

**THE FUTURE OF THE WESTERN CAPE AGRICULTURAL
SECTOR IN THE CONTEXT OF THE 4TH INDUSTRIAL
REVOLUTION**

**Review: Tech Trends in the Context of Agriculture in
the Western Cape**

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1. Introduction

The Background to Innovation in Agriculture

The need for technological innovation in agriculture has never been more pressing. The demand for agricultural products is constantly increasing. Population growth continues to fuel this demand as it has throughout human history. Economic growth also means that the world's population has more wealth per capita, which also adds to global demand. It is obviously essential that global supply meets this demand, so that every person on the planet has affordable access to nutrition at the very least.

The requirement for significant growth in agriculture poses a big problem. How do we produce more from existing farms with constant or even decreasing natural resources? We have finite land and finite water available. In South Africa in particular, water resources are decreasing due to climate change, aging infrastructure and increased usage of water from a growing population. The answer lies in being far more efficient with our constrained resources, at least in the short to mid-term. (Longer term we may be able to biofabricate food at huge scale, for example, but we cannot wait for those innovations to become feasible).

Technology has always been the primary source of improving efficiency. When the availability of all the inputs (food, fuel, minerals etc) we need to sustain life from the natural world become constrained, humans innovate to solve for the best solution given these constraints. This type of innovation spawned the birth of farming itself. Hunter-gatherers could not sustain growing populations and so they started to perfect the way nature produced food. This evolution has led to modern-day agriculture on a truly massive scale. Every year, yields per hectare increase as innovations ranging from better rotation techniques, to genetically modified crops, improve our ability to get more output from limited inputs.

Agriculture has certainly been a laggard in technology adoption. Barring anomalies such as drought and disease, farmers have operated under stable conditions, with constant demand providing more than enough revenue for the majority of farmers. Stable conditions do not drive innovation. After all, why would a farmer spend large amounts of capital on a new technology system when their existing business was making good profits? In order for rapid technology innovation to thrive, it needs to make sense for the user to experiment and adopt new technology. The rate of adoption is determined by two major factors: the need to improve, and the price of technology adoption. Both of these factors have experienced dramatic change in recent years:

The Need to Improve

We have already briefly touched on the increasing demand for agricultural products driven by societal changes. However, increasing demand is not a driver for change for farmers. If anything, increased demand would reduce the amount of innovation, as increasing demand drives higher prices, meaning an easier operating environment for farmers. Easier operating environments do not drive innovation.

Innovation is bred from difficult conditions, and conditions for farmers are becoming increasingly difficult. The largest source of difficulty is climate change. Predictability is massively important for farming. Knowing when to plant crops, water fields, and harvest crops is vital to improving yields and margin. Climate change poses a threat larger than most are willing to admit. Over centuries we have become better at predicting the future by analysing the past. A rapidly changing climate makes our existing knowledge far less valuable. With weather patterns becoming less predictable, farmers need to find tools to predict weather, react to weather, and cope with different levels of resources, primarily water. In South Africa and the Western Cape in particular, climate change appears to be resulting in less water. Farmers are extremely vulnerable to cash flow problems when experiencing more than a year of poor harvests. Climate change makes operating conditions difficult for the farmer, which in turn encourages the farmer to innovate to solve the problem.

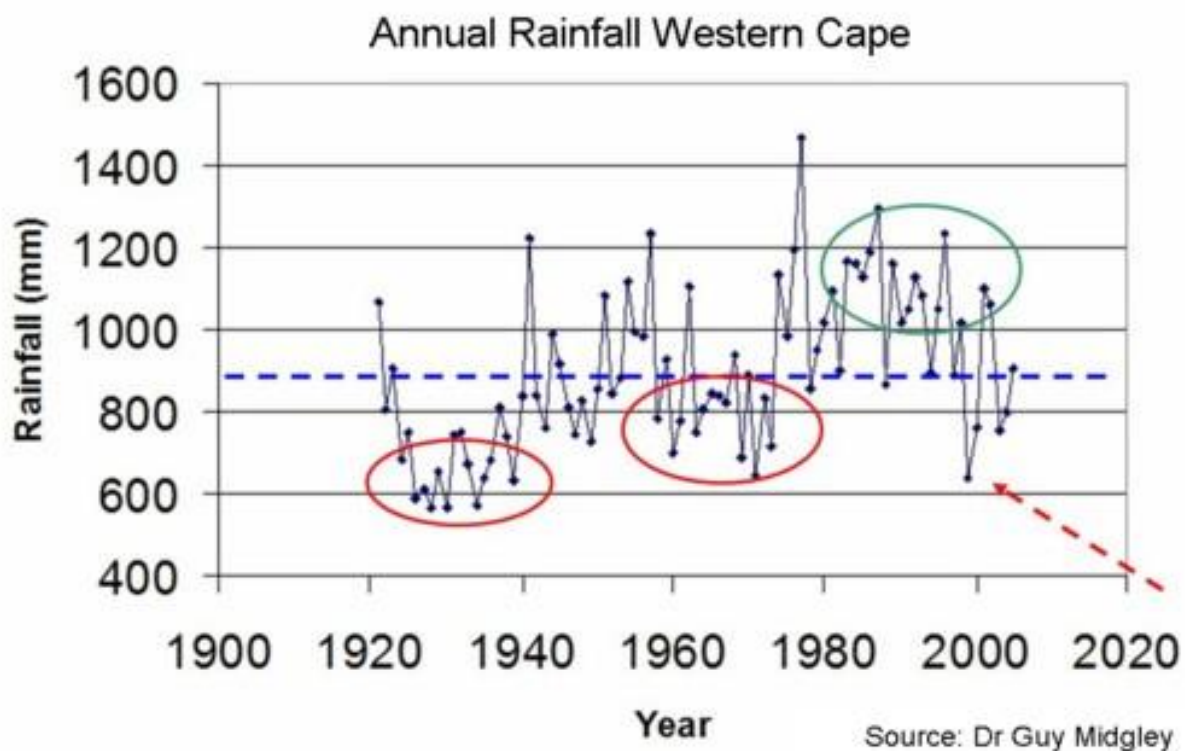


Figure 1: Historical Rainfall in the Western Cape

Competition is the second major factor increasing difficulty for farmers. Farmers adopting new technology are increasing their yields significantly. When enough farmers have consistent bumper crops, this drives the price of produce down. The farmers making higher volumes benefit from improved efficiency. Those that produce the same volumes at the same margins are negatively affected. The Western Cape exports a great deal of its produce and thus competes on an international scale. For example, if fruit farmers in Europe and America use technology to increase yields (and they are), they can dump large volumes in the lucrative Chinese and European markets, this has an adverse effect on Western Cape farmers. Competition makes market conditions more difficult, which in turn encourages the farmer to innovate and become more competitive.

The Price of Technology Adoption

In the past, adoption of cutting edge technology has been synonymous with high costs. Buying the latest machinery is expensive and the higher the cost, the lower the return on investment (ROI). Even if the ROI is likely to be large, the risk of huge upfront costs are definitely a limiting factor for technology adoption. What's more, there has been a dearth of case studies on the benefits of innovation that can be used to calculate likely ROI and justify capital outlay. This status quo has completely changed over the past decade. Of all the reasons for Western Cape agriculture to adopt technology, the decreasing price-to-performance ratio of technological innovation is the most important. This is the most significant trend in human history.

Such a bold statement requires a justification. Why is the price of technology so much more affordable than it used to be? Inflation dictates that prices should increase, but the price of processing power has decreased dramatically.

Moore's Law

Gordon Moore was one of the founders of Intel, the largest chip manufacturer on earth. In the early 1960's, Moore realised that the amount of transistors being placed on a silicon chip was roughly doubling every 12 to 18 months. He wrote a paper on this trend and it became known as Moore's Law. This is important because Intel started to apply Moore's Law as a self-fulfilling prophecy. The company endeavoured to double the amount of transistors on a chip about once every 2 years for the past 60 years. At first, this improvement was negligible. Computer chips were only slightly better each year. After all if you double 1, you get 2. The difference being 1. If you then double 2, you get 4. Again not a large difference. But if you keep doubling, progress starts to move pretty quickly. This is illustrated in the graphic below which shows how significant a doubling is, in today's terms.

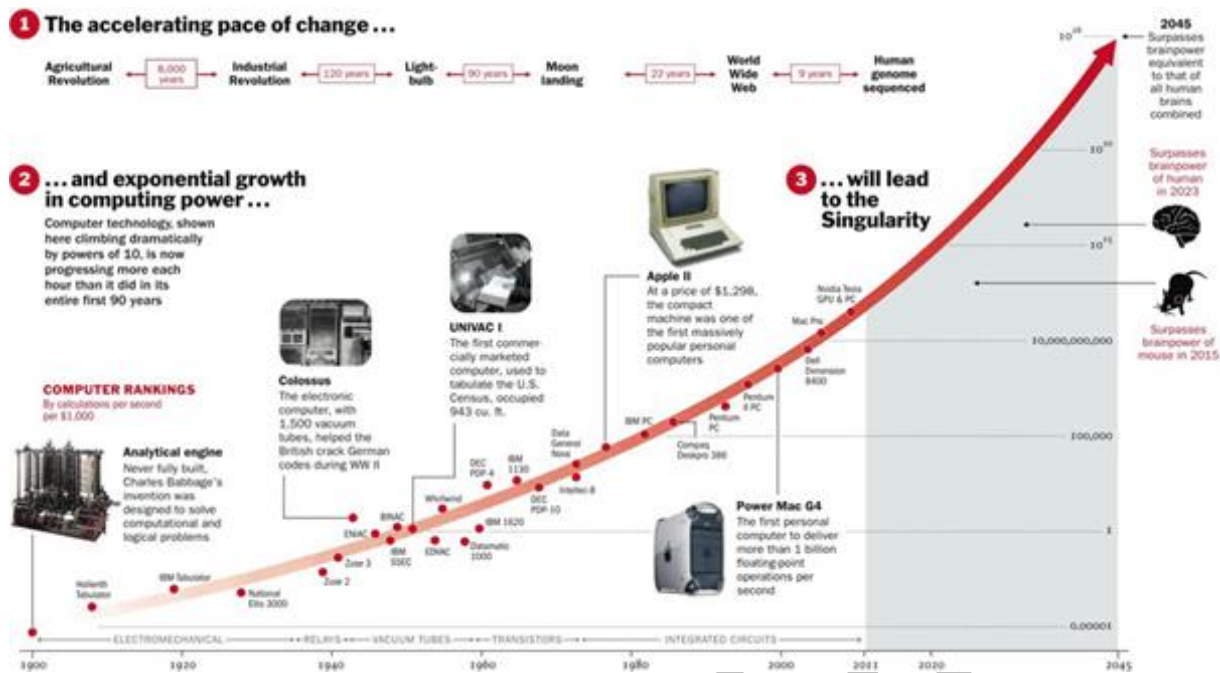


Figure 1: A History of Moore's Law. Source: Ray Kurzweil

On the left hand side of the graph, in the early years of computers, the change in computing power was very slow. But consider that in 1993 Dell was selling a top-of-the-line computer with a 66MHz processor, 8 MB of RAM and a 320-megabyte hard drive for \$4,400. Today you can buy a Dell Inspiron laptop with a 2.4GHz processor, 8GB of RAM, with a 1TB hard drive for \$425! So today you pay one-tenth the price for a computer that is a thousand times more powerful than the computers from 24 years ago. If we take inflation into account the numbers are even more staggering. In an inflationary economy, we are accustomed to prices going up. For computing, in terms of processing power, prices have continued to plummet.

The statistics in our laptop example are impressive, but perhaps understandable over almost a quarter of a century. But even after hearing that example and being told about Moore's Law, the average person expects computers to be only marginally faster next year. The almost unbelievable fact is that **the speed and performance of the incredibly fast computers we have today will be double as fast within 2 years.** In other words, all of the progress we have made in perfecting computing over that last 100 years to get to get to where we are now, will be doubled in about 12 to 18 months time.

Computer chips are all around us. They are in almost every sensor and piece of equipment in use. When chip prices decrease, equipment prices decrease, and are now at a level where the man on the street can afford to have a 3D printer in their kitchen. Twenty years ago you

would have to be a very elite scientist at IBM or Harvard to get access to a supercomputer in order to do data experiments. Today, any man, woman or child can access affordable processing power through cloud computing.

By allowing many millions of people to afford the tools required for scientific discovery, we have exponentially increased the amount of creative thought being dedicated to advancing technology. The result is a speed of technological innovation which can barely be documented, in fields like big data, machine learning, biofabrication, nanotechnology, smart material, the internet of things and many many more. All of these advances have the exponentially decreasing cost of computing power at their core.

2. What Does this mean for Agriculture in the Western Cape?

The result of all of this progress is that it is far far cheaper to buy the resources required to install new technology applications on farms. From ICT infrastructure to sensors and batteries, to nanoparticle membranes, and data analytics, technology adoption is becoming far more accessible from a cost perspective. When calculating ROI, this makes the capital expenditure decision far easier. As more and more farmers buy tech they can afford, more and more tech is built by suppliers who reach economies of scale and decrease prices even further. Widespread adoption begets data which can then be used to make the tech better and better. The massive winner in this cycle is agricultural yield and thus, the South African economy.

In summary, conditions for farming are becoming more difficult. Conditions for implementing technologically driven efficiency are improving. The equilibrium of these two forces is being realised with each passing day. Areas with higher input costs such as California are already employing technology on a large scale. The Western Cape region is starting to meet this equilibrium due to increasing pressure through adverse farming conditions. However, the adoption of technology at current reducing prices is now Western Cape agriculture's biggest opportunity. It is essential that the region adopts new methods in order to compete with global players.

3. The Most Important Technology Trends for Application in the Western Cape

When weighing up technology implementation, it is important to understand the evolution of the technology in order to achieve the full benefits. Is there enough infrastructure in place to support the systems? Has the technology been proven to achieve results? Will the technology make sense given the local environment? (e.g. labour, fuel and electricity costs). The trends highlighted below are the most likely technology implementations to result in positive ROIs in the short to medium term given Western Cape agriculture conditions. This is also taking into account the fact that the region is heavily weighted in terms of producing crops vs livestock, in particular deciduous fruit, wine and increasingly, citrus fruit.

Precision Agriculture

Precision agriculture is probably the most talked about application of technology today. Precision agriculture is facilitated by a convergence of different exponential technologies, the combination of which has resulted in significant gains for early adopters. Information communication, the internet of things, cloud computing, machine learning, and artificial intelligence are just a few of the main areas contributing to precision agriculture.

Though farmers have refined their methods using experience gathered over many hundreds of years, we cannot possibly hope to compete with the accuracy afforded by big data analytics. If we understand every metric of growing a crop, we can use machine learning to prescribe the best way of using valuable input resources. For example, by measuring the consistency of soil, the level of water available, the temperature, all weather metrics, fertiliser usage, crop yields and prices, we can build a picture using data that can be rigorously analysed. The power of prescriptive analytics can then inform farmers of how to achieve the highest yields given a set of constraints.

In the past, the lattice of networks and sensors required to capture, transmit and analyse all of this data would have been too high to contemplate. But due to the reasons stated above, this equipment and infrastructure has decreased dramatically. The picture of big data painted above is the desired end point in the full precision farming picture. But even simple implementations such as drip feeding plants rather than flood irrigation yield positive ROI for farmers.

By collecting and analysing data, farmers can use their limited resources to produce higher yields per hectare. An internet connected farm may have seemed space-aged a few years ago. Very soon, those who do not adopt these techniques will be the outliers.

Education

Precision agriculture allows established best practice in farming to be improved even further. But even larger gains per hectare are available for less advanced farmers who start on a low base. In the past, small rural farmers have not had access to the type of knowledge available to the big business farmers who can afford to spend on research and development. As a result, their farming practices are often outdated resulting in poor yields per hectare.

Any best practice information that can be shared with developing farmers will result in substantial percentage gains. This was well illustrated by the CSIR and the Limpopo Department of Agriculture. The team introduced precision farming techniques in small-holder irrigation farms in Limpopo: The use of drip irrigation systems to irrigate three vegetable crops per year using improved farming practices, such as high-yielding varieties appealing to the market, scientific irrigation scheduling, fertilisation based on soil analyses and in situ available resources for mulching and organic fertiliser (manure, compost and biochar)¹. The result was an increase in crop yields from 10 - 20 tons per hectare to 60 - 80 tons per hectare. A monumental increase. The gains to be made from bringing smaller farmers into the technology age are huge and benefit all.

Sharing best practice at scale has been difficult in the past. High data, costs, a lack of ICT infrastructure and a lack of awareness all contribute towards information not getting into the hands of those who need it most. However, these problems are being addressed by technology. More connectivity is becoming available each day and with portals such as Facebook's Zero (access to Facebook at no cost), we are seeing new and unique ways to communicate best practice to farmers in remote areas. There are numerous case studies of the positive effects of online education for farming. If the Western Cape can get quality information into the hands of its farmers through new technology channels, the resulting increased in efficiency will be significant.

Disintermediation

Disintermediation has been both a positive and negative global trend which has proved extremely disruptive. Uber disintermediated taxi companies. AirBnB disintermediated rental agents. In a time where communication amongst multiple disparate parties was extremely difficult to coordinate, intermediaries and agents thrived as the go-between from farmer to

supermarket. The number of people taking a cut between farm and table ranges from 1 or 2 agents for large players, to 6 or 7 agents for small farms. Every bit of margin added at each step is essentially money the farmer foregoes to facilitate transfers and price negotiations.

The internet and software providers are rapidly attacking this stack of intermediaries. By connecting farmers in a digital co-operative, directly with buyers from big retail outlets, both initial seller and eventual buyer benefit through better pricing. Disintermediation is a truly disruptive element of technology innovation but because the main beneficiaries are the smaller players in any given market, the trend is likely to continue and find favour with users en masse.

4. Conclusion

The need for higher yields in agriculture is increasing for all stakeholders. Growing populations increase demand for more agricultural produce. Constrained resources and increased competition put pressure on creating better efficiency from farmers. The need for economic growth and sustainable employment put pressure on governments.

As time goes by, incremental improvements in farming output become more challenging with constrained resources. However, colossal steps forward in technological innovation have created an opportunity for agriculture to thrive, creating efficiencies that would not previously have been possible.

What's more, the access to technology implementation has become more and more affordable with each passing year, making the ROI on such installations far more appealing. There are many large trends shaping global agriculture but the most important movements in the context of the Western Cape are precision agriculture, online education, and disintermediation. There are large improvements to be made by embracing these trends, and it is increasingly affordable to do so. In the exponential age of technology, improvements in technology are constant and far larger than the average person can conceive without understanding the history and effects of Moore's Law. It is the farmer that masters these techniques that will dominate the global agricultural market, benefiting the economy and the citizens of the Western Cape.

¹ CSIR. 2016. *Innovative farming project scoops two excellence awards in Limpopo*. [Online] Available: <https://www.csir.co.za/innovative-farming-project-scoops-two-excellence-awards-limpopo> [Accessed: 31 October 2017].