High impact innovations transforming Australian agriculture

Agriculture is being transformed by technologies that have the capacity to make the entire agricultural supply chain more precise, more profitable and more sustainable.

With a strong track record of technology integration, the speed of technology innovation means that industries need to proactively seek out alternative sources of technology and sift out those with the potential to be game changers.

This is the fourth report in a series of scans looking for high impact technologies overseas and in other sectors of the Australian economy that will likely disrupt the agricultural supply chain.

The six technologies identified through the research will support industries to be better positioned to maintain a strong competitive advantage and ensure the sector is well placed into the future.

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Full report


How can you harness the technology of tomorrow for the benefit of agriculture today?

This research takes a look at six technology innovations with the potential to shape Australia’s rural industries:

- Cognitive Computing
- Microbiome
- Distributed Economy
- Moisture Harvesting
- Metamaterials
- Programmable Materials

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COGNITIVE COMPUTING
HUMAN-IN-THE-LOOP MACHINE LEARNING • COMPUTER VISION

Cognitive computing technologies are artificial intelligence systems that augment and enhance human capabilities. Machine learning can extract knowledge and patterns from data to learn, predict, and then develop a certain level of autonomous functionality. Human-in-the-loop machine learning has similar capability, but incorporates some human input to achieve more complex functionality and improve problem-solving capabilities. Computer vision is the use of cameras, sensors and artificial intelligence to provide computing devices with the ability to recognise and analyse real-world objects and digital images. This can help humans in difficult tasks such as anomaly detection.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of cognitive computing technologies on a 5-point scale. On average, cognitive computing technologies were perceived to have high potential impact for Australian rural industries. Devices capable of assisted or independent learning, and that can adapt to and perform tasks in changing environments were perceived to have highest impact. Improving the safety and performance of humans had a lower perceived impact.

INNOVATION TRENDS

Cognitive computing technologies have received extensive innovation. Analysis of number of patents published by country shows the USA to be the focus of innovation. However, a considerable number of patents have been published throughout Europe and the Asia-Pacific region.

Analysis of number of patents published per year shows a steady upward trend for machine learning innovation over the last several years. By comparison, computer vision innovation has been steady, with a slight upward trend over the same period.
MICROBIOME
MICROBIOME • PLANT MICROBIOME

Microbiome is a term that describes the complex communities of microorganisms that colonise living organisms. A plant’s microbiome colonises plant surfaces and inner tissue. The exact microbiome composition is influenced by the surrounding soil and air. The plant microbiome is a key driver for plant health, productivity, community composition, ecosystem functioning, and nutrition. Greater understanding of plant microbiomes has the potential to improve resource availability, growth promotion, disease resistance and plant protection.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of microbiome technology on a 5-point scale. On average, microbiome technology was perceived to have high potential impact for Australian rural industries. The use of this technology to better understand and improve plant health and growth, as well as to develop value-added consumer products offers potential impact for Australian agriculture.

The characterisation of microorganisms which are found in plant environments to better understand plant health

Manipulation of a plant’s microbiome to enhance nutrient use, abiotic stress tolerance, and disease resistance

Manipulation of a plant’s microbiome to develop value-added products with health benefits for consumers

INNOVATION TRENDS

Analysis of number of patents published by country identifies the USA as the focus of microbiome innovation. However, a similar number of patents registered with the World IP Organisation suggests that patents will be published to cover a greater number of countries.

Analysis of number of patents published per year shows a steady upward trend of microbiome innovation over the last several years. Patents directly related to plant microbiome technology have been limited. However, there has been a very slight increase in this area since 2015.
DISTRIBUTED ECONOMY
BLOCKCHAIN • DISTRIBUTED PRODUCTION

Distributed economies emphasise small-scale, localised production to facilitate adaptable and innovative economies that create mutual benefit for stakeholders. Blockchain is a distributed peer-to-peer database that records digital events and transactions in an immutable way. Blockchain removes the need for intermediaries, such as banks and brokers, allowing for cheap and instant transactions. Distributed production is the production of commodities in a decentralised infrastructure. This is enabled by the availability of technologies that allow efficient production on a small scale. In farming, this includes technology driven compact farms that demonstrate highly efficient use of inputs with maximum outputs.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of distributed economy technologies on a 5-point scale. On average, distributed economy technologies were perceived to have high potential impact for Australian rural industries. Technology enabled efficient transactions and supply chain management were highest rated. Facilitation of local networks of people and services for the production of goods was perceived to have less potential impact.

Enabling flexible networks of people and services to use sustainable and local resources to produce goods
Shorter and more efficient supply chains that reduce the added costs applied to goods
Secure and immediate transfer of digital assets without the need for third-party intermediaries
Immutable and transparent records of transactions in the supply chain to facilitate accountability and traceability

INNOVATION TRENDS

Overall innovation of distributed production technology has been more extensive than blockchain technology. Analysis of number of patents published by country identifies the USA as the primary location of innovation for both distributed production and blockchain technology.

Analysis of number of patents published per year shows that innovation of blockchain technology has spiked notably since the second quarter of 2015. In comparison, innovation of distributed production technology has remained steady over several years.
MOISTURE HARVESTING

Moisture harvesting is the process of capturing water vapour from the atmosphere, and subsequently making it available in a liquid state. Where moisture harvesting had previously only been possible in high humidity areas, a new system is capable of efficiently capturing moisture from air with relative humidity levels as low as 20%. The system uses a metal organic framework (MOF) material to capture and release water vapour. The MOF material can be tuned for specific environmental conditions and requires little human input when in use. It has the potential to be used for supplementing drinking water and for agriculture applications.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of moisture harvesting technology on a 5-point scale. On average, responses show that the capability to collect water from the air is considered to have high potential impact. Using collected water to support agriculture was perceived to have very high impact in low humidity environments. Although still considered valuable, this capability was perceived to have less impact in humid environments.

APPLICATION

Although moisture harvesting will not supplant existing agricultural water sources, it has the potential to supplement them. It could be used in conjunction with desalinated water, and other water saving technologies and practices, to facilitate efficient farming systems in previously unusable spaces.

Examples of this are controlled greenhouse farming in arid regions with poor soil quality. Compact and vertical farms in urban environments might be another option due to their efficient use of water and other inputs.

**Water vapour in the air is absorbed by the MOF material**

**Heat from the sun is used to release the water from the MOF material**

**Water is collected on a condenser and then stored in a reservoir**

Solar powered devices capable of harvesting water from air at relative humidity levels as low as 20%

The means to collect water in low humidity environments to support agriculture

Supplementing agricultural water supply in high humidity areas
Metamaterials are nanoengineered materials with properties that are not demonstrated by materials found in nature. While many uses are possible, metamaterials are particularly well suited for the creation and manipulation of light. Metamaterials with light absorbing properties can be used to improve the efficiency of solar cells. They can also be used to create thermo-photovoltaics which can create energy from heat.

**EXPERT OPINION**

Experts were surveyed and asked to rate the impact of metamaterials on a 5-point scale. On average, responses show that the perceived impact of metamaterials for Australian rural industries was greatest for their use in enhancing the efficiency of solar cells. This adds to an already strong interest in solar and other renewable energy technologies for rural and agriculture applications. It demonstrates the value of self-sufficiency in Australian rural industries.

**INNOVATION TRENDS**

Analysis of number of patents published by country shows the USA and China as the primary focus of metamaterial innovation. Patents filed with the World IP Organisation and European Patent Office suggests that the number of multi-country patents might increase.

Analysis of number of patents published per year shows that innovation of metamaterials increased through 2012 and then decreased through 2013. There has been an increasing number of metamaterial patents published since 2014, with an upward trend continuing into 2017.
PROGRAMMABLE MATERIALS

OLEOSPONGE • 4D PRINTING

Programmable materials are designed to have specific functionality in response to stimuli. One type of programmable material is 4D material. These materials can be used with 3D printing processes. They are designed to dynamically move, transform and assemble when exposed to certain stimuli (e.g., moisture or heat). Potential applications of 4D material include motorless valves, and adaptable packaging and insulation. Programmable materials can also be static. For example, the Oleosponge, which is material that can be programmed to absorb specific types of chemicals.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of programmable materials on a 5-point scale. On average, responses show that the perceived impact of programmable materials for Australian rural industries was mixed. The ability to selectively target and filter out specific chemicals was highly rated. Absorption of oil, and the capability of materials to transform their shape in response to selected stimuli was perceived to have less impact.

INNOVATION TRENDS

4D printing has limited presence in the patent data. Analysis of number of patents published by country shows the USA as the focus of 4D printing innovation.

Analysis of number of patents published per year shows that innovation of 4D printing technology has increased since 2014. Strongest interest has occurred in 2016 and 2017. The limited number of 4D printing patents is likely due to the experimental nature of the technology. Innovation is likely to increase as the technology matures and commercial applications become more evident.