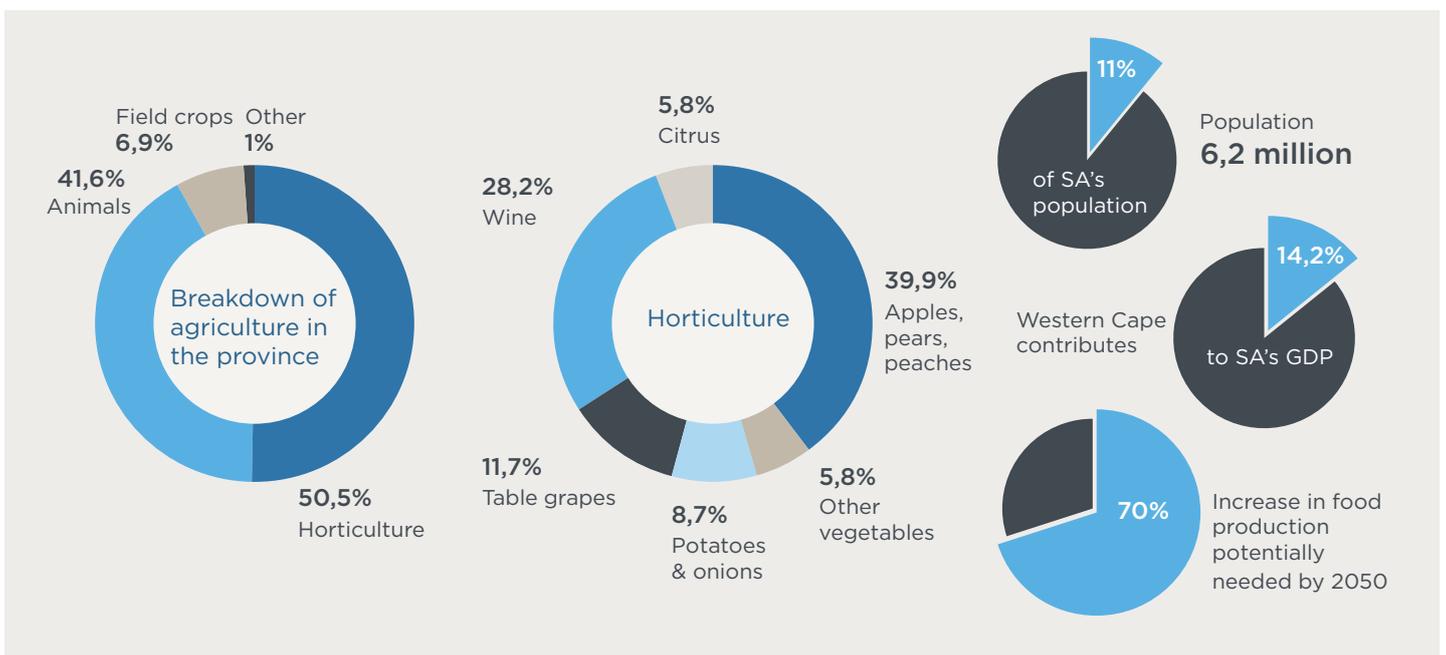


Table 1 (page 11) illustrates the link between the WCDoA's strategy and the NDP's imperatives of job creation, land reform and agrarian reform, environmental sustainability, economic opportunity and human capital development. The strategy shows linkages to provincial and departmental strategic goals to each of these imperatives. There is also a link made to the government's national outcomes; in particular, those most essential to the WCDoA.

The agricultural sector remains important in the province. Agriculture takes up most of the land in the Western Cape (2,5 million ha.). As a winter rainfall region, its agricultural sector is unique in South Africa. The diversity of agro-climatic zones in the Western Cape allows for a variety of agricultural commodities (see Figure 5).<sup>22,30</sup>

Agriculture promotes food security, job creation, economic stability and inputs

to other industries, amongst other advantages. However, poor farming practices, overgrazing and land clearance can lead to erosion and land degradation.<sup>22</sup> Inefficient and ineffective farming methods can have a knock-on effect throughout the agricultural value chain.

Agricultural production in the province is a highly integrated system as illustrated by the typical agriculture-production value chain.<sup>31</sup> However, agricultural production is undergoing marked changes due to rapid shifts in consumer demands, input costs, and concerns for food safety and environmental impact. Its systems also consist of multidimensional components and drivers interacting in complex ways to influence production sustainability.<sup>32</sup>

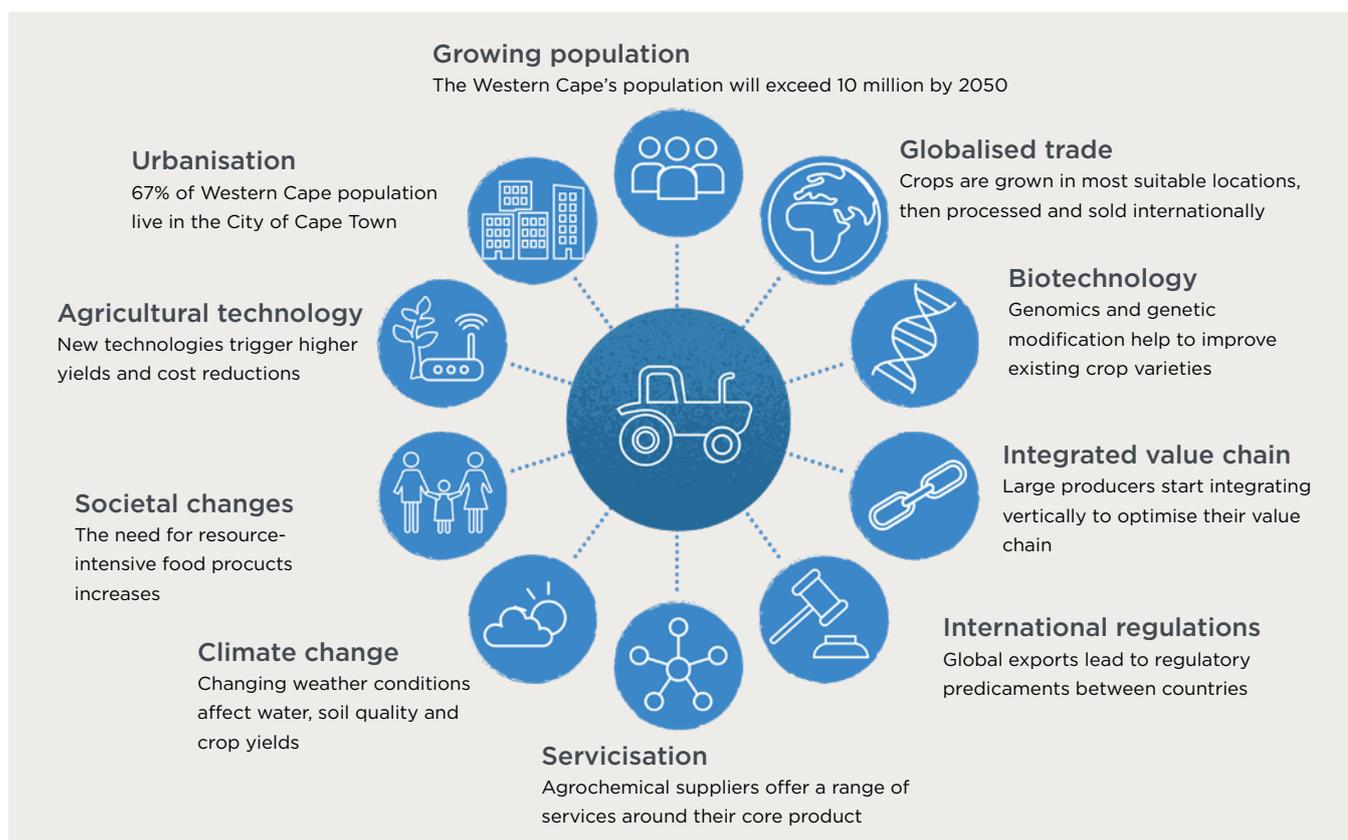
On the demand side, population and economic growth converge to generate the need for increased crop levels and food production. Apart from such

considerations affecting the quantity of demand, there are also other drivers affecting the system. On the supply side, there is apprehension about declining levels of yield gain, whether due to the laws of diminishing returns or the effects of droughts and global warming. The sector encompasses significant diversity and variety at each stage, from research and development-based input companies to generic manufacturers, subsistence farmers to high-tech agri-holdings, biotech enterprises, small and medium-sized enterprises, and multinational corporations.<sup>33</sup>

### Drivers and megatrends set to disrupt farming

The Western Cape's agricultural system does not function in isolation, nor do technological developments take place separately; it always interacts with developments in the global, national and

Figure 6: Megatrends affecting change in farming in the Western Cape<sup>13</sup>



local economy, society and politics. Also, the food systems of the country and province are intertwined in many ways, from the trade in raw materials to final products.<sup>34</sup>

Various drivers and associated megatrends are bound to impact on agriculture in the Western Cape. Figure 6<sup>35</sup> (page 13) contains a list of these drivers and megatrends. This list of examples is by no means complete but serves as a foundation from where further factors regarding the future of agriculture could be identified. Well-functioning markets, increased incomes for smallholder farmers, equal access to technology and land, and additional investments all play a role in creating a vibrant and productive agricultural sector that builds food security.<sup>35</sup>

A large part of the economic value-add of food production in the Western Cape is at the farms but also in food processing and retail. At the end of the food chain is the consumer, whose needs and demands also influence the production and supply of food. On the other hand, companies in the food chain can exert considerable political and social influence, affecting consumer demand. It is a highly complex system and to investigate its future requires many different factors and a significant degree of uncertainty must be considered.<sup>17</sup>

Because the affordability of food mainly relates to income, ensuring access to food remains one of the key pillars of food security and the wider anti-poverty agenda in the Western Cape and South

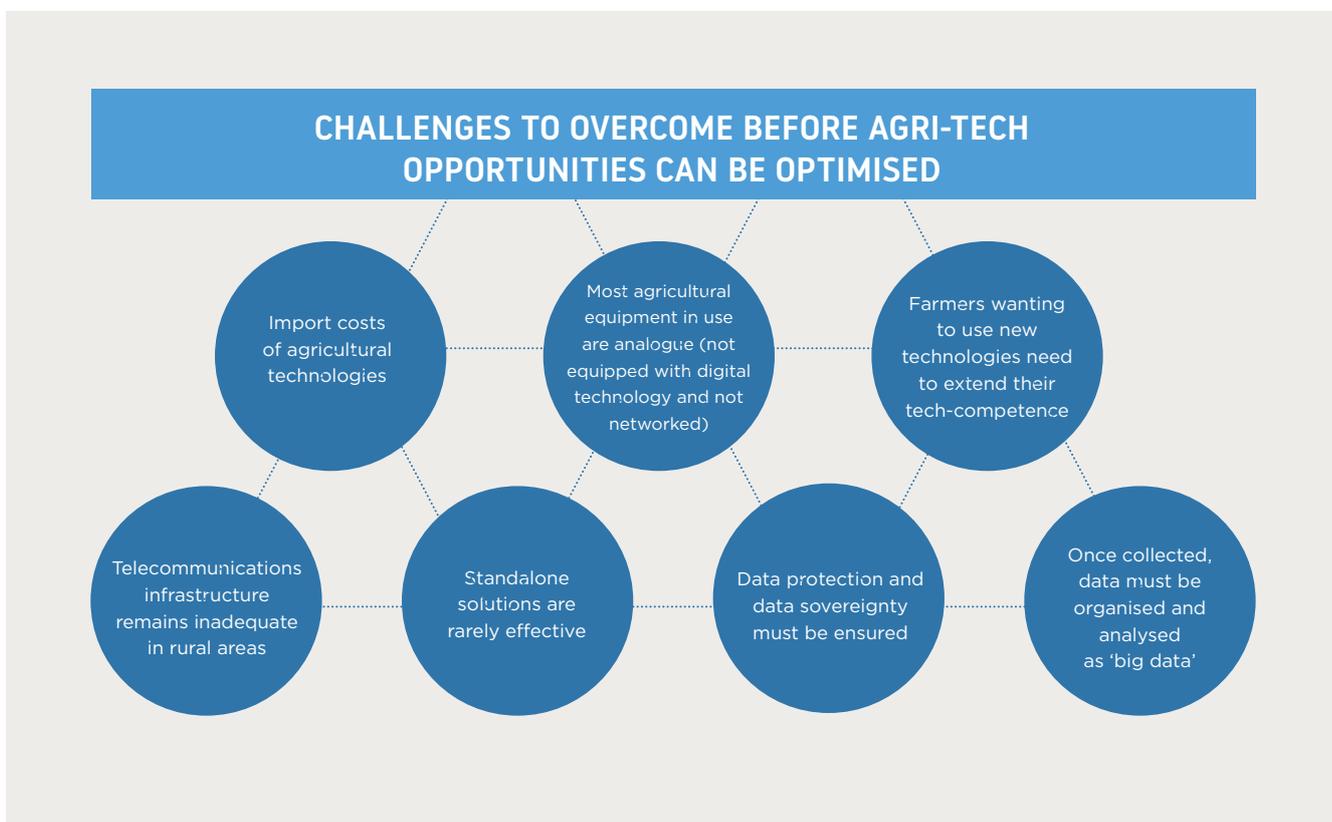
Africa. Agriculture's centrality in the food-water-energy nexus is also of significance.

A growing Western Cape population with increasing urbanisation and a deteriorating natural resource base implies more people to feed with less water and farmland. Satisfying expected increases in water, energy and food needs requires a shift to more sustainable consumption and production approaches, with agriculture and food systems in the Western Cape made more efficient and sustainable.<sup>36</sup>

### Opportunities and challenges

The goal for the local agricultural sector is no longer simply to maximise

Figure 7: Obstacles to using agricultural technologies in the Western Cape



**Table 2: Some promising technologies and applications for the future**

3D printing	4D printing	Smart materials
Robotics	Unmanned aerial vehicles	Sensor technology
Information technology (IT)	Connective infrastructure	Bioinformatics
Biorefinery and biofuels	Genetics	Synthetic biology
Smart farming	Renewable energy	Protein transition
Conservation technology	Transport technology	Weather modification
Food design	Aquaculture	Vertical agriculture

productivity, but to optimise across a far more complex landscape of production, rural development, environmental, social justice and food consumption outcomes. However, significant challenges remain to develop provincial, national and international policies that support the wide emergence of more sustainable forms of land use and efficient agricultural production. The lack of information flow between scientists, practitioners and policymakers is known to exacerbate the difficulties, despite increased emphasis upon evidence-based policy.<sup>37</sup>

When considering the performance of the Western Cape agricultural and food sector in the complex local and global food system, the degree of uncertainty increases with a wide range of sectors and disciplines being involved. In terms of technological developments, these may be influenced by entrepreneurs, researchers and policymakers but also by other developments. In turn, technological developments affect other developments, e.g. in food and health, but also in society. That being said, numerous opportunities exist in terms of the application of technology in pursuit of improving efficiencies in agricultural production. Examples of technologies holding promise for the future of agriculture in the Western Cape include smart farming, information technology and robotics, among others. See other examples in Table 2 above.

Agriculture in the Western Cape is, however, highly dependent on agricultural equipment, infrastructure and labour. Modern farming equipment provides a range of different options for collecting and analysing process data, but not everyone has digital agricultural equipment, is aware of its benefits, or trusts it sufficiently to use it. Yet, the potential of digitisation and using data for agriculture are generally recognised. Digital technologies can help farmers meet these requirements and optimise their processes. But there are numerous obstacles to overcome before these opportunities can be exploited (see Figure 7).

Conversely, technological solutions to overcome these challenges already exist. For example, Bluetooth ‘beacons’ and GPS systems combined with software, standardisation and interoperability mean legacy machinery can now be digitised. Known as partial digitisation, this is a realistic potential way into Agriculture 4.0 for many farmers.<sup>38</sup>

The belief that ‘bigger is better’ that has come to dominate farming and rendered small-scale operations impractical, is changing dramatically with advances in technology expected to disrupt current agribusiness models.<sup>38,39</sup>

Given a view of when digital technologies and disruptive activities have emerged, and are forecast to emerge, it is possible to

plot the Western Cape’s agricultural sector along a timeline to forecast when the most disruptive changes might be felt in terms of driving transformational change.

High impact implies that digital capabilities will transform every aspect of agribusiness. This includes core competencies and resources, value propositions, distribution channels, customer segmentation and engagement, product design and pricing, revenue and cost bases, and operating models. From the above, it is evident that impact is moderate, which nevertheless still implies significant transformation.

The Western Cape agricultural sector is moderately transforming in terms of digital impact, i.e., digital transformation is starting to evolve the back offices, technology platforms, operating processes, product innovation and customer experience, which impacts multiple strategic challenges. Noticeably, however, is the sector’s low positioning in terms of digital maturity. Digital capabilities are progressing in pockets but not yet drawing significant investments. There is no clear digital leadership, a lack of awareness and skills, reliance on outsourcing for digital capabilities, lack of adequacy of support through sector policies, substandard view of cyber risks and partial availability of cybersecurity tools.<sup>40</sup>

The Western Cape’s agricultural sector is globally competitive and known for its production stability, supported by well-developed infrastructure for input supply and output processing (it contributes 4% to the provincial GDP). This could also partly be attributed to the fact that it has always been a good adopter of the new technologies that are being used in global markets as they become available. These technologies are, however, generally imported and adopted into the local market, and it is these global

digital solutions and innovations that are impacting the agri-sector locally. Similarly, because most of agri-production in the Western Cape (wine and fruit especially) is exported (17% of the province's exports), changing customer expectations are driven by preferences and demands originating abroad. It is, therefore, important to understand the trends and areas of transformation that affect the sector.<sup>40</sup>

The sector holds significant potential for growth and development, with agri-processing already a large contributor to the economy and the potential to scale. However, the significant absorption of unskilled labour that contributes to economic and social growth poses challenges considering the impact of automation set to replace certain types of agri-labour. This includes examples such as auto-steering tractors, robotic milking, autonomous spraying drones and manned robotic harvesting implements.<sup>40</sup>

Also, wide-scale use of digital capabilities is still a challenge and not accessible to most farmers. Small-scale farmers and other participants within the agricultural value chain are starting to adopt and benefit from greater access to information to inform their operations and improve output and so, the transformation is starting. But the take-up of digital technologies and capabilities has yet to penetrate all aspects of business models in the agri-sector.<sup>40</sup>

The Western Cape's agricultural sector's response to the 4IR should be integrated and comprehensive, involving the agri- and public sectors in the province, as well as academia and civil society to adapt, shape and harness the potential of disruption.

## Future scenarios for the Western Cape

Drawing on the literature consulted, three alternative scenarios for the future of the

agricultural sector were conceptualised. The baseline scenario ('Agri Cul-de-Sac') considers what the future of farming could be like if the drivers and trends continued its current trajectory. Alternative scenarios were then extrapolated from the baseline, given specific changes in the drivers and trends.

### Scenario 1: Baseline scenario ('Agri Cul-de-Sac')

In this scenario, disruptive technology developments persist at an exponential rate while the provincial agricultural sector advances at a linear, incremental rate. New energy mixes to address the growing demand are not receiving the sense of urgency it needs. Water shortages, dry and arid climatic conditions and environmental degradation continue unabated.

Knowledge as basis for economic value, supported by democratisation of information and increasing personalised choices, is affecting the nature and extent of the growing middle class' buying behaviour and patterns. Conflicting ideologies and social pressures on society continue relentlessly, and failure to reach political consensus and cooperation result in an ever-weakening economy, unable to deliver on the social expectations of citizens, and exasperating the financial pressure on the agricultural community.

Amidst an increasingly connected global economy and economic integration, and while the adoption of technology offers new and efficient ways for farming and agriculture, the stifling effects of the local economy mean that producers are evolving too slowly, and face waning returns from the shrinking buying power of the local market.

The population growth of, and migration to, the Western Cape continues to further burden infrastructure, and increasing pressure is exerted on agriculture and food

production to serve the urban expansion. The increase in unemployed youth further aggravates degradation of the social fibre in the province.

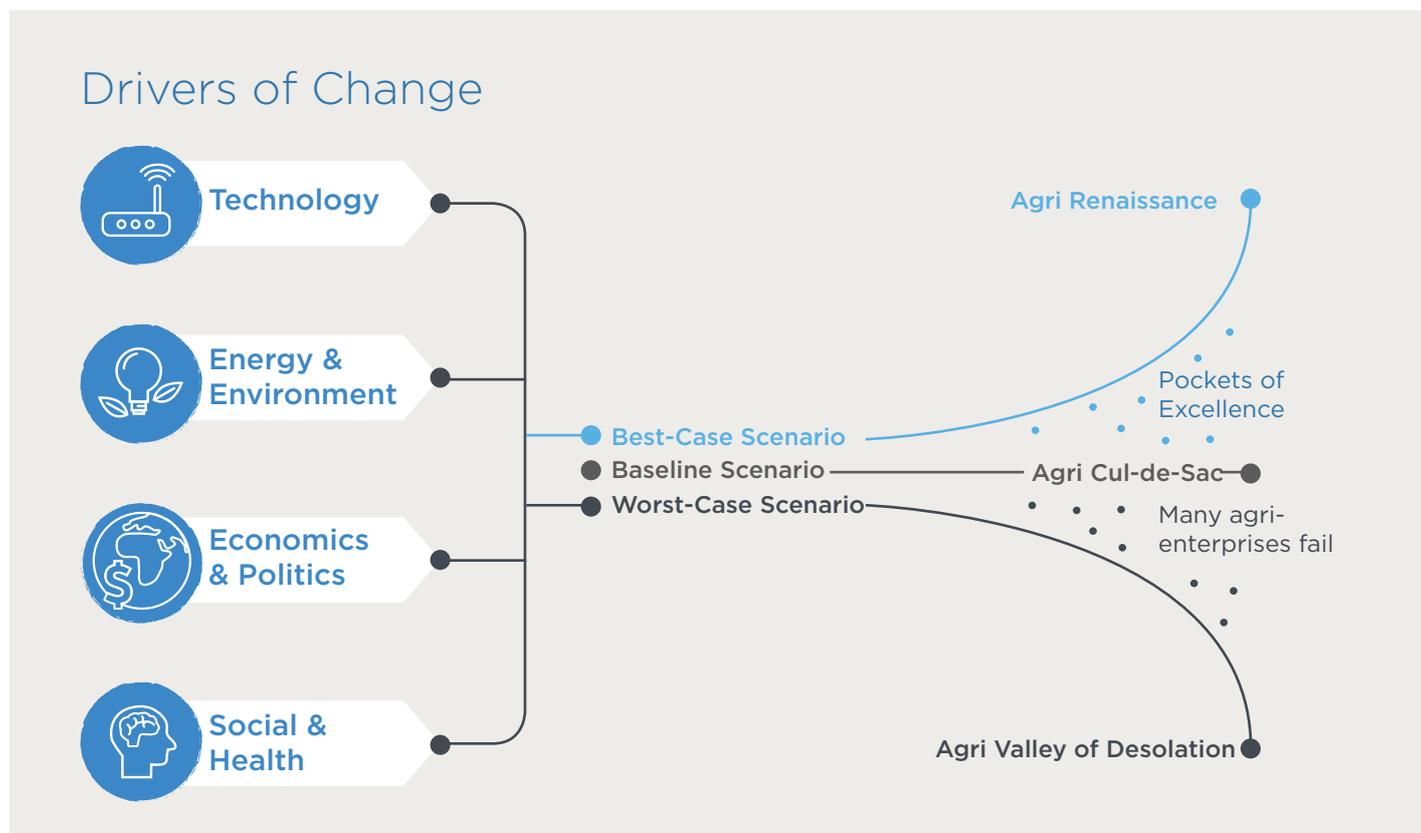
### Scenario 2: Best-case scenario ('Agri Renaissance')

In this best-case scenario, agriculture embraces technology developments through the adoption of, amongst others, farm-management software, precision agriculture and predictive data analytics. This helps to monitor crop health, weather and soil quality, robotics and drones, production value chain platforms, and smart irrigation – resulting in higher yields and significant cost reductions. The accelerated adoption of technology offers new and efficient ways of farming, leading to increased competition amongst agri-producers.

Commercially viable renewable energy alternatives via wind, solar, biomass and waves are achieved, while innovative applications to water usage and management become commonplace. Initiatives aimed to prevent, adapt to and mitigate climate change, and soil erosion have positive knock-on effects throughout the value chain. Dissemination of relevant knowledge by the agri-sector is aligned with buying behaviour and patterns of the growing middle class. Amidst increasing automation, vocational education has adapted to meet the demands of new skills requirements. Ideological and social pressures on society are relieved through inclusivity and concerted efforts toward collaboration by all stakeholders.

The achievement of political harmony and cooperation results in economic expansion, able to meet the social expectations of citizens, and within which the agri-community thrives. This shift implies that agri-producers can evolve at a rate aligned with change in the larger business environment, and enjoy

Figure 8: Future scenarios for the Western Cape



profitable returns from an expanding local and global market. While the zeitgeist is disruptive, agri-producers manage to invest in mitigation strategies to cope, and by positioning themselves as partners in inclusive sustainable development, they enhance their social contract among citizens and societal stakeholders. Due to the opportunities presented by expanding markets and conducive conditions, new AgTech entrants see the Western Cape as highly favourable, resulting in a series of mergers and acquisitions that stimulate a strong tech-enabled agri-environment, posing significant challenges to the value proposition of local producers.

#### or 'Pockets of Excellence'

'Pockets of Excellence' is a sub-scenario in which only some agri-producers can make the social, financial, technological and business model transition to navigate the immediate future. Consequently, these isolated producers maintain a competitive position, while their peers are

overwhelmed by the external changes in the environment.

#### Scenario 3: Worst-case scenario ('Agri Valley of Desolation')

In the worst-case scenario, the drivers of change converge in a destructive, reinforcing cycle of decline. Agri-producers are unable or unwilling to respond to technology advancements and developments in AgTech. Others adopt technology as an attractive production increase and cost-reduction mechanism. Many agri-producers drift towards a survivalist attitude.

Energy security has become so under pressure that affordable uninterrupted availability of energy sources is taking severe strain, while water shortages, soil deterioration and related climate extremities lead to many producers shutting down their operations. As ideological and political conflict worsens,

the economy stalls, followed by further ratings downgrades and a series of divestments by significant players in the provincial agricultural production value chain. Social pressures rise, further eroding the social fabric characterised by power struggles and increasing non-political actors impacting provincial events. Youth unemployment reaches unprecedented levels, escalating social ills, crime and violence. The infrastructure cannot support the demographic shifts and urbanisation, placing further pressure on agriculture and food production. In this scenario, agriculture in the Western Cape becomes a desolate sector.

#### or 'Some Agri-Producers Fail'

'Some Agri-Producers Fail' is a sub-scenario in which economic conditions get worse. Established agri-players with strong market penetration can survive while some are unable to make the transitions required, and fail.

# The rise of agricultural technologies

*It is well understood that technology will alter how humankind interacts with the environment in the context of the Fourth Industrial Revolution (4IR), in particular activities such as agriculture on which we rely to get food on our plates. But what is the potential of technology in the context of farming in the Western Cape?*

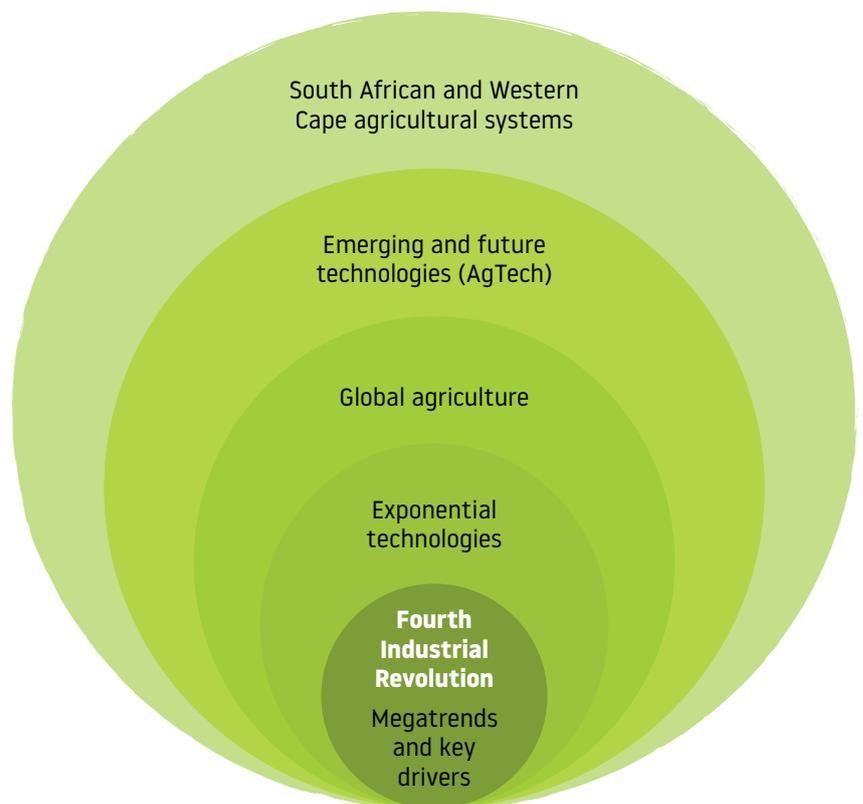
## Taking a closer look

In addition to the number and interrelatedness of the technologies being developed, it is the speed at which these technologies are being improved upon, innovation, and finding new applications not previously considered that remain key.

Exponential technologies are impacting multiple industries and facets of humanity, not least of which are systems of production, overall management and governance norms.<sup>2</sup> These technologies can both in themselves and through their convergence create new products and markets, redefine customers and consumers, and reshape the very fundamentals of the way we do business.

This section of the report integrates literature reviews on technologies of the 4IR in the context of the agricultural sector of the Western Cape. Views obtained from experts in agriculture and discussion groups of value chain participants were analysed to derive high-level conclusions

Figure 9: Systems, drivers and technologies



and recommendations on the impact of the 4IR on agriculture in the Western Cape.

Technology is defined elsewhere as ‘the systematic application of (exact) scientific knowledge for practical purposes’.<sup>18</sup> Although this is a wide definition, technologies in agriculture that immediately spring to mind include remote sensing, precision seeding or fertiliser application and others mostly related to mechanisation. This, however, offers only a very limited view of the potential impact of technologies related to the 4IR on agriculture in general, and potentially in the Western Cape.

In agriculture, information and communication technologies have grown significantly in recent years in both scale and scope. The Internet of Things and technologies such as big data analysis and robotics have revolutionised agriculture. Breakthroughs in artificial intelligence (AI), robotics, information management and processing, biotechnology, nanotechnology and autonomous vehicles have also sharpened our focus on the impact of technology on our world.

But the convergence of technologies may also cause compound interference when the underlying technologies are starting to influence the rate of acceleration of each other. The advances in artificial intelligence and machine learning are, for instance, allowing for greater and faster advancements in robotics. This, in turn, allows for faster and greater advances in artificial intelligence and machine learning, and so the cycle continues.

### The technology matrix

The base technologies were initially identified from the literature by the Netherlands Study Centre for Technology Trends (STT)<sup>18</sup>, and were classified into current and future technologies with application in agriculture (functional applications and systems). Furthermore, the contextual framework of these technologies is also emphasised (including policy, climate, labour and resources).

The technologies studied were mostly limited to those with direct application in agricultural systems and applications, even if potentially in future. Literature studies highlighted certain technologies, which

were driven by the 4IR, and which were known to disrupt industries, including agriculture. These technologies were then mapped according to categories used in a recent World Economic Forum (WEF) report<sup>41</sup> that considered the role of technology innovation in accelerating food systems transformation against our selected technologies (Table 3).

In selecting these technologies, its relevance to the South African agricultural sector – in particular, that of the Western Cape agricultural sector – was tested. The existence of these technologies in South Africa, albeit at different stages of development and application, supported the list of technologies used in this study. These technologies are also known to be the focus of development in other territories globally. It is expected they would eventually play some significant role in South Africa’s agricultural sector, as the country also experiences the international megatrends described elsewhere in this report.

**Table 3: Mapping of selected technologies in comparison with the methodology in the WEF study<sup>41</sup>**

Categories	Cited technologies	Our mapped technologies
Advances in science	Next-generation biotechnologies and genomics, sequencing • Efficient energy technologies	Protein transition • Biofabrication • Genetics • Synthetic biology • Bioinformatics • Food design • Food preservation technology • Renewable energy • Biorefinery and biofuels • Recycling and waste management
Digital building blocks	Big data and advanced computing systems • Internet of Things • Artificial intelligence • Machine learning • Blockchain	Artificial intelligence/machine learning • Information and communications technology/information technology • Internet of Things • Big data • Blockchain • Cryptocurrency
New physical systems	Autonomous vehicles • Unmanned aerial vehicles • Robotics • Manufacturing advancements (3D and 4D printing) • Advanced materials • Nanotechnology	Unmanned aerial vehicle technology • Transport technology • Sensor technology • Robotics • 3D and 4D printing • Advanced/smart materials

## Overview and applications

This section provides a snapshot of relevant and emerging agricultural technologies as outlined above. More

comprehensive descriptions and references are provided in Annexure A, where the definition, current uses,

future development and an indication of synergies with other technologies are shown.



### Smart farming

Smart farming is also known as satellite agriculture, location-specific crop management or precision farming. Precision farming uses geographic information systems, GPS, variable-rate technology and remote sensing technologies, where smart farming also incorporates technologies like robotics, the Internet of Things and big data.

In smart farming, a farmer considers the individual needs of a plant or animal instead of a field or a herd, taking into account specific soil and climatic conditions to optimise yield. It is based on data analysis and requires decision support systems and adapted technology, which is mostly dependent on other technologies.

Recent developments in this field include ever-increasing data exchange between machines, management systems and service providers, development of injection systems, weed burners and specific implements for crop rows. Smart farming is expected to increase production per crop, and make production systems more efficient in future.

#### Current uses

Current uses of smart farming include, amongst others, precision planting, precision spraying, precision irrigation, field monitoring, data management and precision weeding.

#### Future uses

In future, smart farming robots perform autonomously. Sensors allow them to evaluate situations and make decisions.

#### Synergistic technologies

Artificial intelligence • Machine learning • Robotics • UAVs • Information and communication technology • Big data



### Bioinformatics

Bioinformatics is an umbrella term for the body of biological studies that use computer programming as part of their methodology and a reference to specific analysis 'pipelines' that are repeatedly used, particularly in genomics. Common uses include the identification of candidate genes and nucleotides, in order to understand the genetic basis of diseases and to understand the organisational principles within proteomics. This includes nucleotide and amino acid sequences, protein domains, and protein structures.

The sequencing of the genomes of plants and animals provides enormous benefits for farming. Bioinformatic tools can be used to search for the genes within those genomes that are useful for the agricultural community and to elucidate their functions. This specific genetic knowledge could then be used to produce drought- and insect-resistant crops and improve the quality of livestock, among other uses.

#### Current uses

It is used for crop breeding, to improve nutritional quality, animal production and to control infectious diseases, among others.

#### Future uses

It can be used to improve plant resistance to diseases and to increase cultivation of crops in poorer soils, among others.

#### Synergistic technologies

Smart farming • Genetics • Sensor technology • Information technology and infrastructure



### Information and communication technology (ICT)

This refers to the connection of telecommunications (telephone lines and wireless signals), computers, software, middleware, storage and audio-visual systems. It enables network users to access, store, transmit, and manipulate information. Its infrastructure components include hardware, software, networking, wireless, and computer systems, among others.

#### Current uses

Embedding ICT systems in farm processes using sensors is enabling more precise management. Robotics and automation have reduced human labour in many tedious operations. Real-time data input from sensor networks and the ability to process 'big data' improve efficiency on farms.

#### Future uses

ICT will advance agriculture by enabling real-time access to cloud computing, in particular image recognition and video analytics. There is a need for ICT to transition from large farms in developed countries to smallholder agriculture in developing countries. Luckily, sensors are becoming cheaper, but also more versatile, multifunctional and robust, and more easily networked. To bring this technology into smallholder agriculture, there would need to be significant aggregation and sharing of data and information.

#### Synergistic technologies

Artificial intelligence • Machine learning • Internet of Things



## Smart water

Water technology has a significant role to play in alleviating some of the impacts of drought in agriculture. It can increase water efficiency and productivity. Monitoring technologies can, for instance, improve the integrity of water supply networks. Electronic instruments, such as pressure sensors, that are connected wirelessly in real time to centralised and cloud-based monitoring systems, can detect and pinpoint leaks.

### Current uses

Smart water technologies include remote sensing, solar power for irrigation, UAVs, seasonal hydrological forecasting, intelligent irrigation and waste-water treatment technologies. There are many remote sensing platforms available that can be very useful in reducing irrigation, but also potentially to monitor water resources.

### Future uses

All of the smart water technologies are useful to reduce water stress within the next decade. Their overall impact will be determined by the affordability of the technology, its geographical viability, how complicated the technology is for farmers to use and the perceived risks that it presents to society.

Remote sensing technology provides farmers with free access to satellite information about how well their crops are growing and how much water they are using. In future, smart farming robots perform autonomously. Sensors allow them to evaluate situations and take decisions.

The introduction of solar energy desalination could make this technology more cost-effective.

### Synergistic technologies

Smart farming • Renewable energy • Water management and recycling • Climate and weather



## Nanotechnology

This is the engineering of functional systems at the molecular scale (of 1-100 nanometres). One nanometre is a billionth (or  $10^{-9}$ ) of a metre.

In the 'bottom-up' approach, materials and devices are built from molecular components that assemble themselves chemically by principles of molecular recognition. In the 'top-down' approach, nano-objects are constructed from larger entities without atomic-level control, similar to additive versus subtractive manufacturing.

### Current uses

It is used to minimise nutrient losses in fertilisation and increase yields through optimised nutrient management, among others. There are already soil-enhancer products that promote even water distribution, storage and consequently water saving. It appears the high costs involved in developing nanotechnology restricts large-scale commercial adoption by farmers due to the lower margins achieved in agriculture.

### Future uses

It seems that a cost reduction of the useful applications may be the best advancement for these technologies in agriculture.

### Synergistic technologies

Robotics • Smart materials • Biofabrication



## Protein transition

Protein transition becomes synonymous with meat substitutes, in response to environmental concerns around global warming due to, amongst others, methane gas production by animals and population growth. There are three broad categories of alternatives to meat, namely meat alternatives (including plants and fungi), cultured meat or in-vitro meat (meat derived from tissue and cells grown in a laboratory), and genetically modified organisms (animals that have had their genome artificially altered). Cloned animals are possibly a fourth category of artificial meat. Replacing meat from livestock with meat cultures in laboratories involves growing protein cells from a culture of animal stem cells, or the whole muscle is synthesised in a laboratory. The principles of tissue engineering are applied. Protein substitution can also be used for animal feeds.

### Current uses

Insect burgers and vegetarian 'butcher' meat are on the market. These products look like meat, but are made from the proteins of mushrooms, soy or dairy products. Chicken nuggets and croquettes contain a mixture of meat and 'alternative proteins'. This technique is used in meat substitutes from plants and mycoproteins. The commercial insect sector for protein replacement is likely to grow rapidly.

### Future uses

Cloning of meat from animals that are genetically modified, diet makeovers (including insect-based protein diets) and artificial meat based on cell and tissue culture cell production could follow.

### Synergistic technologies

3D printing • Genetics • Aquaculture • Renewable energies



## Sensor technology

Sensors detect events or changes in its environment and send information to other electronics. Sensor technology is used to collect soil, crop and animal data through the integration of different kinds of agricultural equipment and machines, aircraft, drones or even satellites. Sensors can provide real-time information, enabling producers to farm more effectively. It can also be useful in planning, crop/livestock management, as well as in processing and harvesting. Sensors are also used in transport technology, to improve farm security and for product traceability. It can be integrated into the entire value chain in farming, supply chain or post-harvest systems.

### Current uses

Of particular relevance are environmental (climate), soil and water monitoring (terrestrial sensors), and remote sensing devices.

### Future uses

Sensors are base elements that form and mould several further applications. Without sensors, weather stations, remote sensing, robotics as well as data applications including smart farming and precision agriculture are virtually impossible. Sensors are bound to become smarter, smaller, cheaper and more integrated into farming systems.

### Synergistic technologies

Smart farming • UAVs • Robotics • Internet of Things • Machine learning • Big data • Nanotechnology • Smart water • Transport technology • Information technology



## Unmanned aerial vehicle technology

Unmanned aerial vehicles (UAVs), sometimes termed 'drones', are part of unmanned aerial systems. UAVs are aircrafts without on-board human pilots that are controlled autonomously or remotely. Drones have advantages over piloted or satellite surveys, including improved accuracy and resolution, and frequency of data delivery.

### Current uses

Drones are used for surveying, remote sensing, and crop health assessment. After planting, drone-driven soil analysis can, for instance, provide data for irrigation and nitrogen level management. Drones can help to identify which parts of a field are dry or to precisely apply pesticides to crops through early detection.

### Future uses

UAVs increase the viability of large-scale spraying technologies, as well as yield detection using other sensing systems. It may also change the way weather sensors are operated and may enable localised and real-time weather data on a farm level.

### Synergistic technologies

Robotics • Sensors • Internet of Things • Artificial intelligence • Precision and smart farming • Smart water



## Robotics

Robotics deals with the design, construction, and operation of robots in automation. This is a field where multiple technologies and disciplines overlap. Robots are typically designed to perform tasks that humans cannot do, or cannot do as well as a machine could.

### Current uses

Industrial robotics, bionics and autonomous vehicles are examples of agricultural uses. Robotics is at the cutting edge of increasing the food supply as well as increasing yield on farms. Tasks like planting and packing lend themselves to automation. Specially designed and integrated robots can reduce the number of systems and components needed to create simpler, more reliable machines. Examples include robots that can identify ripe berries and harvest them automatically at high speed without damaging the crop.

### Future uses

With advances in machine learning and big data analytics, robots can now learn from incredibly large samples of data. Robots seem likely to start to emulate human intelligence and usefulness more closely. More and more tasks previously reserved for the human operator who had to use discretion will be performed by machines. The line between what humans can do well and what machines can do well is becoming increasingly blurry.

It seems inevitable that as artificial intelligence becomes more powerful, human involvement in tasks such as manually operating a machine will become less valuable. As costs of robotics fall, opportunities for farm labourers seem likely to decline in frequency. Farmers will look to adopt robotics in all facets of farming should the price reduce enough to warrant the investment.

### Synergistic technologies

Big data • Sensor technology • Precision and smart farming • Internet of Things • Information technology • UAV technology • Machine learning • Artificial intelligence



### Food preservation technology

This is a process of maintaining the original quality or existing state of food by treatment(s) that will prevent its spoilage or deterioration. It implies putting microorganisms in a hostile environment to cause their death. Food preservation refers to several techniques used to prevent food from spoiling, including the application of heat (such as canning and preserving), fermentation and controlled atmosphere techniques (containers).

#### Current uses

The main benefit is the inactivation of foodborne pathogens, natural toxins and enzymes.

#### Future uses

It could be used in packaging and the 3D printing of food, among others.

#### Synergistic technologies

Food design • Sensor technologies • Smart materials • Biofabrication



### Renewable energy

Renewable energy can reduce the environmental impact of agriculture while making farms more competitive. The declining cost of renewable energy is a major driver for its adoption on farms. It can be generated from biomass, solar, wind, tidal, wave, and hydroelectric power.

#### Current uses

Technologies that are already in use include biomass, wind and micro-hydro energy, solar photo-voltaic, solar thermal and solar water heating installations.

#### Future uses

Many of these technologies are in the early adoption phase and set to develop in future as costs are driven down. Considerable potential exists to generate renewable energy in the province.

#### Synergistic technologies

Smart water • Waste management and recycling



### Synthetic biology

This is the design of biological systems and living organisms using engineering principles with the objectives of contributing to research on the fundamental mechanisms of life itself, deploying biology as a technology for constructive purposes, and extending or modifying the behaviour of organisms and engineering them to perform new tasks. Synthetic biology combines scientific disciplines and involves the design of biological systems, using standardised components that have been created in a laboratory. This goes beyond the transfer of pre-existing individual genes, encompassing a broader range of genetic engineering strategies, from the tinkering of the genetic code itself to the complete synthesis of microorganisms, including the design of novel proteins and metabolic pathway engineering. Two different approaches may be distinguished: the modification of existing cells, or the complete construction of artificial systems.

#### Current uses

It is used to increase biomass yield, in chemical synthesis, biosensor applications, biomaterials, plastics and textiles, among others.

#### Future uses

It can be used to create new crops with desirable traits (drought-tolerance and pest-resistance). By manipulating genes, brand new foods can be created with new properties or flavours. The development of new gene-delivery technologies will enable the development of new seed products with multiple genetic traits. It could be used to develop new types of eco-friendly pesticides, among others.

#### Synergistic technologies

Genetics • Bioinformatics • Biorefinery and biofuels



### Transport technology

Transport includes moving goods or commuters by road, rail, air and water. Some of the key components of transportation addressed by technology include infrastructure (roads, rails), equipment and vehicles, people, supply and demand for cargo, and energy.

#### Current uses

Transport technology includes transport aggregation, self-driving cars and electric vehicles, among others. Autonomous tractors could presumably work unmanned around the clock and use GPS and sensor technology. The grower could remotely monitor and control the machine using a device such as a tablet. By having numerous, smaller autonomous tractors, farmers could reduce soil compaction and reduce labour costs.

Battery technology still needs to improve for effective usage of electric tractors. However, the usage of electric tractors will soon become cheaper than existing machines as the price and efficiency of batteries and solar panels improve.

#### Future uses

Apart from the hyperloop train, flying cars and magnetic levitation, cryptocurrency credits may apply to the agriculture value chain.

#### Synergistic technologies

Robotics • Vertical farming • Sensors



## Artificial intelligence/ Machine learning

Artificial intelligence (AI) is a branch of computer science dealing with the simulation of intelligent behaviour in computers. It describes a machine which exhibits human intelligence by performing acts such as learning, reasoning, perception, planning and problem-solving.

Machine vision is the technology that, in machines, automates the capture of images and the analysis thereof. It can perform image analysis at high speed and in combination with other sensory information.

Machine learning is a method of data analysis that automates analytical model building. Using algorithms that iteratively learn from data, machine learning allows computers to find hidden insights without being explicitly programmed where to look. It is essentially a predictive computer program that becomes better over time as it learns from success and failure.

### Current uses

AI has many applications in smart and automated agriculture. Sensors around the farm give real-time updates to the AI system, which can be trained to send the correct response to that area. This can guide a farmer toward 'perfect' farming and when used at scale, would create tremendous efficiencies. Within farm robotics, an AI system could coordinate many robots to work harmoniously so that the farm runs more efficiently and reacts to changes more quickly and effectively.

### Future uses

Areas where AI is advancing is through big data analytics and prescriptive modelling. AI will continue to develop rapidly.

### Synergistic technologies

Information and communication technology • Robotics • Information technology • Big data



## Vertical agriculture

Controlled urban agriculture, or controlled environment agriculture, includes any form of agriculture where environmental conditions (such as light, temperature, humidity, radiation and nutrient cycling) are controlled in conjunction with urban architecture or green infrastructure. It can be defined as a system of commercial farming whereby plants, animals, fungi and other life forms are cultivated for food, fuel, fibre or other products or services by artificially stacking them vertically above each other, such as in a skyscraper, used warehouse, or shipping container(s). The concept anticipates the cultivation of fruits, vegetables, medicinal, fuel-producing plants and other plant products in the cities and their sales directly within the cities, thereby reducing the transportation costs and promoting efficient utilisation of land and water resources.

More modern versions of vertical farming use indoor farming techniques and controlled environment agriculture technology, where all environmental factors are controlled.

### Current uses

It is used for continuous crop production. The land productivity of vertical farming is more than twice as high and faster as traditional agriculture. For the same floor area, vertical eco-farm systems' multi-level design provides nearly eight times more growing area than single-level hydroponic or greenhouse systems or open field systems.

### Future uses

It could be used for water purification desalination and the atmospheric capture of water. Vertical agriculture will allow production closer to the consumer, thus cutting transport cost.

### Synergistic technologies

Biorefinery and biofuels • Renewable energy • Sensor technology • Aquaculture • Smart farming • Information technology



## Food design

The term 'functional foods' refers to processed foods containing ingredients that aid specific bodily functions in addition to being nutritious. Functional foods may, therefore, be defined as natural or processed foods that contain known or unknown biologically active compounds, which provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease.

### Current uses

It is used to produce food products with less fat, sugar or salt without affecting the taste, structure and (eating) experience; products with a different structure (for example less grainy or easier to chew); and products with a specific aesthetic attraction (including smell, shape and colour).

### Future uses

3D printing may enable households to design their own food, and print it. It could be possible to produce personalised foods (based on nutrigenomics, derived from an individual's genetic profile).

### Synergistic technologies

3D printing • 4D printing • Synthetic biology



### 3D and 4D printing

3D printing is a term used to describe manufacturing that builds products from a 3D design by depositing materials layer by layer. It is also called 'additive manufacturing'. Almost anything can be modelled in 3D and be made of plastics, metals or even organic matter. 4D printing adds a fourth dimension to 3D-printed objects, namely movement. It works by 3D printing with multiple materials and embedding movements into the 3D-printed object so that with a bit of energy, it pulls itself into shape, much like proteins automatically folding in living cells.

#### Current uses

While 3D printing is not currently as directly applicable to farming as other technologies, it is being used in some agricultural operations. Most additive manufacturing methods are used upstream in agricultural equipment manufacturing. 3D printing and 3D-printed foods, meats and vegetables could have a large impact on agriculture (biofabrication). Equipment manufacturers are using 3D printing, which has brought down the cost of machinery and resulted in faster development of new equipment. 3D-printed equipment is emerging in the field of hydroponics, with open-source equipment and designs used.

#### Future uses

4D printing could enable self-assembling and repairing products as well as smart materials that can perform basic computations. While this technology is not commercially available, good progress is being made in the field. The rapid prototyping of tools and replacement parts for farmers in remote areas is also possible. The alternative is parts that would need to be imported at great cost. This also reduces waiting and downtime.

#### Synergistic technologies

Food design • Sensor technology • Smart materials • Smart water • Waste management and recycling



### Biorefinery and biofuels

Biorefining is the processing of biomass into a spectrum of marketable bio-based products (food, feed, chemicals and materials) and bioenergy (biofuels, power and heat).

#### Current uses

It is used in starch-based biorefineries (wet and dry mills) and the fractionation of feedstock, among others.

#### Future uses

Algae could be used to produce fuel and for refining waste water and manure into high-value products, among others.

#### Synergistic technologies

Genetics • Bioinformatics • Waste management and recycling • Synthetic biology



### Internet of Things

The Internet of Things (IoT) refers to any object that is connected to the internet. Internet-connected things can communicate and react with each other without the need of human intervention. This is creating a truly vast array of networks and sensors, which may also be directly applicable in the agricultural environment.

#### Current uses

Current use in agriculture is linked to any sensor connected to the internet, able to produce data that can then be analysed.

#### Future uses

It is expected to play a key role in weather prediction, agriculture supply chain management in future. IoT in agriculture is limited by current connectivity in outlying regions.

#### Synergistic technologies

Information and communication technologies • Big data • Sensor technology • Machine learning • Artificial intelligence • Robotics • UAV technology • Smart farming



### Genetics

Genetic engineering, also called genetic modification, is the direct manipulation of an organism's genome using biotechnology. It is a set of technologies used to change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce improved or novel organisms. As well as inserting genes, the process can also be used to remove, or 'knock out', genes.

Genetic engineering, therefore, alters the genetic makeup of an organism. Agricultural genetics is the applied study of the effects of genetic variation and selection used to propagate desired and useful traits in animals and crops.

#### Current uses

It is used to improve herbicide tolerance, to delay fruit ripening, produce food products with improved nutritional value, and for research (including genetic engineering and tissue culture), among others.

#### Future uses

It could be used to develop genetically modified crops for small-scale farmers, to improve crop yield, and enhance the nutritional content of crops, among others.

#### Synergistic technologies

Synthetic biology • Biorefinery and biofuels • Food design • Bioinformatics • Protein transition

## What does this mean for farming in the Western Cape?

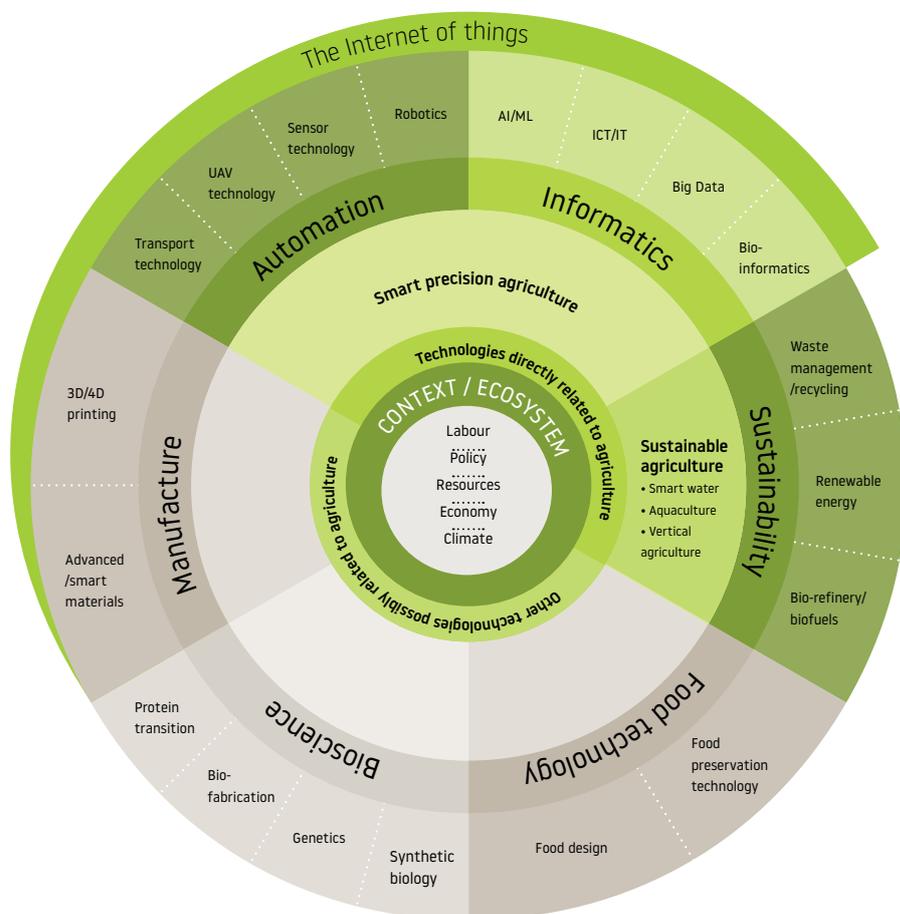
The Western Cape Digital Disruption Report<sup>40</sup> takes the view that agriculture disruption will have a medium impact over a long-term (5-10 years) compared to other industries, i.e. financial services, partly because the industry displays low digital maturity.

The majority of farms within South Africa are classified as small businesses, which creates challenges in full-scale adoption of digital technologies and capabilities, and so the impact of digital transformation is not deeply felt.<sup>40</sup>

Global megatrends, envisaged to shape the future of global agriculture, brought into sharp focus the role that technologies could play. This is particularly the case for the envisaged effects of food systems, and the transformation thereof, to feed a growing global population (estimated to reach 8,5 billion people in 2030).<sup>42</sup> Other trends expected to influence food systems are inequality of wealth and slow economic growth, urban migration, poverty, reliance on small producers for food production, malnutrition, depletion of natural resources due to unsustainable agricultural practices and climate change, large-scale displacement of people, and the advent of the 4IR.<sup>36,43,44,45,46,47</sup> Many of these issues are already relevant to the current environment but need to be altered within the context of policy, resources and social issues specific to the Western Cape.

As may be inferred from Table 3 (page 19), our technology mapping exercise is close to that of the cited literature, which provides some confidence that this study is in line with international thinking and rationalisation of the categorisation of the selected technologies.

Figure 10: Technologies, systems and applications



A growing Western Cape population with increasing urbanisation and a deteriorating natural resource base implies more people to feed with less water, farmland and rural labour. The expected increases in water, energy and food also requires a shift to more sustainable consumption and production, with agriculture and food systems made more efficient and sustainable.<sup>36</sup>

**In the Western Cape agricultural context, the following considerations must be mentioned:**

- 1. Sustainable farming technologies** and systems and related technologies. These include smart water and renewables aligning with a focus on sustainable agriculture systems

(including the SmartAgri initiative and Fruitlook). The technology used in site selection for farming and planning will be crucial.

- 2. Informatics** (including artificial intelligence and big data) is very important but strongly linked to skills development to exploit technology in a farm management context.
- 3. The context of labour and policy** may drive the applications of technologies such as robotics, UAVs, and certain sensor applications. The agricultural sector is a focus of the provincial government due to the large absorption of unskilled labour that contributes to economic and social growth.<sup>40</sup>

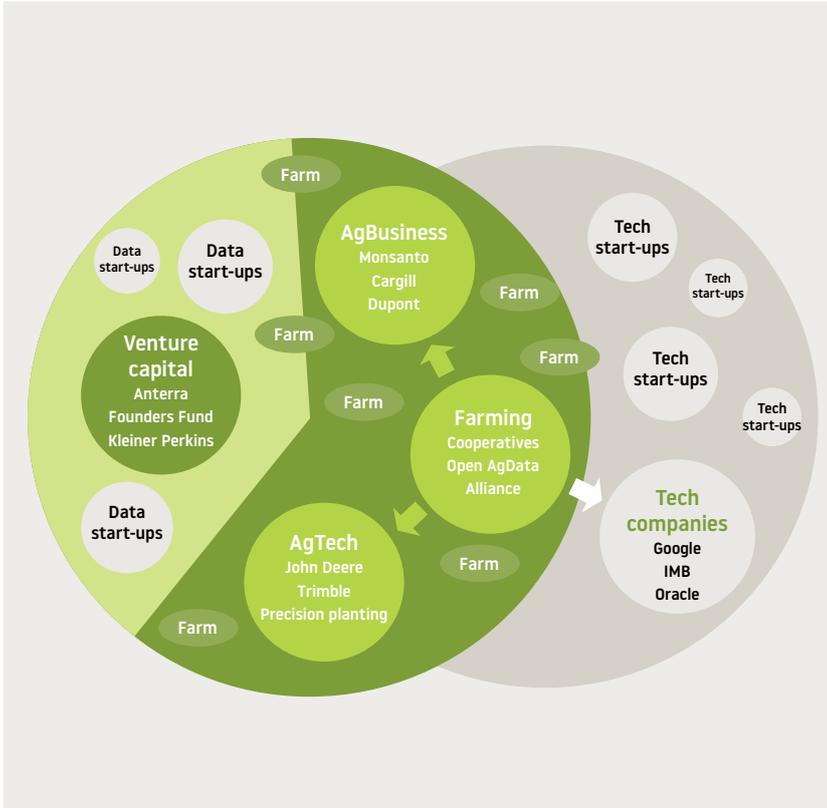


Figure 11: The landscape of big data as an example of a network with business players in agriculture<sup>48</sup>

Technologies were initially classified according to the previously mentioned Dutch study, but as literature was consulted, a visual representation (Figure 10 on page 26) was developed to group technologies functionally into agricultural applications and systems. This highlighted the contextual nature of technology, in order to emphasise that these technologies rarely stand without contextual issues, alterations, application modifications, etc. For instance, labour policy may affect how robotics will develop, while UAV applications may be modified due to legislative policies. Climate and weather are also seen as contextual, as it is an overarching natural system in which technologies play a role in assessing, acting on and predicting future scenarios.

There is an apparent lack of integration between the scientific community and the producers of hardware, as well as the designers and implementers of informatics.<sup>48</sup>

Some technologies will only find their way into the provincial agricultural domain with proper links between the science, application and enabling environments with regards to policy and incentives for entrepreneurs. As an example, the landscape of big data is presented from the study by Wolfert<sup>48</sup>, where an effective network is shown (Figure 11).

Technologies are also rarely operational in isolation in agriculture. This is why we also attempted to show the links between different technologies, systems and applications. To illustrate some of the interactions between systems, see Figure 12 (above) where 'smart systems' interact with a theme of event and data management. This can be pulled through to both smart farming systems and smart water as dealt with in our technology review.

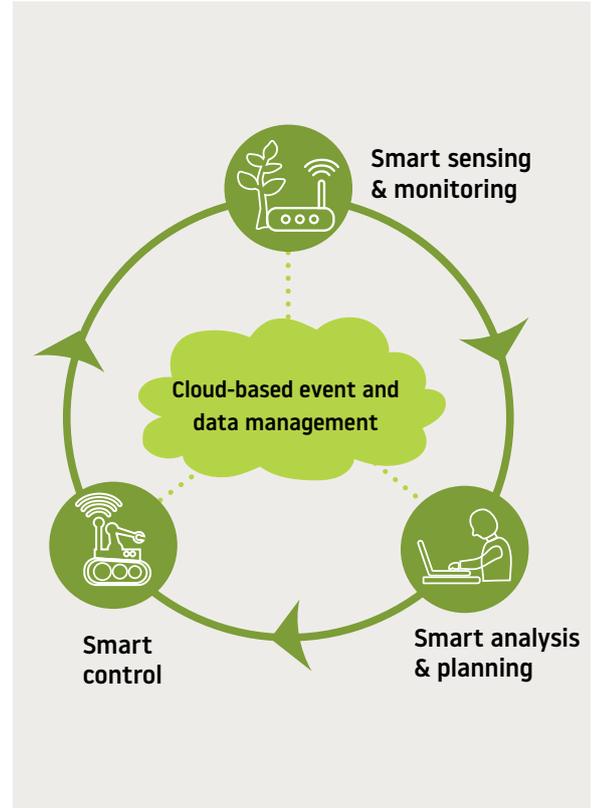


Figure 12: Using data to enhance smart farming<sup>48</sup>

The 4IR provides opportunities for the provincial government to create mechanisms that will allow for the appropriate response to the revolution, in line with global responses in this space. This can be done through a systemic approach to understanding prevailing megatrends and demands, value chain systems, the desire to promote value chain linkages, and creating a conducive environment to embrace the 4IR for effective production systems.

Also, we can conclude, similar to the WEF report<sup>41</sup>, that 'innovation ecosystems' are needed adjacent to agriculture, to incentivise and accelerate technology innovation. The key elements to achieve this are enabling policy, infrastructure, investment, business support services and access to academic and research institutions.

## Future disruptions in agriculture

Agriculture disruption will take place over a longer period compared to other industries. There is the view that agriculture is still a digitally immature sector, especially in the Western Cape.<sup>40</sup>

In general, our view on future technology disruptors are in line with global thinking regarding agriculture-specific disruptors as reflected on in the Western Cape Digital Disruption Report<sup>40</sup> and Deloitte’s analysis (‘From Agriculture to AgTech’) on the subject<sup>13</sup>. For comparative purposes, we have included their breakdown of

agricultural disruptors in Table 4 and Figure 13 below.

The following disruptive technologies were identified from the Deloitte study<sup>13</sup>:

- Advanced application of **biological technologies**, tissues, and organisms (biotechnology);
- Advanced **manufacturing technologies** including 3D printing and robotics;
- **Autonomous vehicles** that perform tasks like phenotyping or fumigating plants; and
- **Devices and sensors** communicating data via mobile and **smart connectivity**.

This study further highlighted some innovations that also incorporate technology into the innovative solutions mentioned. See Figure 13 below.

The main differences we found with respect to technologies are related to a focus on local issues such as drought (water management related technologies) and about the use of genetics (GMOs). We take a much wider view on future agricultural disruptors in the province to include bio-manufacturing, bioplastics and bio-energy.

**Figure 13: Innovation fields and technological innovations that could help harvest ‘value zones’<sup>13</sup>**

Smart agricultural technology innovators harvest these value zones by building simple, customer-centric solutions

### Identified innovation fields

### Innovators’ solutions to capture value zones



#### Rerouting value chains

Reducing inefficiencies along the value chain  
Includes farm2consumers, waste-reduction technologies and other technologies

**Meal kit delivery, off-farm delivery, e-groceries, crop waste reuse, food waste reuse and reduction, shelf-life enhancing and monitoring**



#### Crop efficiency technology

Increasing yields at decreased input  
Includes satellite imaging, drones, robotics, artificial intelligence, big data, irrigation and soil technologies

**Agricultural data analytics, robots, drones, sensors, Internet of Things monitoring, farm equipment sharing, efficient irrigation systems, soil and crop technologies, smart phenotyping, satellite imagery**



#### Biochemicals and bio-energy

Ongoing trend to biological production technologies  
Includes bio-energy production, biochemical and biomaterials

**Biologically produced agrochemicals, microbe-based bioengineering, biocrops and -seed, bioplastics, bio-energy, biogas plant technology**



#### Foodtech and artificial meat

Fairly new trends towards replacing meat  
Includes artificial meat and other sustainable protein technology as well as food technology

**Plant-based meat and egg substitution, sustainable protein, genome engineering, livestock genetics, macronutrient products**



#### Contained farming

Newest investment trend in the AgTech sector  
Vertical farming is largely focused on greenhouse and indoor farming technologies, hydroponics, etc.

**Smart indoor agriculture, vertical farming, contained farming data and technology platforms, LED lighting, aqua- and hydroponics**

Table 4: Agriculture-specific disruptors contained in the Western Cape Digital Disruption Report<sup>40</sup>

Business transformation themes	Agriculture disruption
Customer experience and value propositions	<p>Customer access to supply-chain information, expectations of sustainable production methods</p> <p>Customer ability to source directly from producers</p> <p>Ability to integrate into customer experience applications such as recipes or matching products</p>
Optimisation of operations	<p>Smart metrics create opportunity for zero-loss operations</p> <p>Simulation of production scenarios virtually enables rework to ensure best possible combination of inputs and best approaches before implementation, reducing risk of errors or poor yields</p>
Nature of work	<p>Directed work ensures the workforce executes the right operations or maintenance tasks at the right time</p> <p>Typical worker becoming an operator of smart machinery that requires increased digital literacy</p>
Technology themes	Agriculture disruption
Internet of Things	Remotely monitored and managed agricultural equipment and machinery using internet and digital sensors
Big data	<p>Enhanced farm management and decision-making regarding real-time operations, productivity and efficiency</p> <p>Greater accuracy in assessments of the condition of assets, enabling predictive maintenance</p> <p>Opportunity to share or aggregate data across providers at a regional or cooperative level</p>
Mobile connectivity	<p>Various applications for farm management, equipment inventory, improving crop productivity, tracking commodity prices and indicators, etc.</p> <p>Access to agricultural information</p>
Artificial intelligence	<p>Forecasting weather, crop yield, prices, pest and disease</p> <p>Precision quantification and application of nutrients and other inputs to improve yield and reduce waste</p>
Automation, robotics and 3D printing	<p>Various applications and agribots – drones to survey fields and crop, robotic harvesters, virtual assistants</p> <p>Partly 3D-printed infrastructure and production equipment components supporting improved maintenance (i.e. parts for implements)</p>

# The findings

*Today's global agricultural sector is on the verge of turning into a high-tech industry. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive. How do we ensure that agriculture in the Western Cape flourishes in the context of the 4IR?*

## About the findings

The findings of this report are presented within the framework of the five key research questions as specified in the research terms of reference and illustrated in Figure 14. Each of these themes is reported on based on an integration of the views solicited from expert interviews and focus groups as well as the literature review.

### Our main research questions:

1. What are the variables influencing change in the global agricultural environment?
2. What are the technologies and trends that will most likely have an impact on the Western Cape agricultural and agri-processing sector?
3. How can we describe and rank the economic, social and political impacts of these trends?
4. What should be done to minimise negative impacts and maximise positive opportunities?
5. Who needs to do what to enable the Western Cape agricultural sector to reap the opportunities associated with the 4IR, and to minimise its adverse effects and unintended consequences?

### Key trends reshaping the farming future

The most important trends that will reshape the global agricultural environment over the next five years are:

#### Climate change and water

Climate change will affect the total value chain from the quality and quantity of water available to primary agriculture, through to food-processing quality issues and the shelf life of foods. Extreme climatic events may disrupt food production due to slow adaptation to droughts, floods, hail and other natural causes. All indications are that we will have a hotter climate in future and that there will be less rainfall over the next 50 years than in the past. This means that farming will need to be productive under constantly changing climatic conditions. As the effect of climate change spreads globally, South Africa will need more drought-resistant and high-yielding varieties to deal with higher temperature conditions.

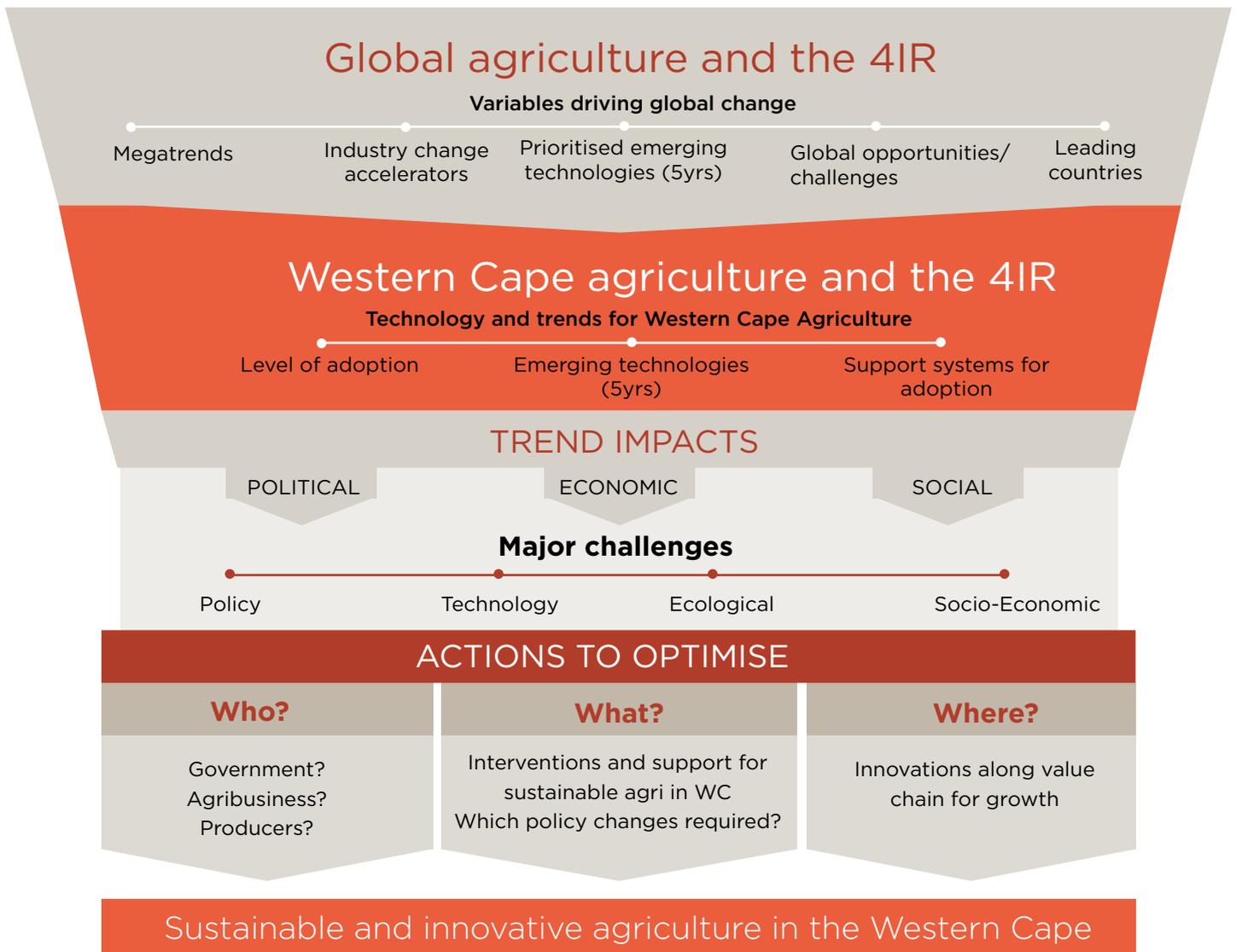
Although weather modification does not seem to be a short- or medium-term option for agriculture, coupled with high levels of consumer resistance, adaptation to climate change can be achieved through site selection and practice

modification (including cultivation under nets or in greenhouses). Climate variability may affect product consistency, especially during periods of heat and drought stress that may affect product yield and quality. Climate change may also affect weed resistance and biodiversity as well as the types of pests and diseases farmers may encounter in future.

According to the industry stakeholder groups interviewed, climate change is an evolutionary process that requires ongoing adaptation. This adaptation could even mean that crops are now better suited to areas where they could not have been grown before (i.e. champagne in England). An example of this is the introduction of alternative crops, which is part of the decision-making process of any farming operation. The SmartAgri plan of the WCDoA provides the framework for dealing effectively with climate change.

#### Big data, AI and machine learning

Big data, AI and machine learning are predicted to affect every aspect of the natural world concerning agriculture. The ability of humans to manipulate biology and improve biological systems will pay off in future. Furthermore, the ability to



**Figure 14: Overall study process and approach towards innovative agriculture**

make data more user-friendly through visualisation techniques implies that the results of (real-time) data analysis will be better understood and implemented in real time.

Big data provides productive insights into farming operations, drives real time operational decisions and can be used to redesign processes for game changing business models. It is likely that two extreme scenarios will dominate the big data landscape: (1) Closed, proprietary systems in which the farmer is part of a highly integrated value chain; and (2) open, collaborative systems in which the farmer, and every other role player, in

the chain network is flexible in choosing business partners for technologies and food production.

**Automation (including robotics, UAVs and transport technologies)**

Automation can assist in making planting, harvesting, processing and packaging more efficient, and is predicted to have a significant positive impact on farm production. From drones to self-driving tractors - automation will increase farm performance and decrease waste.

Robotics is considered a major emerging field in agriculture, but still requires development to realise its full potential.

The application of drones and satellites will increase to meet farming requirements and consumer demands.

**Precision farming and technology integration**

To reap the benefits of precision farming, multiple technologies need to work together in an integrated farming system, regardless of scale. Technology acceleration and the driving down of costs, facilitated by the integration of synergistic technologies and enabling platforms will be important precursors to wide-scale technology adoption.

### The consumer

Consumers are increasingly concerned about food quality, nutrition, traceability, and the use of herbicides, pesticides, fungicides and antibiotics in agriculture. In the future, food production will be driven by consumer demand for higher quality and nutritious food. Farm production

will increasingly be influenced by consumers who require a balance between ethical farming and environmentally sustainable practices, and economically viable production. Direct sales to the consumer (B2C) will continue to increase. Interestingly, the central role of the consumer in product and environmental

impacts was also confirmed by the industry discussion group, who further emphasised that economy and markets – and not necessarily the climate – drive farming. In response, farmers continuously adapt to meet market demands as a priority.

## Change accelerators that drive agriculture innovation

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### Producing more with less land

In the developed world, the available agricultural land is heading towards full utilisation. The (arguably) only option is to produce more food on smaller land sizes or adapt existing production systems.

### Small farming needs to be commercial and should produce a surplus

Enabling markets and structures will need to be developed so that smallholder farmers can participate within the agricultural value chain. This may require innovations by incorporating digital communication technologies in which the farmer has access to the end-consumer or the retailer. The first requirement will be to ensure that these smallholder producers are productive in a commercial sense, and producing for a market in which their produce will be exchanged for monetary gain profit. It is here that concepts around defining, developing and implementing a

digital quotient for these participants will need to be defined.

The cost of technology (hardware, storage costs, processing costs, data) is coming down and will accelerate technology adoption.

### Future farming will include technology uptake

The technologies considered most beneficial for increased productivity are broadband infrastructure, satellite-based augmentation systems (ICT and IoT) for connectivity in rural areas, GMOs, genetic sequencing and gene-editing, precision farming, robotics and mechanisation and big data handling and processing.

To achieve technology uptake, smart farming technologies will need to be rapidly adopted through technology demonstrations and piloting. Smallholder farmer success will require the adoption of innovative financial instruments, the precursor of which is a growing economy

wherein the financial backing of new and innovative financial instruments will be possible.

Ensuring effective technology uptake requires closer collaboration between key stakeholders and, specifically, agricultural practitioners, industry bodies, the science community and government.

### Consumerism shapes products

Consumerism, and the demands of consumers, shaped by their changing needs and perceptions, inform the buying power and needs of the consumer of the final (agricultural) product. The most important drivers of this behaviour are health consciousness, access to information and the need to know about fair trade practices and the origin of products (traceability and environmental sustainability practices). Related to this is the price the consumer will pay for products.

## Table 5: Countries leading in agricultural innovation

Table 5 provides a summary of agricultural innovation and new technologies by country, compiled from our interviews with experts.

Countries/Region	Examples of innovation and new technologies
Argentina	Conservation tillage
Australia	Production and marketing information on digital platforms; precision crop breeding; crop and livestock genomics; robotics; water management; precision/conservation production
Australia, USA	Water and irrigation technology
Australia, New Zealand	Forestry technology
Brazil	Cooperative forestry-management technology
China	Applications of genetic engineering technologies; genomics and advanced breeding; policy innovations; genome technologies; drone technology
Dubai	Creating support structures for large-scale drone deployment and implementation; the important aspect is not the drones, but rather the management system surrounding their use
East Africa	Knowledge bases and knowledge sharing
England	Large-scale implementation of hydroponic systems
European Union	Innovations in the aggregation of farms to exploit economies of scale
France	Wine technology
France, Germany, UK	Precision and conservation production systems; genetics and biotechnology (in research more than production); automation of production systems in controlled environments
Germany, Netherlands	Integrated pest management
Germany, India, China	Gene-editing
Germany, Israel, Japan, Canada, Korea	Automation and robotics
Germany, USA, Switzerland	Seed production
Israel	Desalination technology; management of water resources (e.g. coastal aquifer management/storage technology and adaptation of crops to scarce water conditions); water-management techniques (e.g. drip irrigation); controlled environment agriculture
Japan	Indoor vertical farming
Japan, Russia, Sweden	Aquaculture
Kenya	Cell phone technology applications
Netherlands	Vegetable production and horticulture technology; urban and vertical agriculture; robotic dairies and greenhouses
Netherlands, Italy, Scotland, Greenland, Sweden	Biofuel and agri-grid-adaptation
Northern European countries	Use of all agricultural technology
South Africa	Water saving in irrigation systems (water-use measurement and the elimination of water losses); SovTech analytics application
UK	Automation
USA	Automation and mechanisation; imaging cameras on wine farms; desalination and farming in tough conditions; gene editing; genomic applications to crops and livestock; both genome engineering and genomic selection in breeding; precision production systems and use of data analytics for optimisation of inputs and production; innovations in start-funding models and entrepreneur support
USA, China, UK, Japan, Canada	Leaders in AI; China will become the world leader in AI due to investment quantum that surpasses that of the USA, and is double that of global investment size
USA, UK	Fully autonomous farms, driven by higher labour costs

## Emerging technologies and innovations that could change farming

Most respondents agreed that it is not useful to distinguish between global agricultural technology trends and technologies applicable to the Western Cape when looking at agricultural technologies. These technologies need to be considered within the context of the agricultural sector, regardless of current levels of adoption on a regional basis.

A respondent indicated that “agriculture as a whole has been slow relative to other industries, to transform driven by technological advances. The two major reasons for this are an inhibitory regulatory environment and slow adoption rate”. Yet many agricultural technologies are expected to play a significant role in the future, including automation, the Internet of Things, remote sensing precision, and smart farming. Respondents indicated that the integration of sensors or other technologies for water management already featured prominently in the Western Cape.

In contrast, automation was not viewed by the experts as a dominant technology likely to disrupt the labour sector. This is due to the prevailing view that labour is still relatively cheap in South Africa and is supported by labour legislation as well as the sheer preponderance of the sector.

### Water-management and related technologies

Water and electricity are precious commodities on farms, given their impact on profitability and food production. The recent drought in the Western Cape and the growing conflict amongst users given water scarcity have put the need

for efficient water use in the agricultural sector firmly in the spotlight. To optimise water use and remain economically sustainable, producers are increasingly looking at ways to do more with less water. In future, farmers will need to produce higher yields through beneficial water use, especially given rising input costs and more erratic weather patterns emerging.

### Smart water technologies

Nine smart water technologies can be used in the Western Cape (see Table 6 below).

The overall impact of these technologies will be largely determined by their affordability, geographical viability, how user-friendly they are, and the perceived risks that these technologies present to society at large.

Remote sensing technology is a highly effective technology because it is cost-effective and easy to use. Cellular technology also has the potential to provide producers with early warning systems to adapt to unforeseen events.

Drones or unmanned aerial devices, on the other hand, are a more expensive technology that requires a high level of discernment and training to interpret the data at a farm level. If this can be simplified and made more accessible, it could vastly extend the management capabilities of farmers, enabling them to detect problems that are not always visible to the human eye.

Many intelligent irrigation systems have been devised, ranging from drip systems to soil water sensors. These systems,

if implemented, can potentially reduce agricultural water use significantly.

Water treatment technologies have not yet taken off, for various reasons. With regard to desalination, the cost of the electricity required to run such plants is prohibitive. Solar energy desalination has the potential to make this more cost-effective. Nanotechnology is still perceived as high-risk, given the possibilities of nanoparticles escaping and contaminating water. The relatively high cost of implementing this technology is another barrier. Similarly, managed aquifer recharge is seen as high-risk in South Africa. Most are situated just 60 metres below the surface and located in fractured porous rock.

It is clear that better water management practices and technologies are needed to optimise yield, eliminate the wasteful use or run-off as well as reduce fertiliser and chemical run-off (which affects water quality). There is a revolution under way in water footprint studies, as this will probably become an important (farm) business metric like carbon accounting.

Although technology could help address the problem, policy changes may also be crucial. Currently, the Water Act (National Water Act, Act No. 36 of 1998) requires farmers to measure, log and be able to report their water usage. Policy should be linked to the provision of this technology to smaller farmers. The industry discussion group’s response was that concerted efforts to farm with 40% less water than is currently used is needed to optimise water availability. This must be supported by promoting climate-smart farming.

Table 6: Top nine smart water technologies

Item	Rank	Comment
Remote sensing	1	Access to information
Smart monitoring of water	2	Reduces waste
Cell phones for weather forecasts	3	Provide useful information to even smallholders
Seasonal hydrological forecasting	4	Very important for water budgeting
Unmanned aerial vehicles (UAVs)	5	Detects problems normally not visible
Intelligent irrigation	6	Reduces water use and management costs
Solar power for irrigation	7	Reduces cost of irrigation significantly
Aquifer recharging	8	Vulnerable to contamination
Wastewater treatment technologies	9	Still too expensive

## Automation (robotics, UAVs and transport technologies)

Robotics is at the cutting edge of increasing food supplies. Specially designed and integrated agricultural robots can reduce the number of systems and components to create simpler and more reliable machines, which will result in greater adoption.

The use of UAVs in agriculture is as diverse as general monitoring fly-overs or farm security, to assess vegetation health, track animals or even direct mechanisation such as sterile insect release or crop spraying. The view is that in agriculture, automated equipment of all kinds across the value chain can reduce costs and improve efficiency.

The industry discussion group stated the importance of relating agricultural labour to output and productivity. The group took the view that labour costs across the agricultural sector could not be uniform, but rather that the quantum of wages payable, for example, was sector-specific. A view is that the labour losses incurred because of technological interventions can be compensated for by

the services industries needed to support these automated systems. The view was also held that South Africa would need to incorporate hybrid designs where automation is initially limited to repetitive functions such as sorting.

## Internet of Things and low-cost sensors

Current uses are linked to any sensor connected to the internet, able to produce data, which can then be analysed. It is predicted that in five years, farm sensors will influence production, market analysis and logistics, much in the same way as is currently the case for machine learning.

## Remote sensing technologies

The agricultural sector uses sensor technology mainly to collect data on soil, crops and animals through integration into all kinds of equipment and machines, aircraft and drones or even satellites. They can be integrated into the entire value chain in farming, supply chain or post-harvest systems – from providing weather data to product processing. In the Western Cape context, remote sensing technologies

become more relevant when considered in conjunction with water-management technologies. Remote and local sensing systems for collection of a wide range of data for production management should be integrated with efficient data analytics to provide decision-guiding tools at the correct resolution.

## Precision agriculture and smart farming

Precision farming is made up of software solutions including technologies like automation (see Figure 15 below). According to experts, the expansion of smart farming will result in increased production per crop, and more efficient production systems.

Precision farming manifests in different farming types, including vertical farming, controlled (urban) environment agriculture, dairy farming and livestock farming.

Currently, approximately 89% of all land in the Western Cape is farmland, and 67% of the Western Cape population already live in the Cape Metropole. This offers an opportunity to escalate peri-urban and

urban agriculture through the use of smart farming practices. Respondents indicated that vertical farming is growing fast and will become prominent in the province.

The financial sector are launching AgTech innovation hubs and have indicated that urban agriculture proposals would be considered. Urban farming economics may not be massively profitable, but offers opportunities for social entrepreneurship.

### Genetics

The focus groups acknowledged that even though agricultural genetics impact agriculture, different global regions respond differently to it. For example, GMO technology is sufficiently developed for incorporation into commercial food production; however, the EU is not supportive of this technology, whereas the USA is open to it. Australia is not

supportive of the genetic manipulation of organisms but supports CRISPR technology (used for gene editing). We need to take a long-term view on these technologies and communicate benefits and the science to consumers given that there is still a lot of misunderstanding. There was even an expert view that in South Africa, the legislation and protocols linked to genetic modification are much less complicated and onerous than in many other countries. Consumer resistance against GMO technology still remains a big challenge in South Africa, mainly due to a lack of credible information.

### Artificial intelligence and machine learning

Artificial intelligence (AI) and machine learning will continue to develop rapidly. While this has obvious implications for

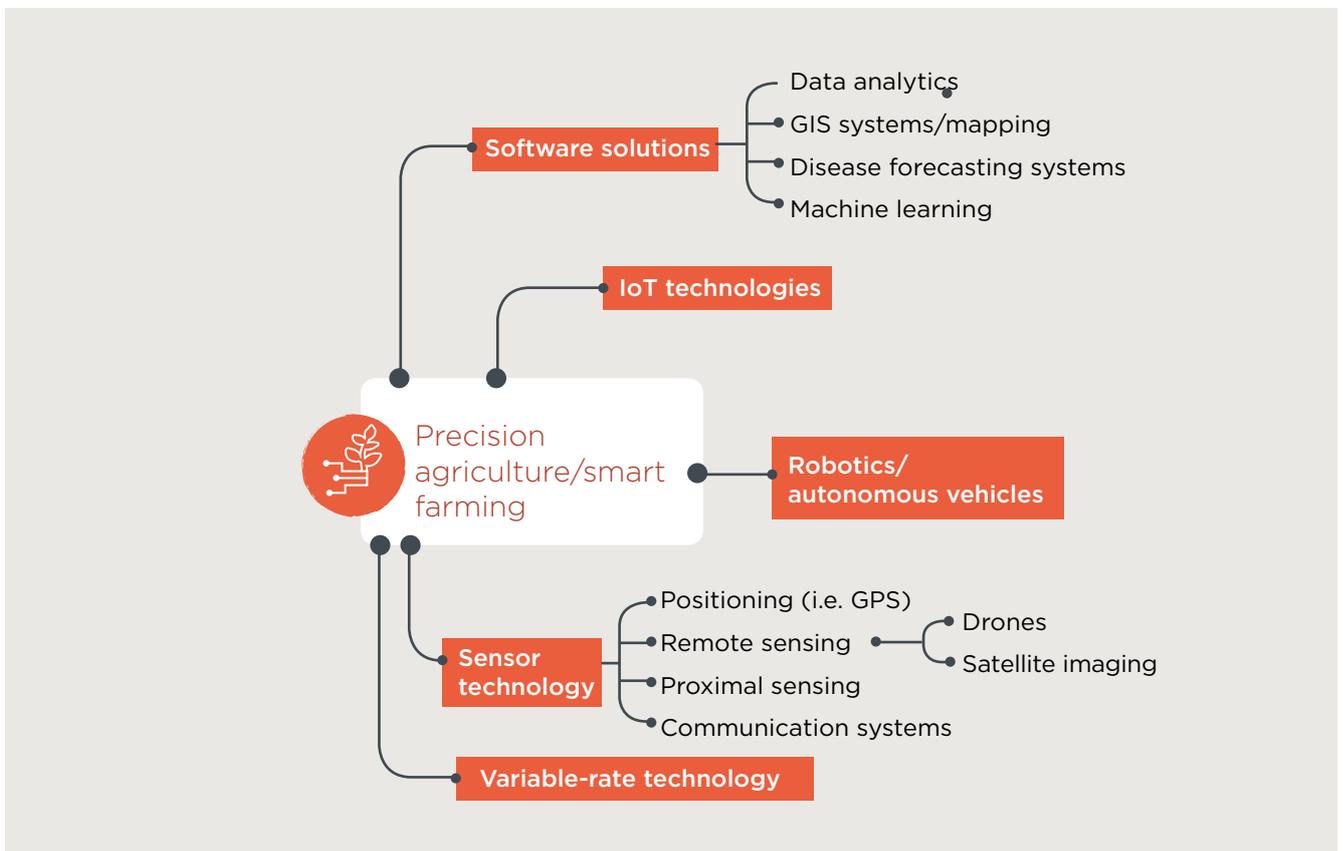
many people’s skills becoming redundant, the economic growth potential is huge. Governments and businesses, including farms, need to understand the impact of AI on employment, to put measures in place to upskill people into areas that are least affected by AI, or new areas that emerge as a consequence of it.

### Some contextual issues to consider

#### Cost issues

Although the cost of technology is decreasing worldwide, South Africa is still a net importer of most technologies. Cultivars and seeds are sometimes protected by patents and plant breeders’ rights owned by large global companies, which makes local access more expensive. Without economies of scale, it appears very difficult to justify the investment in expensive technologies. There needs to be

Figure 15: Precision agriculture and smart farming



a special dispensation for small farmers to facilitate the acquisition and distribution of agricultural technologies. For them, opportunities probably lie more within niche markets and in working together with larger commercial farmers.

### Research and information issues

To facilitate the adoption of technologies, further input from the scientific community is needed on topics such as the availability of technologies and how to optimise the extraction of benefits. New research efforts should not only focus on single technologies and their use, but more on the integration of technologies into the farming system and value chain.

### The adoption of technologies

In the past, South Africa has been efficient at adopting existing (international) technologies and has achieved very high rates of return. For example, the rate of return on horticulture has achieved 100% ROI, grain 35% ROI, and livestock 40% ROI (if adjusted for the portion of technology focused on disease). This success (spill-in technologies) was achieved right up until the early 2000s. The cause has been ascribed to decreased state spending on research and development in its own research entities, or the general decline in spending on the development and adoption of technologies. In response, the

Western Cape will need to aggressively develop its agricultural technologies and associated supporting systems, establish technology demonstration farms and run trials on the farms of existing participating farmers across the value chain.

### Agriculture diversity

Considering that the Western Cape's agricultural sector includes the production of deciduous fruit, grapes, wine, vegetables, dairy products, wheat and other field crops, these crops have different capacities to change and use different types of technologies. Crop suitability studies and investigation into new crop options (not considered as 'technology' but essential to the sector) to determine whether land is being used optimally and what new opportunities may be presented in the future need to be initiated.

Investments in the farming sector are continuing even under existing economic pressures. Although the price of land is increasing due to solid demand, together with the reality of diverse agricultural opportunities, it ensures that the required capital remains available for the sector.

This section should be read with the understanding that the challenges listed here could very well be opportunities, and the converse.

### **Seven technologies are expected to have high impact in the Western Cape. These are:**

1. Water-management and related technologies (where smart water technologies can be used)
2. Automation (including robotics), UAVs and transport technologies
3. Internet of Things and low-cost sensors
4. Remote sensing technologies
5. Precision agriculture and smart farming
6. Genetics
7. Artificial intelligence and machine learning

## Opportunities and challenges

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### Adoption of innovation and technology

All respondents agreed that it is both useful and necessary to consider the adoption of technology and innovation differently with respect to smallholder and commercial farmers.

There are a total of 69 966 commercial farming units in South Africa, of which 4% have a turnover of larger than R5 million, 21% have a turnover of between R1 million to R5 million, and 75% have a turnover of less than R1 million.<sup>49</sup>

To reap the benefits associated with the 4IR in agriculture, smallholder farmers need a different approach than mega farmers. The two dominant themes from the expert interviews were that smallholder farmers could not compete with mega farmers due to economies of scale and the cost of technologies that is hugely restrictive for small farmers.

To make the acquisition and holding costs feasible for smallholder farmers, respondents indicated that government support is needed to reduce the costs of technology. This can be in the form of shared platforms, financing schemes, servicing solutions, and subsidised internet services. Agri-entrepreneurship programmes are also required.

### Enabling and support systems needed

The enablers and support systems necessary to facilitate the adoption of innovations and new technologies in the Western Cape are:

### Dissemination of information

Access to information and emerging technologies should be facilitated through the sharing of data, exemplified by the My SmartFarm concept, which is linked to platforms and databases. Such platforms should have maintenance support. This will accelerate the uptake of these platforms by various industries, such as the wine industry, which initially had a 3% adoption in the first five years. Information platforms should be used to create equitable access to provincial information on agriculture for all farmers regardless of size.

The development of sufficient case studies, technology demonstrators, and technology pilots (model farms) to increase technology adoption, should be promoted. Extension specialists need to be able to demonstrate technologies and communicate the benefits, proper application and system requirements. Extension services can be supplied by all role players in the agricultural value chain. Agribusiness-based technology advisors and specialists should strengthen their market intelligence and share this with their clients to keep them up to date.

### Develop the business case

The value and returns on investment on innovation and technology should be independently determined and made public for practitioners to use in the development of their investment business cases. There are insufficient independent verification agencies to validate the claims made by commercial suppliers of new technology. Independent case studies from the science and academic community as well as services from agri-entrepreneurs can fill this current knowledge gap. Valid business cases need verified information, including ROI data.

### Education and training

The current adoption of agricultural technologies is constrained by a lack of knowledge and education about the availability and benefits associated with available innovations. Agricultural and business education institutions (including agricultural schools, training colleges, universities) should be actively influenced by a stakeholder forum coordinated by the provincial Department of Agriculture to ensure the development of the necessary curricula (leading practices, ROI, technology futures, etc.) to support technology adoption and usage.

### Financial support

As already indicated, technology requires investment – this is a critical success factor for developing the agricultural sector. Financing schemes should target smallholder farmers. Partnerships between small farmers and large farmers to facilitate access to financing and technology should be actively encouraged through incentives such as increasing dam capacities, larger access to river catchment systems, and infrastructure development (roads, energy and railways).

### Growing entrepreneurship

4IR developments create a myriad of service-related business opportunities for agri-entrepreneurs, which should be actively promoted through partnerships with relevant technology hubs. Regional hubs could be commodity-based to be developed with funding from the private sector in partnership with tertiary institutions.

### Agri-parks

The national government launched the agri-parks programme in 2015 as one of the cornerstones of rural economic

transformation. The vision for agri-parks is that it will be farmer-controlled entities that serve as catalysts around which rural industrialisation can take place.<sup>50</sup>

Agri-parks are one-stop shops for agro-production support, processing, logistics, marketing and training within district municipalities. In the Western Cape, Ceres, Beaufort West, Bredasdorp, Oudtshoorn and Vredendal have been identified as agri-hub sites.

### Social challenges

In general, the global trend is that unemployment rises with the adoption of technology, due to the decline in the need for unskilled and semi-skilled labour. This will inevitably lead to urban migration. Unskilled labour costs might decline in the short run due to the over-supply of this type of labour. However, for skilled categories of labourers who can use the available technologies as part of their daily job, equitable wages will need to be paid to accommodate the increase in adoption of technologies. Tied in with the maintenance of a labour force is the requirement to ensure that labour legislation is conducive and that retraining, reskilling and social development is part of sustainable jobs. The loss of jobs due to technology is not a zero-sum because technology in itself also enables the creation of new jobs direct to and related to the relevant technology.

A further consideration is a requirement for reforms that adequately address housing needs, self-feeding schemes (food gardens), educational needs, medical needs, and financial support systems such as access to banking services and credit

for farmworkers and smallholder farmers. If not addressed, these challenges would lead to urban migration.

Two central issues, namely minimum wages and the need to upgrade skills and capabilities for the future success of agriculture, are prevalent themes in the discussion on the social challenges to be addressed in order to establish a view on measuring productivity per Rand spent and to transform work in agriculture.

### Technological challenges

Access to inputs such as seed, fertiliser, and appropriate cultivars will need to be optimised, alongside management practices such as fertiliser application know-how, the use of plant-protection agents such as biocontrol agents, water-management practices, soil-management practices (crop rotation), livestock-feeding technologies and practices, and agronomy practices. Access to effective extension services remains a challenge, and whilst other developed nations use on-line extension services, this is not as well-developed in South Africa. Access to technology and how this is organised is also an issue. This includes access to the internet, the integration of data gathering through sensor technologies, data processing and mechanisation.

The requirement for testing of genetic modification technologies (genetic engineering and biofabrication) cannot be overemphasised. This is to be conducted through rigorous testing, pilot studies, and demonstration facilities. More investment in this regard needs to be considered.

### Ecological challenges

Over time, organic agriculture and conservation agriculture have gained prominence in the agricultural sector, due to increased interest in the effects of climate change and the development of microclimates (some of which may be beneficial) and ways to mitigate this. This has had the effect of making it possible to charge a premium on organic produce, and more so where standards such as EuroGAP have been implemented. As a result, the choices of farmers have been influenced to involve the adoption of high-impact practices, alternative technologies (like vertical agriculture) and alternative protein products.

The coordination and management of water and soil resources are required at both national and provincial level to create and sustain farming systems. Water-use policy needs updating to be in line with the current reality. Allocation of water rights is being leveraged for transformation objectives. Whilst these objectives are acknowledged, it is believed that water rights should be universal or based on context and needs. Water is also related to sustainable farming, and its usage needs to be measured to achieve some control. Despite the clear reasons for this approach, some farmers are resisting this measurement requirement.

### Policy challenges

Policy aspects will be covered elsewhere in this section.

## The path ahead: Shaping the future of farming

What can be done to enhance the uptake of agricultural technologies in the context of the 4IR? This section outlines practical suggestions for government, industry, producers and the private sector.

### Direct interventions needed

Direct interventions needed to ensure the sustainability of the agricultural sector in the Western Cape are the following:

<p>Government policy</p>	<p><b>Clarity is required on the policy related to land.</b> This is important in lieu of the recent parliamentary developments on land expropriation without compensation, and the likely effect on land ownership rights. According to the financiers interviewed, there is uncertainty on policy and where policy is heading (legislation on expropriation without compensation, for example). The prevailing logic is that this would influence investment decisions. However, the current trend is that the bigger role players continue to invest in land, which remains at a premium in the province.</p> <p>Related to this is <b>labour legislation and reforms</b> required to government levies to support the agricultural sector. There is a strong view amongst respondents that trade assistance and incentives should be revised to support agricultural exports and imports. Import assistance includes the relaxation of regulations on agricultural equipment (e.g. robotics and drone use) to facilitate efficient production by farmers.</p> <p><b>Faster decision-making by the government</b> on critical infrastructure needs such as the construction of dams, rail and shipping infrastructure is necessary to develop the agricultural sector.</p>
<p>New credit lines</p>	<p><b>Credit assessments should be customised for farmers</b> so that the use of technologies such as drone footage or sensor readings should be admissible in support of credit applications.</p>
<p>Entrepreneur development</p>	<p>The commercialisation of agricultural inventions should be supported by <b>funding interventions</b> and focused entrepreneur-support interventions, which include agri-tech development support, the development of cooperatives and start-up support. Key to this is agri-accelerator development and skills import through exchange programmes from other regions.</p>
<p>Education and training</p>	<p>It is clear that the global agriculture market represents a big growth opportunity for current and new participants, but for that to be part of the opportunity, investment in agricultural technologies is a prerequisite. The leverage points are not necessarily individual technologies but how an integrated agri-system is linked to a farming system and a biosystem. Key enablers for utilising these technologies are the appropriate capabilities and skills.</p>
<p>Talent</p>	<p>The industry discussion group highlighted the importance of <b>attracting future talent</b> to the sector, possibly best addressed by co-opting private industry to invest in skills development.</p>
<p>Agri-industry collaboration</p>	<p><b>Assisting or enabling the adoption of the technologies</b> and innovation based on scientific reference cases and early adoption scenarios is crucial, supported by forums for engagement between the science community and commercial agriculture to jointly define and resource the new research agenda.</p>

## Key innovations needed

Important innovations required to ensure growth and sustainability of the Western Cape's agricultural value chain are:

Input supply	<p><b>Adopt waste-management</b> systems, new crop types, new land-use optimisation techniques, and renewable energy technologies</p> <p><b>Increase the local manufacturing</b> of chemicals and biologicals</p> <p><b>Improve data for research</b> and development support of supplier product claims</p> <p><b>Smallholder farmers</b> Promote adoption of technology by smallholder farmers through knowledge sharing and access to finance . • Adopt financial incentives. • Develop alternative lending models for smallholder and some large commercial farmers. • Develop means for credit evaluation specific to smallholder farmers</p>
Production	<p><b>Greater adoption and use of existing technologies</b> (e.g. robotics, remote sensing and precision farming)</p> <p><b>Generate and use data</b> (property boundaries, catalogues of soil types, climate, recommended crop types and <b>recommended</b> crop diversification) for increased productivity</p> <p><b>Incorporate the Internet of Things</b> into sensor and automation of equipment</p> <p><b>Expand investments</b> in urban agriculture, covered farming and shade nets</p> <p>Implement <b>gene manipulation technologies (breeding and genetic engineering)</b></p> <p><b>Accelerate the dissemination of innovation and protected inventions</b> (plant patent rights)</p> <p><b>Emerging farmer support</b> to be augmented appropriately with funding and knowledge-sharing</p> <p><b>Implement labour capacity</b> building in conjunction with the adoption of mechanisation technologies</p>
Post-harvest management and agri-processing	<p><b>Develop local industry</b> in wine cellar equipment and barrels, for example for import replacement</p> <p><b>Increase scale in downstream production and value-addition</b> for economic competitiveness, by adopting technologies such as reconfigurable processing machines, and multi-leasing agreements</p> <p><b>Develop and cultivate new crops and processed products</b> for large new markets such as China and India (specific food preferences)</p>
Distribution	<p><b>Unlock opportunities for direct foreign exports</b></p> <p><b>Innovations in packaging</b> (biopackaging and recycled material) and the reduction of storage space needed</p> <p><b>Incorporate automation</b> and smart management tools into logistics and quality control</p> <p><b>Employ data analytics</b> in supply chain management and disseminate this information to farmers for strategy and operations</p> <p><b>Incorporate the Internet</b> of Things into logistics</p>
Retail and consumption	<p><b>Development of local brands</b></p> <p><b>Acceptance of the treated use of human and other waste</b> as input into agricultural production systems</p>

## Overall policy changes needed

Policy changes that will enable the agricultural sector to benefit from the opportunities presented by the 4IR are:

<p>Policies to support access to technology information</p>	<p><b>Funding of research</b> for technology impact studies. • Government to fund capacity-generating platforms (capex infrastructure) for research. Private industry is to maintain these infrastructure platforms and disseminate the information. • Western Cape agri-policy should actively support collaboration between state and private-sector research. This should be funded by both the government and the private sector; research and development outcomes must be accessible to all users and government research must link to science councils' and private industry's needs and must address research area gaps. This approach should reverse fragmentation and divergent research agendas. The WCDoA should further invest in regional research bodies.</p>
<p>Policies related to financing new technologies and research</p>	<p><b>Financial instruments</b> Creation of customised financial instruments for smaller farmers. • Policy of innovation funding and identification of modern technologies across the value chain in consultation with strategic consultative groups. • New instruments such as crop insurance, or discount models to counter drought relief (disaster management) are required. • Promote new financial instruments for crop insurance based on the use of technology (IoT, smart farming), to improve productivity and producer success.</p>
<p>Infrastructure policies</p>	<p><b>Infrastructure</b> Revision of conditions or criteria in current policy to approve infrastructure spending such as the construction of public dams, roads, rail, etc., and including the approval turnaround times.</p>
<p>Policies for capacity development</p>	<p><b>Entrepreneur development</b> in agriculture (agri-accelerators, agri-incubators, shared-services platforms, cooperatives development). • Agri-technology testing/piloting/demonstration, data collection, processing and sharing policy. • Coordinate study tours focusing on best farming practices and technologies to other countries, with a specific commodity focus.</p>
<p>Land policy</p>	<p><b>Clarification</b> and certainty on land reform policy</p>
<p>Labour policy reforms</p>	<p><b>Labour</b> Minimum wage • Categories of labour • Benefits</p>
<p>Economic development policy</p>	<p><b>Trade</b> agreements to support exports (tariff policy revisions).</p> <p><b>Markets</b> Large commercial farmers and government should research and develop new market opportunities in Africa for agricultural products, with assistance from existing agencies such as WesGro and Wines of South Africa (WOSA).</p> <p><b>Investment</b> More investment should be attracted.</p> <p><b>Value chain</b> Direction on how to further integrate primary and secondary agriculture should be given, including how to vertically integrate value chains. • Stimulate and facilitate the investment in entrepreneurial opportunities in the development of local agriculture innovation technologies to replace imports. • Measures should be put in place to resurrect struggling industries such as the poultry industry. • Stronger branding of South African and regional commodity sectors to prevent fragmentation and present a unified South African and regional message around commodities (e.g. wine). • Government to facilitate the opening-up of preferential markets, through expediting processes such as phytosanitary requirements.</p>

## Change management to support 4IR possibilities<sup>51</sup>

For change to be sustainable and impactful over time, there is a range of activities, awarenesses and methods that must be applied.<sup>51</sup> The change approach that is proposed for this project is called the 'ESP of Change'<sup>51</sup> and consists of nine elements that are infused with various levels of ESP, or Empathy, Space and Pressure.

Adopting and engaging with the opportunities associated with the 4IR starts with an individual mindset, attitude and competence level to reap the benefits. The change process associated with this project is, therefore, a people-centric approach where leaders in the sector display a combination of ESP. Change in the context of this evaluation starts and ends with leadership as a core capability to influence the required changes in the sector and amongst role players.

### The ESP of Change

The ESP of Change process model is shown in Figure 16.

**The rationale for an overarching ESP departure view is the following:<sup>50</sup>**

**Empathy:** Empathy remains perhaps the most essential, yet least appreciated, facet of guiding and entrenching change. When designing and applying any of the ESP tools it is essential to build empathy into the process. This includes providing time to digest information regarding change and the opportunity to interact directly with the drivers or proponents of change, among others.

**Space:** When introducing change it is important for people to be given the time and opportunity to digest and internalise the reasons and implications of change. On the whole, methods that offer space create the foundation upon which a creative minority and critical mass can

work to build a committed, although probably inactive and cautious, majority.

**Pressure:** Pressure encourages people to behave differently and to adopt and entrench the requirements of the future. As Figure 16 illustrates, each tool and method has varying levels of space and pressure with a relatively constant depth of empathy.

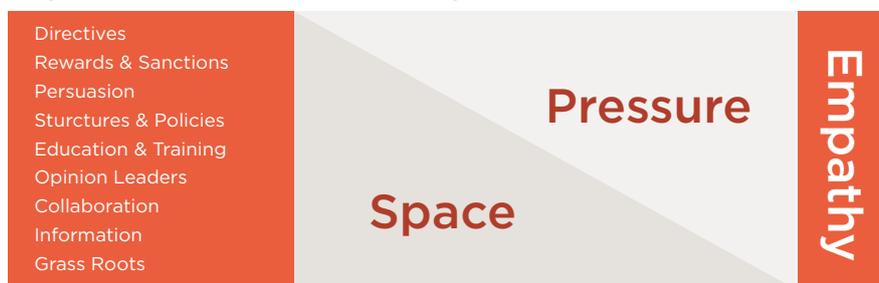
At the deep end of space, the stakes to take action are not very high. As we move across to the deep end of pressure, the stakes increase rapidly. Change becomes increasingly non-negotiable.

Relying on or entering into the pressure zone too soon creates counter-productive

reactions. People cannot be forced or manipulated to change against their will. Ideally, the earlier phases of change should provide empathy and space, with a steady move towards decreasing space and increasing pressure. Relying primarily on methods in the space zone entrenches very little change. In all probability, it will remain a talk-shop with ongoing discussion, and very little real action.

Utilising the ESP tools or approaches is not a linear or chronological process. The pressure zone's methods may thus be almost absent during the initial phases of change, while emphasis is placed on those in the space zone. Over time, greater emphasis must be placed on the later methods that induce pressure.

Figure 16: The ESP of Change model



### What does this mean for farming?

Successful farming operations can be considered businesses for which specific disruption business themes are identified (customer, operational optimisation, and the nature of work). In addition, there are also the disruptive technology themes, which have been identified and discussed (e.g. AI, robotics, IoT, etc.). Considering these two domains, the question is how best to drive changes in practice and technology adoption?

In introducing new technology possibilities, new thinking paradigms and new ways of operations, it is always advisable to use a holistic change model and approach.

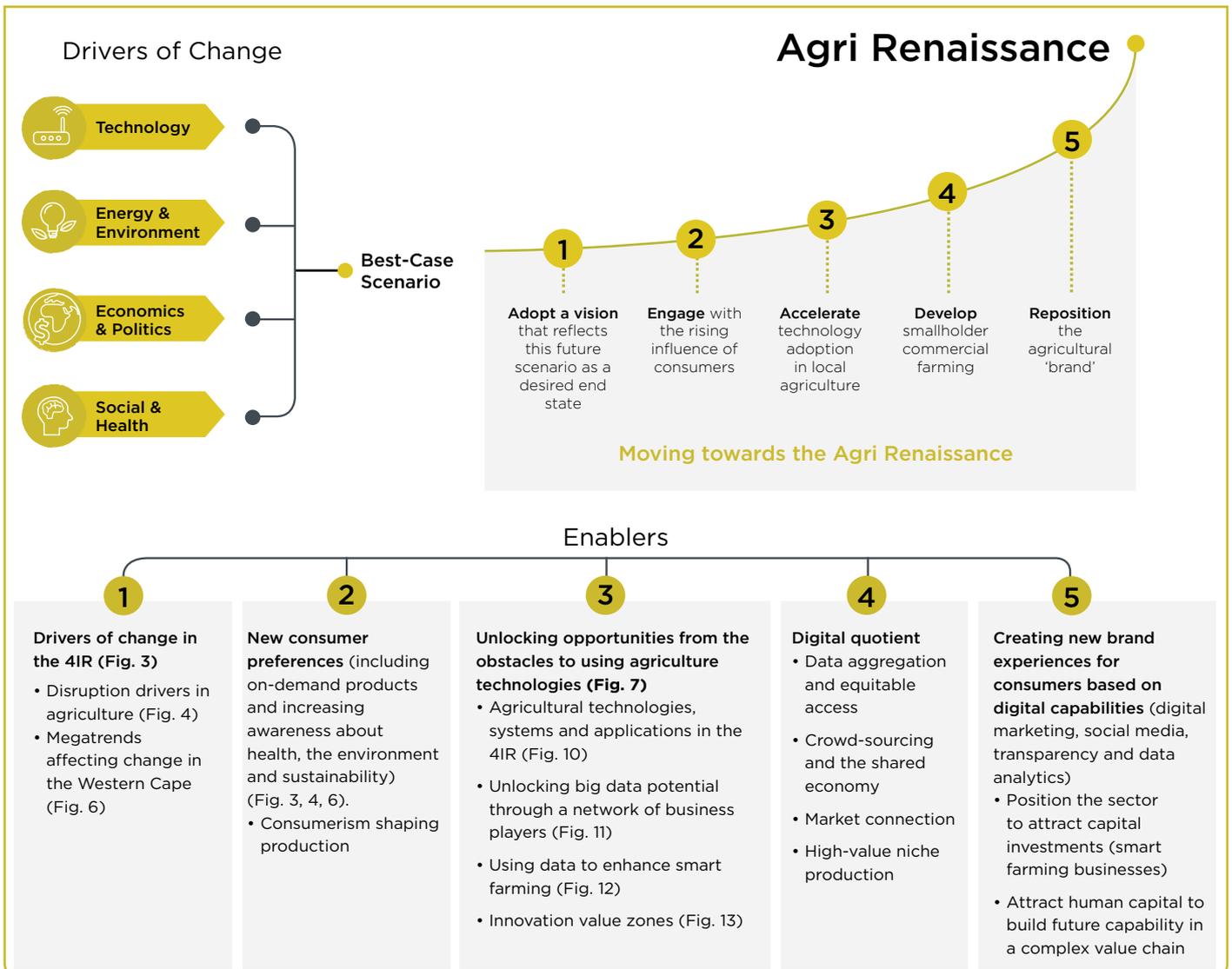
There is no one or other method that is the best way of ensuring successful change. The change model outlined here starts with a space-led approach that needs to be complemented with pro-pressure processes to stimulate execution – all done with empathy for the target change audience.

In the context of this project, the primary target change audiences who can benefit from new technologies and a 4IR paradigm are established and emerging Western Cape-based commercial farmers (large, medium and small) who produce for surplus to a market; together with agri-processing businesses in the value chain.

# Conclusions and recommendations

*The Fourth Industrial Revolution provides opportunities for the Western Cape to put in place mechanisms that will allow for the appropriate agricultural responses to the revolution, in line with global responses in this space. This can be achieved by employing a systemic approach to understanding prevailing megatrends and value chain systems and the creation of a conducive environment for effective farming systems.*

Figure 17: Enablers to accelerate the dawn of the ‘Agri Renaissance’ scenario in the Western Cape



## Recommendations

Recommendations are grouped into a stakeholder view to facilitate action and are based on the findings discussed in the previous chapter.

The triple helix (technological advancement, economic growth and development, and socio-institutional structuring and stability) nature of the agricultural sector suggests that embracing an industrial revolution requires engagement at several levels and in different contexts to achieve the growth that the industry has experienced

over the last 300 years. As such, the recommendations are economically and socially intertwined: production-driven efficiencies are the result of customer-centric value chain demands and requirements, illustrating the impact of emerging technologies of the 4IR on the relationships and dynamics of the agricultural value chain.

### No. 1 Agri Renaissance as the desired end-state

The 4IR will happen. In fact, it has already started. The Western Cape agricultural

system needs to shape its own future. A way of doing this is to focus on the desired end-state, which in this report is described as an 'Agri Renaissance' (see Figure 8). The pathway to achieving this scenario is depicted in Figure 16.

**In this best-case scenario, the following features characterise the Western Cape agricultural sector.**

Strategic initiatives are initiated in alignment with the recommendations of this evaluation and report. Role players embrace technology developments through the adoption of, amongst others, farm-management software, precision agriculture and predictive data analytics. This enables producers to monitor crop health, weather and soil quality using robotics and drones. Together with smart irrigation, this results in higher yields and significant cost reductions. The accelerated adoption of technology offers new, efficient and sustainable ways of farming, leading to increased competition amongst agri-producers in a new, AgTech-enabled normal.

The four strategic focus areas associated with the SmartAgri plan is achieved.

Dissemination of relevant knowledge by the agri-sector is aligned with the buying behaviour and patterns of the growing middle class. Amidst increasing automation, vocational education has adapted to meet the demands of new skills requirements in the province. The loss of jobs due to technology is not a zero-sum, as technology in itself also enables the creation of new jobs direct and related to the relevant technology. For unskilled workers to migrate successfully to new job opportunities, retraining and reskilling opportunities are offered, making them employable in entry-level jobs within the agri-sector and other sectors of the economy. Technology is used to support successful land reform as demonstrated in the use of new crowdfunding platforms,

thereby accelerating agricultural economic opportunities in rural areas.

State of the art technologies are seamlessly integrated into the agricultural system to optimise productivity and sustainability. Technology is affordable, well understood and user-friendly through open platforms customised for agriculture.

Agri-producers evolve at a rate aligned with change in the larger business environment and enjoy profitable returns from an expanding local and global market. Due to the opportunities presented by expanding markets and conducive conditions, new AgTech entrants see the Western Cape as a highly favourable regional investment destination.

## No. 1 Recommendations

### For government

1.1 The WCDoA's **strategic positioning** should align with and support the Agri Renaissance desired end-state, i.e. the department's vision should reflect this scenario with strategic initiatives to accelerate growth in agri-economic outputs.

1.2 The department should cooperate with tertiary institutions in the province and the Department of Telecommunications to **develop digital skills and capability** for

the agricultural sector. The iKamva National e-Skills Institute Bill (Government Gazette, Vol. 629, November 8 2017, No. 41233) is very relevant as a potential partner for future e-skills capacity development in agriculture. Tertiary institutions should make digital quotient and digital license courses and certification available to the sector. Reskilling and retraining opportunities are vital to growing the number of employed workers in the sector.

### For academic institutions

1.3 Tertiary education institutions engaged in agricultural education, training and development should strengthen their current curricula by including theory, skills and technologies related to the 4IR. This differentiation would create competitive advantages for first adopters.

## No. 2. Engage with the rising influence of consumers

The rapidly **increasing access to information** related to farming practices allows **consumers to be better-informed** than ever. This information is becoming increasingly available throughout the agricultural value chain. Informed consumers are changing the demand for agricultural products due to concerns about food quality, nutrition, traceability

to origin, the use of herbicides, pesticides, fungicides (crops), and antibiotics (livestock) in production and processing. Resistance to the use of chemicals and non-environmentally friendly compounds is on the increase. Consumers also influence retailers to ensure that they stock products from producers that meet certain requirements. Direct sales to the customers (B2C) continues to increase as the consumer drives demand for niche nutritious and high-quality products.

An upside to this is the increased ability by producers to market their individual brands, effectively eliminating the middleman. It appears that a shift is taking place, from a focus only on production-driven efficiency to consumer-related demands and requirements.

Therefore, one desired end-state could be that consumers are linked into the value chain using technology.

## No. 2 Recommendations

### For producers

2.1 Agri-producers in the supply chain should list products on the **blockchain** as an opportunity that will allow the tracking of food origins, which will be demanded more and more by the consumer, for complete transparency.

### For producers • processors

2.2 Agri-producers and processors should increasingly use innovations in **packaging** (e.g. biopackaging such as the use of agar-based biodegradable plastics, and recycled material) that are environmentally centric and reduce storage space in logistics and packing. Another opportunity is related to **food preservation**, namely organically

packaged food with a consumer indication in the form of bio-derivative packaging. This provides ready-packed produce through automation, with smart indicators towards freshness.

### For consumers

2.3 Consumers should **use current legislation** (e.g. Consumer Protection Act, No. 68 of 2008) to enforce their right to accurate and truthful information from retailers and producers regarding quality, production practices, health and nutrition. This will reduce 'greenwashing' (a form of spin in which green public relations or green marketing is deceptively used to promote the perception that an organisation's products, objectives or policies are environmentally conscious).

Increasingly, producers and retailers will need to prove the authenticity of their claims to ensure their product claims are accurate and truthful.

### For government • agribusinesses • scientists • producers • retailers

2.4 The WCDoA, agribusinesses and the science community must be jointly accountable for responsibly informing consumers about **genetic engineering technologies**. Consumer resistance against these technologies remains a significant challenge in South Africa, mainly due to a lack of credible information. The scientific community can do much more to put the facts on the table in a balanced way.

## No. 3. Accelerate technology adoption in agriculture

The realities and opportunities associated with the 4IR could be better positioned and understood by the Western Cape agricultural sector. Technologies need to be considered within the context of the sector, regardless of current levels of adoption on a country or regional basis. Agricultural disruption through innovation and technology will likely have a medium impact over the next five to ten years, partly because the industry displays low digital maturity. There is a range of technologies that are seen to be globally

transformative and locally relevant. Increasing the technology adoption rate will create direct improvements in agriculture and will positively impact the digital maturity of the sector.

The adoption rate is influenced by the ability and willingness of role players in the value chain to respond positively to opportunities associated with the 4IR. We are dealing here not only with technology adoption challenges, but also with people's ability and willingness to change.

Seven technology areas will have a substantial impact on farming practices in

the province in the next five to seven years, and need to be prioritised to accelerate access and eventually full adoption. These technology areas are: **water-management and related technologies** (where nine smart water technologies can be used – see Table 6); **automation** (including robotics, UAVs and transport technologies); the **Internet of Things** and **low-cost sensors**; **remote sensing technologies**; **precision agriculture and smart farming**; **genetics**; **artificial intelligence** and **machine learning**. These technologies' adoption rates may be affected by the lack of clarity on the policy related to land-ownership rights.

## No. 3 Recommendations

### For suppliers • scientists • government • producers

3.1 Suppliers, scientists, the WCDoA and producers should aggregate and **disseminate information** about the above-mentioned seven technologies in a transparent, open-source and equitable basis covering all categories of commercial farmers. Relevant agri-forums, interest groups, and tertiary education institutions should be leveraged to communicate and inform stakeholders. The write-up of successful case studies should be encouraged and incentivised. The GreenCape market intelligence report could be used to showcase application examples of the 4IR.

### For government

3.2 The WCDoA should **lead initiatives for expanding and improving current databases**. The aggregation and dissemination of information also include linking data from all parties in the agri-value chain to expand the variety, denseness and volume to the benefit of all stakeholders. Other opportunities include opening up the databases of original equipment manufacturers (e.g. John Deere) for sharing information about local agricultural production (planting and harvesting) and related information with more than just its customers. Original equipment manufacturers could be requested to make this information available. Alternatively, this could be legislated.

This and other important agricultural data should become part of a shared information platform that facilitates the collation and use of information in the sector. For example, Cape Farm Mapper could be expanded to include original equipment manufacturers' planting and harvesting information and compared with and used in conjunction with the department's fly-over data.

3.3 The WCDoA must support the **sharing of knowledge related to agricultural technologies** and associated supporting systems, establish technology demonstration

farms, run trials on the farms of existing participating farmers across the value chain, and share this information on a variety of platforms that are easily accessible to all farmers. Such platforms should have maintenance support.

3.4 The department should coordinate the **creation of a capacity** to develop business cases for investing in technology. This requires independent, verifiable information on return on investment and associated benefits and productivity improvements. This should be independently determined and made public for practitioners to use in the development of their investment business cases. There is a lack of sufficient independent verification agencies to validate the claims made by commercial suppliers of new technology. Independent case studies from the science and academic community as well as services from agri-entrepreneurs can fill this current knowledge gap. Financial institutions, investors in AgTech incubation and development, and tertiary institutions can also fulfil an independent verification role.

3.5 Together with technology service providers, the WCDoA should investigate options to reduce the **cost of acquiring new technology** for smallholder farmers. Options include shared platforms, financing schemes, servicing solutions, and subsidised internet services.

### For government • producers • scientists • agri-suppliers • agri-advisors • industry bodies

3.6 All role players in the value chain can supply extension services. Extension specialists must be able to demonstrate technologies and communicate its benefits, proper application and system requirements. For example, commercial agribusinesses should be more involved in evaluating existing technologies and applications to better engage with and advise their farming customers. This should involve the matching of farmer needs and technology products in the market. Agribusiness-based technology

advisors and specialists should strengthen their market intelligence and share this with their clients to keep them up to date.

### For scientists

3.7 The agri-science community should **stimulate the adoption of technologies**. The scientific community should provide inputs on the availability and integration possibilities of technologies. Research efforts should not only focus on single technologies and their uses but more on the integration of technologies into the farming system and value chain.

### For investors • producers

3.8 Financial institutions should develop **financing products** suitable not only for large farmers but more specifically for new entrants and smallholder farmers with regard to the acquisition of assets related to AgTech. Successful and sustainable farming requires investment on an annualised basis. This is a critical success factor for developing the agricultural sector. Information about the attractiveness of the sector for capital investment should be widely communicated.

### For government • businesses • entrepreneurs • investors • industry bodies

3.9 Agri-entrepreneurs, investors, the provincial department and industry bodies should collaborate to **stimulate entrepreneurship** across the above-listed technologies. Regional hubs could be commodity-based to be funded from the private sector in partnership with tertiary institutions. The South African Government agri-parks programme is one of its cornerstones of rural economic transformation. These agri-parks are to be fully developed to reach their objectives as one-stop shops for agri-production support, processing, logistics, marketing and training within district municipalities. In the Western Cape, the following districts have been identified as agri-hub sites: Ceres, Beaufort West, Bredasdorp, Oudtshoorn and Vredendal.

3.10 Business and the WCDoA should initiate competitions, challenges and ideas fairs to stimulate the understanding and application of the 4IR technologies in the agricultural sector. These innovation challenges could include annual drone challenges and agricultural robot

(agribot) challenges to stimulate awareness and interest in AgTech through innovation.

Potential cooperation partners include the private sector technology accelerators (Silicone Cape, Deloitte and Touché business accelerators, Wesgro ICT

desk, etc.), as well as academic-based technology accelerators (Stellenbosch University LaunchLab, UCT GSB Bertha Centre for social innovation and entrepreneurship, Co-Lab for e-inclusion and social innovation at the University of the Western Cape, etc.).

## No. 4. Smallholder commercial farming development

Seventy-five percent of all South African farmers are smallholder farmers. Small farmers do not have equal access to finance as large farmers due to the difference in asset base, potential production on the farm and their collateral available. Land ownership as collateral is, however, critical in structuring viable financing. The first requirement will be to ensure that these smallholder producers are productive in a commercial sense, and producing for a market in which their products will be exchanged for monetary gain profit.

It is therefore imperative to create conducive conditions for smallholder farmers to become commercially sustainable. Such conditions include: (1) an incubation period focused on developing new entrants and creating a productive mindset; (2) education on technology, farming practices, and biology; (3) mentorships to support skills development; (4) business education to develop commercial acumen; and (5) financial assistance through rent or buy options and other funding alternatives. Smallholder farmers and government must work together to unlock the sector's full potential.

In the context of the 4IR, the concepts around defining, developing and implementing a digital quotient for these participants will need to be crafted. The agricultural sector should prevent a digital divide outcome in the Western Cape, wherein only certain role players benefit from 4IR opportunities.

## No. 4 Recommendations

### For government • investors • producers

4.1 The WCDoA should develop an integrated framework for the on-boarding and development of new entrants into the sector. This must include each of the five enabling conditions described above. Aspects of this framework can also be relevant for the support of existing smallholder farmers.

4.2 The provincial government, in cooperation with financial institutions, should develop financing schemes that target smallholder farmers. The WCDoA, together with the Department of Rural Development and Land Reform, should facilitate the acquisition of title deeds by individuals or entities or explore other forms of collateral (providing guarantees of land ownership to secure funding, e.g. Venture Capital funding to free up government funding for other imperatives); or employ new insurance products such as weather index insurance for smallholder farmers coupled to loan facilities; or explore financing of technologies, by banks; or incentivise larger (mega) farms to offer their farms as collateral for smallholder farmers. Smallholder farmers should come together to overcome the challenge of scale and be organised collectively to present a bigger business case to gain access to finance.

### For agribusinesses • smallholder farmers

4.3 Agribusinesses and smallholder farmers should continue to create partnerships to facilitate access to financing, markets and technology. This should be actively encouraged

through incentives such as increasing dam capacities, greater access to river catchment systems, and infrastructure development (roads, energy and railways) to increase production capacity on current and new land. Enabling market access and participation in market structures by smallholder farmers through partnerships with large agribusinesses needs to be accelerated. This will enable smallholder farmers to better participate in the agricultural value chain.

4.4 Agri-entrepreneurs should be encouraged and supported by the WCDoA and the financial sector to develop crowdfunding platforms and other AgTech propositions aimed directly at developing smallholder commercial farmers.

4.5 Agri-entrepreneurs should actively invest in collaborating in the value chain through equipment rental services, seeding services as an alternative to owning planting equipment, advisory services, and analytic data services. To attract agri-entrepreneurs to these new business opportunities, the WCDoA should establish an annual AgTech innovation competition, aimed at supplying services to smallholder farmers.

4.6 The department should stimulate the creation of business cases in the domain of the sharing economy and crowdfunding through innovation challenges, idea fairs and competitions. This should be in collaboration with both academic-based and private sector technology accelerators.

4.7 Smallholder farmers should explore **high-value niche market products** to be cultivated in smaller quantities. There is also the opportunity to define and supply specific local markets and communities with home-grown commodities.

**Sharing economy**

4IR thinking promotes a different way of thinking about assets and their utilisation. This is unlocked through a sharing economy mindset, where the value chain participants seek partnership opportunities by collectively using current assets through sharing arrangements. Examples are peer-to-peer lending, crowdfunding, equipment sharing, equipment rental services, and knowledge and data sharing.

**Crowdfunding**

Crowdfunding, an alternative means to traditional funding arrangements, is a business opportunity for agri-

entrepreneurs. Crowdfunding platforms that enable smallholder farmers to obtain financing to grow their businesses already exist elsewhere in Africa. For example, online applications enable investors to monitor progress and expected yields. At the end of the harvest cycle, investors recover their capital plus a pre-agreed profit margin. Such applications also provide a farming platform that enables individuals or groups of people to become part of an agricultural system.

In this way, a network of small farmers secures funds, equipment and technical support to plant and harvest crops.

Purchase orders from prospective buyers are secured beforehand to ensure that supply matches demand. With the bulk of small farmers lacking the capacity to operate at scale, this business model allows them regular access to working capital to hire more labour and to cultivate larger farmlands.

Another approach – a form of contract farming – is the lease of farmlands from communities and then to contract farmers to plant crops based on market demand.

**No. 5. Reposition the agricultural sector’s brand for the 4IR**

The agricultural value chain offers a variety of exciting and interesting career opportunities due to the complexity of the value chain elements, its integration and the variety of knowledge bases required to contribute (e.g. food scientists, marketers, economists, production specialists, veterinarians, data analysts, finance and investment, geneticists, general management, etc.). Globalisation contributes to making a local farming and processing unit a part of the international agricultural market. However, the agricultural sector is currently not well-branded as a prime career destination.

New brand experiences for consumers based on digital capabilities like digital marketing, social media communication and data analytics would reflect the changing nature of the agricultural sector. The sector is an attractive destination for future capital investments due to the application of smart farming technology-based applications.

**No. 5 Recommendations**

**For government • industry associations • academic institutions**

5.1 Industry associations, academic institutions and the WCDoA must formulate a collective narrative and strategy for attracting a variety of future young talent to the sector. The core message could centre on rapid evolution in agriculture in the context of the 4IR. A YouTube video on the exciting opportunities of the agricultural sector as a future career should be created and distributed on social media platforms as part of a strategic communication strategy. This communication video should be created by the youth, for the youth, as part of a WCDoA youth initiative. Younger generations are more inclined to adopt technologies as part of their lifestyle; a critical behaviour to speed

up technology adoption in the sector.

5.2 The WCDoA should cooperate with tertiary institutions and industry associations in the province to implement agri-accelerator development programmes (fast-track learning) through skills exchange programmes to and from global territories that are leading agricultural technology innovation. This initiative can also include study tours focusing on best farming practices and technologies used elsewhere, with a specific 4IR and commodity focus.

5.3 Role players in the agricultural value chain should adopt, in their marketing approach to consumers, new brand experiences based on digital marketing, data analytics and social media.

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