Transformative technologies

Five megatrends impacting Australia's rural industries over the coming 20 years were identified by the Rural Industries Research and Development Corporation (RIRDC) and CSIRO in 2015. One megatrend is transformative technologies, which will change the way agricultural products are made, marketed and transported.

The potential for these emerging technologies to advance rural industries is described in a series of eight fact sheets developed by RIRDC. The technologies are diverse and are at different stages of development, and some are converging to create higher levels of integration in farm management. Despite their diversity, common themes are emerging.

- Sensors
- Artificial intelligence
- Gene editing
- Nanomaterials
- Robots
- Synthetic biology
- Internet of things
- 3D printing

Agriculture will be transformed by new technologies

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

Sensors will generate real-time, continuous data about the health and status of individual plants and animals, enabling more informed decisions and improved production efficiencies. Artificial intelligence will convert data into decisions for the entire supply chain and will guide robots to operate in a range of scenarios, including on farm, in supply chain logistics and processing.

Nanomaterials in pesticides will deliver site-specific, slow-release applications targeting specific pests and diseases, while nanovaccines will deliver medicine directly to affected tissues or organs. Synthetic biology may result in more nutritious crops that thrive with less water, requiring fewer chemical inputs. Gene editing will facilitate faster and more precise plant and animal breeding.

Consumers will have access to more information about their food and fibre than ever before, with technologies providing greater transparency on provenance and production systems, with complete traceability back to the farm gate.

Commercialisation of transformative technologies will occur within 5–15 years

Most transformative technologies are in proof of concept, R&D or trial stage with pathways to some form of adoption or commercialisation due within the decade.

As datasets grow and increasingly sophisticated sensors and software are developed, the accuracy and efficacy of data interpretation will improve within five years. Robots for precision applications in horticulture are already being trialled in Australian orchards, and robotic tractors are 10 years away from adoption on broadacre farms. 3D printed prototypes are supporting the development of new agricultural machinery and 3D printed food may be familiar within 15 years.

Globally there are 3000 registered patents for pesticides using nanomaterials. Gene editing is already reducing conventional breeding outputs to 1–2 generations, rather than 10 or more years.

While all technologies are showing promise in laboratory or field trials, and some are in use by early adopters, a lack of information about the return on investment (at 2016) limits the ability to predict how quickly the technologies will be adopted in agriculture.

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Application of technology will change farm operations

Decision-making will change from a broadacre or herd scale, to management of an individual plant or animal, lifting precision agriculture to a new level.

Sensors, ranging from electronic receivers through to nanoscale biosensors, will generate data that indicates plant stress, predicts animal yield and soil health. Robots using artificial intelligence will assess and respond to sensed data and operate without human intervention. Data and performance information will be processed through an internet of things to provide a complete picture of the factors that influence farm operations, supporting more informed decisions to improve efficiencies.

Synthetic biology and gene editing will develop new plants and animals with better adaptive capacity to climate extremes and for previously unfarmed environments. Agricultural nanomaterials will enable greater economies of scale through the slow-release and targeted application of production inputs. Synthetic biology has the potential to produce agricultural products, such as milk and saffron, without the need for a farm at all.

Technology will change the skills needed in agriculture

Low-skilled labour and manual jobs will gradually disappear as technologies replace humans in a range of roles and new skills will be required for careers in agriculture.

The shift from observable decision-making to decision-making based on data may mean farmers (and advisers) spend more time in the office than in paddocks, particularly if the data is linked to automated machinery operation. Sensors and the internet of things will predict machinery maintenance needs before breakdowns and 3D printers will enable farmers to manufacture their own spare parts. Eventually, farms may be managed remotely.

Future careers in agriculture will require IT skills, but change should occur incrementally allowing the workforce to re-train and adapt. Transformative technologies will also attract a new generation of people with different skill sets to careers in agriculture.

Technology may improve the quality of life for farmers as farm operations become automated, reducing pressure in peak periods and creating more leisure time. If the input savings are as predicted, it may also improve farm incomes.

Development and convergence of technologies is occurring at a faster rate than regulation

Policy and regulation have not necessarily kept pace with the rapid advancements in some technologies, and policy makers must balance opportunities with public safety.

Ground-based robots are already operating in farm trials, but safety and liability laws for autonomous machines making decisions in relation to plants and animals have not been developed. Use of the internet of things is increasing, but laws to control data access and security are unclear. 3D printing will allow individuals to manufacture goods, but the line between replication and counterfeit has yet to be determined.

Nanomaterials are already used in existing products like sunscreens and food additives; however their potential use in farm chemicals requires case by case approval by regulators. Gene editing and synthetic biology processes do not neatly fit within the current regulatory framework for gene technologies, creating ambiguity about their application.

Public perceptions will need to be managed

The potential applications of technologies are expanding at a rate greater than the general public's capacity to understand the opportunities.

Public perceptions of robots and artificial intelligence are driven by broader, negative commentary about a future dependence on robots. There may be concerns about the regional impacts of robots replacing humans on farms and the consequences of artificial intelligence making decisions about animal welfare are yet to be fully considered.

Gene technologies are already viewed negatively by some consumers (and banned by some governments). Even where gene editing doesn't meet the definition of transgenic, adoption of the technology may be limited if definitions are ambiguous. Synthetic biology is an avenue for creating artificial life, which poses complex social and ethical concerns.

There is a clear need for ongoing discussion between the research community and the public to ensure acceptance of these new technologies.

RIRDC has developed a series of fact sheets and infographics describing eight new and emerging technologies that will transform Australian agriculture. All documents in the series are available for download at www.rirdc.gov.au

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