Submission No 9

TECHNOLOGY AND THE AGRICULTURE AND MINING SECTORS

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NSW Government Submission to the Inquiry into technology and the agriculture and mining sectors

PREPARED BY THE NSW GOVERNMENT

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The $20.9 billion[1] NSW primary industries sector is a major contributor to the economic and social fabric of NSW and provides food and fibre for Australia and its trading partners. NSW primary industries support 86,000 direct jobs[2] and a further 67,000 jobs in manufacturing, many of which are in regional communities.

The Department of Primary Industries (DPI), within the Department of Regional NSW (DRNSW), plays a central role in the NSW Government's commitment to rural and regional NSW by driving a strong primary industries sector. DPI works across industries and with communities and has a clear focus on productivity, growth and ensuring the sector's sustainability for the benefit of all NSW citizens. DPI is committed to maximising outcomes for NSW primary industries, the communities they support and the resources they rely on.

The agricultural sector faces significant future challenges and technological innovation will play a critical role in many areas, including mitigating the impacts of drought, contributing towards carbon neutrality and addressing biosecurity and food safety risks. Integrating current and emerging technologies into agriculture and building research and development (R&D) capacity is key to the future prosperity and stability of the sector. Barries to uptake of technology include poor on-farm connectivity, a lack of technical support, poor user experience, low digital capability levels, and unclear benefits to businesses.

The NSW Government is committed to supporting farmers and regional communities grow, thrive and plan for the future, including through a range of investment measures to support the development and adoption of technology.

NSW mining sector technology and innovation

In 2018-19, mining contributed to about 50 per cent of total NSW merchandise export[3] ($29.3 billion), paid $2.1 billion in royalties, and directly employed almost 30,000 people (and 119,000 people indirectly), mostly in regional NSW[4].

The NSW resources sector is vibrant, with world-class deposits, a highly skilled workforce and a reputation for safe, responsible and innovative mining practices. The NSW Government strongly supports the minerals industry and the responsible development of mineral resources.

The minerals industry positions NSW as an essential supplier to meet growing global demand for metals used in the advanced technologies of today and tomorrow—smart devices, batteries, electric vehicles and many other new and emerging applications. Many regional communities in NSW depend on the coal industry, which provides over 22,000 direct jobs and around 89,000 indirect jobs.

[1] NSW Department of Primary Industries *Performance, Data & Insights 2021, Statistics Tables, 'Output'* dpi.nsw.gov.au/about-us/publications/pdi/2021/statistics-tables#stats-output
[2] NSW Department of Primary Industries Performance, Data & Insights 2021, Statistics Tables, 'Jobs & Businesses' dpi.nsw.gov.au/about-us/publications/pdi/2021/statistics-tables#stats-jobs-businesses-aggregated
[3] Merchandise exports are defined as goods which subtract from the stock of material resources in Australia as a result of their movement out of the country (abs.gov.au)
[4] *Future Ready Regions Strategy* nsw.gov.au/regional-nsw/future-ready-regions

Driving new investment in exploration and mining and forging a path for high-tech and critical minerals projects will be a focus in 2021-22 and beyond. The NSW Government supports the development and use of new technologies, systems and products to continuously improve hazard control, risk management, and health and safety outcomes at mines.

Low emissions coal technologies can play a vital role in reducing the State's future greenhouse gas emissions and can contribute to the Commonwealth Government's commitment to mitigate the effects of climate change under the United Nations Framework Convention on Climate Change Paris Agreement. Advancements in the capture and storage of carbon dioxide will also assist the NSW Government to meet its target of zero-net emissions by 2050.

Barriers to technology uptake in metal ore mining include limitation on technical resources and capability; technology readiness of electric or hydrogen fuel cell heavy vehicles; the large capital investment required for abatement projects; regulation barriers; safety and community considerations; and electricity grid infrastructure required for electrification.

NSW research and development

High-quality research and innovation underpin advances in assets, processes and communications in agriculture and mining. To secure these benefits, NSW must build on its competitive advantages, accelerate the translation and commercialisation of scientific research and increase the rate and speed of adoption of new technologies.

Research strengths and the expertise and infrastructure they rely on are embedded across the NSW higher education and research sector, in national research institutions headquartered in NSW and in NSW Government agencies. Investment in industry relevant education and training will be key to developing thriving regional communities to support the agricultural and mining industries of the future.

Deeper and focused linkages between scientific expertise, industry and government will help scale technology industries and translate cutting edge research into start-up, scale-up and opportunities for small and medium-sized enterprises.

The NSW Government is currently developing a 20-Year NSW R&D Roadmap to identify competitive advantages in both research and industry and to inform future investments. Consultations are underway to identify priority technologies and applications for NSW, including how these technologies can support and enable applications in agriculture and mining.

Opportunities for regional NSW presented by agriculture and mining technologies

Agriculture sector

Integrating technology into agricultural businesses is important to the long-term prosperity and stability of Australia's agriculture industry. Australian agriculture faces significant future challenges and technological innovation will be critical to ensuring prosperity, stability and resilience.

The acceleration of tech-enabled production and monitoring methods has the potential to increase

the gross value of production (GVP) of farming businesses by 25 per cent; equating to a $3 billion per annum GVP increase in NSW[5].

New information technologies can create opportunities to improve climate adaptation responses through better management of short-term variability, including extreme events. Technologies can also reduce or allow inputs to be used more effectively and more strategically and will universally influence the sustainability of Australian agriculture.

Increased use of technology and improved connectivity in the agriculture sector can also improve health and safety outcomes. Working in the agriculture industry can be physically demanding and workers face challenges of working outdoors, working in all types of conditions, often in isolated areas. Technology offers solutions to minimise manual tasks and autonomous vehicles could alleviate risks of working with large machinery.

Drought mitigation and tolerance

Improvements in technology and management practices can help reduce the impact of drought. Research, development and innovation must translate to practical tools that will support business and production decisions in the lead up to and during drought. User-friendly digital tools will allow primary producers to benefit from shared knowledge to inform and validate their decisions and investments.

Research and development (R&D) programs undertaken by the agricultural industry to mitigate against drought have already driven significant benefits, including improved drought tolerance in crop varieties, biosecurity management, animal welfare and landscape management.

DPI works in partnership with key agricultural industries on drought-tolerant crop and pasture varieties, genetic improvement in livestock breeds, grazing strategies, soil management practices and farming systems better able to cope with drought conditions. Studies show that R&D accounts for about half of the productivity growth achieved in Australia's agricultural sector, which has always operated in a highly variable climate.

As drought severity and frequency is predicted to change into the future, there is a need for more transformative research to support the continued growth of the sector in NSW. This includes:

- innovative technologies to monitor changing conditions on farms to better predict when drought response decisions need to be made,
- new varieties and breeding lines of plants that are more drought tolerant,
- improved animal genetic selection, and
- improved animal-welfare management actions, such as supplementary feeding and temperature management.

The NSW Government has invested in the further development of the Enhanced Drought Information System, which aims to provide farmers with world-leading weather and climate data so they can make better business decisions.

Case Study: DPI Drought Feed Calculators - A free app available to Australian sheep and cattle producers to develop feed rations during drought and dry seasons. The app consolidates and translates animal nutrition research advice at point of sale. Refer to: thegate.org.au/dpi-innovation/case-studies/case-study-dpi-feed-calculators

[5] Perrett, E., Heath, R., Laurie, A. and Darragh, L., 2017. Accelerating precision agriculture to decision agriculture - analysis of the economic benefit and strategies for deliver of digital agriculture in Australia, Australia Farm Institute, Sydney. pp 331.

Carbon neutrality and climate resilience

Agriculture can make a significant contribution to the goal of net zero emissions. This goal needs to be achieved without the loss of productive capacity from the sector, with the abatement enduring, resilient and credible. Opportunities include:

- developing and supporting the availability of new knowledge, technologies and management practices to reduce emissions while maintaining productivity.
- developing new approaches to, and cost-effective measurement of, carbon storage and sequestration within agricultural production systems, including blue carbon.
- supporting adoption of energy efficient and renewable technologies to reduce energy costs and improve energy security.
- supporting the agricultural industry to adapt to climate change, increased climate variability and extreme events through new technologies, management practices and production systems.

Sustainable, accessible and cost-competitive sources of energy and storage are major factors in on-farm productivity and associated off-farm regional business viability.

Technologies to mitigate biosecurity and food safety risks

Biosecurity is a top priority for the NSW Government. Biosecurity is the foundation of productive agriculture and is vital to the protection of our unique natural environment and the continued health and safety of everyone in NSW.

Biosecurity outbreaks are increasing in volume, complexity and severity globally; placing significant pressure and risk on the sustainability of the NSW $20.9 billion[6] primary industries and $6.6 billion[7] export market economies and the community.

Surveillance, diagnostics and response technologies are critical to the predication, detection and response management of biosecurity and food safety risks within NSW. Faster detections, enhanced analysis and better risk assessments using techniques and technologies such as sensor technology, data analytics and artificial intelligence (AI) help minimise the spread and maximise the opportunities for containment and eradication of significant animal and plant pests and diseases, and weeds and contaminants.

AI, machine learning, satellites and autonomous vehicles will be critical in environmental monitoring and pest control. Smart technologies are needed to control invasive animals (both native and exotic) so as their impact on agriculture and the environment remains within a tolerable window. Highly specific biological sensors, chemical synthesis and simulation have the potential to revolutionise the protection of Australian borders from biosecurity threats – this includes protecting agricultural pastureland and livestock.

Case Study: eDNA Surveys
Environmental DNA (eDNA) surveys rely on the detection of trace DNA in water, soil, air or effluent which is left behind as animals, plants and bacteria release skin cells, gametes, pollen, bodily fluids and other material. DPI has successfully applied eDNA survey methods to the detection of invasive aquatic weeds such as Frogbit and this technology will be applied to a range of situations to detect target species and diseases in a variety of settings. This will include:

[6] NSW Department of Primary Industries *Performance, Data & Insights 2021, Statistics Tables, 'Output'* dpi.nsw.gov.au/about-us/publications/pdi/2021/statistics-tables#stats-output
[7] NSW DPI Performance, Data & Insights 2021, Statistics Tables, 'Exports' dpi.nsw.gov.au/about-us/publications/pdi/2021/statistics-tables#stats-exports

- water sampling of farm dams, reservoirs, and other standing water to monitor for target species or diseases
- sampling of effluent from feedlots, abattoirs and nurseries run off to confirm presence of pests and diseases
- pollen/spore air sampling to test for weed and disease presence (could be used via sentinel monitors, container/vessel sampling, drone capture or units on the top of vehicles travelling routine routes)
- soil sampling for weed, disease and pest presence
- sampling of plants for traces of pests such as Serpentine Leaf Miner from mine sites in leaves

Ag-tech

Ag-tech is a digital service sector, supporting but separate from agriculture. The global market for ag-tech products and services is estimated to be US$500 billion and growing at a rate of eight per cent per annum. There is an opportunity to capitalise on NSW strengths in digital technology and agricultural systems to secure a leadership role and returns from this growing market.

A large portion of ag-tech 'start-ups to scale-ups' are clustered in NSW, particularly the Greater Sydney area, complemented by regional agricultural precincts and hubs. Ag-tech is underpinned by a highly skilled workforce and research outcomes from world-leading universities.

The *NSW 2040 Economic Blueprint*[8] prepared by the NSW Chief Economist identified ag-tech as an industry of the future. Independent analysis commissioned by the Council of Rural Research and Development Corporations found that full implementation of ag-tech can provide an overall ongoing improvement of productivity of up to 20 per cent.

There are a range of ag-tech devices currently available for producers to purchase which can increase the efficiency, profitability and resilience of their farm business. These can be connected via the Internet of Things (IOT) and include weather monitors, soil probes, water level sensors and cameras for monitoring stock and equipment.

Case Study: Pairtree Farm Dashboard - An innovative farmer friendly digital dashboard that centralises the data sets from across the entire farm operation and throughout the supply chain to simplify ag data for better farm decisions. Refer to: thegate.org.au/dpi-innovation/case-studies/case-study-pairtree

In NSW, advanced diagnostic, testing and demonstration capabilities are available through, but not limited to, the following initiatives:

- **DPI's GATE** - the *Global Ag-tech Ecosystem*[9] (more information on the GATE is provided in the section below)
- **University of New England's SMART farms education and innovation centre**[10] which has enhanced information and communication technology and audio-visual capabilities able to develop and test a range of sensing, diagnostic and management tools.
- **Charles Sturt University's Global Digital Farm**[11] - a fully-automated commercial farm, developing and operating autonomous machinery, and improving farming practices with AI-

[8] Available at treasury.nsw.gov.au/sites/default/files/2019-11/0909-02_EconomicBlueprint_Web.pdf
[9] thegate.org.au
[10] une.edu.au/research/research-centres-institutes/smart-farm/about-the-smart-farm
[11] news.csu.edu.au/latest-news/look,-hands-free-australias-first-fully-automated-farm-to-be-built-at-charles-sturt-in-wagga-wagga

informed management decisions, new sensor technologies measuring interactions between plants, soils and animals, and developing new carbon management and measurement models.

- **University of Sydney's International Centre of Crop and Digital Farming**[12] - based at the Plant Breeding Institute north of Narrabri. Centre facilities will include genetic and agronomy laboratories, robotics and digital farming technologies
- **Future Food Systems Cooperative Research Centre**[13] – supports innovation and growth across the value chain.
- **Food Agility Cooperative Research Centre**[14] –creating new data-driven technology for the agrifood industry using AI, robotics, blockchain, sensors, advanced data analytics and more.

Advanced genetic technologies

Future prosperity and stability of the sector will likely require a balance between digital and biological technologies. Gene technology with AI, machine learning and big data capabilities is critical and has the capability to deliver the biggest and longest lasting gains and impact to the agricultural industry. For example, the design and delivery of microbes, plants and even animals with enhanced genomes would be rapidly accelerated by drawing together the fields of synthetic biology, machine learning and artificial intelligence into a high throughput BioFoundry. BioFoundries are highly automated facilities to rapidly, and at scale, design, construct, screen and test the production of synthetic organisms to express specific traits that would enhance the productivity and profitability of primary industries, underpin biosecurity and market access, deliver new options to manage natural resources and invasive species.

Synthetic biology, gene editing, epigenetics, eDNA, rapid complete genome sequencing and analysis, speedy bar coding and gene drive are all key sciences likely to transform the productivity and biosecurity of NSW agriculture.

About half of the one to three per cent annual increase in productivity in crops[15] and livestock[16] since the 1950s is estimated to have been driven by enhanced genetics, with rates of genetic gain predicted to more than double with the implementation of emerging technologies such as synthetic biology, gene editing, epigenetics, eDNA profiling and rapid complete genomics.

Genetically modified (GM) technology can help to create more pest resistant crops, maximise yields and reduce water requirements. This makes agriculture more productive with lower environmental impacts. These benefits can also drive innovation and productivity growth in the agricultural sector—particularly when drought conditions and longer-term climate change threaten NSW agriculture.

On 1 July 2021, the NSW Government lifted the ban on the use of GM crops by allowing an 18-year moratorium to lapse. Adoption of GM technology is forecast to deliver up to $4.8 billion in total gross benefits across NSW primary industries over the next ten years.[17]

[12] sydney.edu.au/news-opinion/news/2020/09/01/University-invests-agriculture-multimillion-dollar-research-centre-Narrabri.html
[13] futurefoodsystems.com.au/about/
[14] foodagility.com/about
[15] Evenson RE and Gollin D. 2003 - Crop variety improvement and its effect on productivity – FAO
[16] Thornton PK. 2010. Livestock production: recent trends, future prospects – Phil. Trans. Royal Soc. B.
[17] Minister for Agriculture and Western NSW – Media Release 'NSW lifts ban on GM crops', 2 Mar 2021 dpi.nsw.gov.au/about-us/media-centre/releases/2021/ministerial/nsw-lifts-ban-on-gm-crops

An opportunity from biotechnology is biological sensors and bio-composites used in early detection, more cost-effective identification and control of plant and animals' pests, invasive species, production agriculture or infectious disease.

Nanotechnology has the potential to increase primary production and could achieve this in a highly specific and environmentally conscious manner. This includes application of nanomaterials for disease detection and management, crop protection, smart delivery of active ingredients, plant and animal nutrition, nutrient management, filtration and desalination.

Synthetic biology

Synthetic biology is the deliberate design of biological systems and living organisms using the principles of engineering. It provides a better understanding of the biological world, to reconstruct or redesign biological systems or parts for a particular purpose. Applications can include new control measures for pests and diseases, new crops, green fuels, and environmental and food processing monitors.

The merging of digital, biological and engineering technologies into critical inter-disciplinary fields such as synthetic biology may offer the most transformative opportunities for agriculture.

Synthetic biology can find ways to improve plant carbon efficiency, reduce synthetic fertiliser usage by optimising plant nitrogen and phosphorous utilisation and improve the nutritional value of crop plants. Synthetic biology has the ability to create smarter management and control systems and eliminate the use of pesticides and herbicides. Such advancements may reduce input costs and increase profitability.

The ARC Centre of Excellence in Synthetic Biology headquartered at Macquarie University provides a hub for the advancement of synthetic biology technologies. It will train the next generation of synthetic biologists, capable of establishing the start-up companies of the future. A world leading synthetic biology 'biofoundry' has been established at Macquarie University, with co-funding from the NSW Government.

Ribonucleic Acid manufacturing industry

The NSW Government is establishing a ribonucleic acid (RNA) manufacturing industry in NSW, including commitment of $96 million for an RNA pilot manufacturing facility to enable commercialisation of RNA products. RNA technology also contributes solutions to agricultural and biosecurity challenges. For example, there are several identified animal diseases that would benefit from the NSW mRNA vaccine production capability. NSW has key expertise in this space including through the Elizabeth Macarthur Research Institute and the University of Technology Sydney iThree Institute.

Automation – AI, Robotics, remote sensing systems and autonomous vehicles

The emergence of automation provides enormous opportunities to increase productivity in agriculture. Although a reduction in labour costs is an important outcome of automation, the design, management, and maintenance of agricultural systems also provides opportunities for the creation of well-paying, highly technical jobs in rural communities. It also allows more efficient use of agricultural inputs, such as pesticides and fertiliser.

Automation, remote sensing (including drones, satellites, GPS-based technologies and sensors) and machine learning will be critical technologies in the:

- collection of key insights from large datasets captured by on farm sensors and agricultural machinery
- identification of untapped opportunities by learning from digital data collected across multiple devices i.e. environmental sensors, satellites, digital cameras, inputs and yield information collected by tractors

- collection of accurate agronomic data such as yield, numbers of pest insects and weeds, and localised real time environmental monitoring
- improved efficiency and efficacy in application of agricultural inputs
- improved product handling and packaging, e.g. product quality in post-harvest horticulture.

Case study - GoMicro – A phone clip on microscope and AI App to help farmers and agronomists detect pests, leaf disease and assess food quality accurately. Refer to: thegate.org.au/project/incubation/go-micro

Drones and emerging aviation technologies

Drones are used extensively in NSW. Agricultural drone technology has been improving in the last few years and the benefits of drones in agriculture are becoming more apparent to farmers. Drone applications in agriculture include mapping and surveying, cropdusting and spraying, soil, water and pest management, planting cycles, fertiliser use and data collections to inform yield predictions.

Surveying data from drones can inform many agriculture decisions including understanding the emergence pattern of a crop for supplementary sowing or treatment; estimating yield and animal counts; and multi-spectrum analysis for water, soils, disease and growth properties

Advances in drone carrying capacity can allow for tanks of fertilisers and pesticides in order to spray crops. Drones such as this are capable of spraying crops with far more precision than a traditional tractor. This helps reduce costs and potential pesticide exposure to workers who would have needed to spray those crops manually.

Work is being undertaken to identify opportunities for increasing uptake and use in NSW and growing the industry. This includes addressing regulatory barriers, advancing applications in the agricultural industry, better use of data and strategies for education and skills development. The NSW Productivity Commission White Paper *Rebooting the Economy*[18] (May 2021) concluded that more permissive regulatory frameworks that support the use of drones in agriculture could unlock net benefits of up to $500 million in NSW in the next 20 years.

To support uptake of drones in agriculture, DPI's Tocal College offers a Drones in Agriculture Course[19], funded through the NSW Government's $15 million AgSkilled 2.0 investment. The course develops skills in safe agricultural drone use and data processing to improve planning, productivity and water-use.

Case Study: StevTech – A drone based agricultural service based in Parkes, NSW. StevTech is examining fusing drone data with other agri-data for simple precise and easy decisions. Refer to: thegate.org.au/project/incubation/stev-tech-project

[18] productivity.nsw.gov.au/white-paper
[19] tocal.nsw.edu.au/courses/short-courses/agskilled/drones-in-ag

Autonomous vehicles

Autonomous vehicles and robotics are in use in many field situations and their use is likely to continue to expand, predominantly based on innovations occurring internationally that are then tailored to Australian conditions.

Case Study: Agerris – is commercialising technology from the University of Sydney's Australian Centre for Field Robotics. Agerris' Digital Farmhand platform is a solar-electric autonomous robotic platform with on-board intelligent sensors. The platform operates on row crops, is able to manage weeds, spot spray crops and cultivate. Refer: agerris.com/

Sensor technology

Sensor technologies offer farmers a better understanding of the status of climate, soil moisture and agricultural production, as well as real-time information on the effects of climate variability and change. Sensor technology could also add value to the monitoring of seasonal conditions at a state level, if farmers agreed to share this information with official networks. Adopting sensor technology in the agricultural sector would be a natural extension of DPI's current deployment of sensing technologies through the DPI Climate Change Research Strategy[20].

Mining sector

The integration of new technology by the mining sector and government presents opportunities to improve efficiency, monitoring, safety, environment and rehabilitation outcomes.

Research and development

NSW is a leading supplier of innovative mining equipment, technology and services solutions for the resources industry. Many products and services used today by the global mining industry were developed in NSW. These include coal longwall mining equipment, hydraulic roof supporting systems, roof bolting machines, advanced mining technologies, and mine planning and evaluation software.

NSW is also home to world-class universities and research institutes that combine research capability, industry collaboration and innovative solutions for all facets of mining projects. These include research, design, construction, project management, equipment supply and remediation. This includes the University of Sydney *Rio Tinto Centre for Mine Automation*[21] which undertakes applied research in autonomous systems, orebody modelling and systems optimisation and the *University of Newcastle Institute of Energy and Resources*[22] which works with industry partners on improved productivity and efficiency, low emission and renewable technologies, advanced materials and sustainability.

The NSW Government supports the development and use of new technologies, systems and products to continuously improve productivity, hazard control, risk management, and health and safety outcomes at mines. The NSW Resources Regulator's *Innovation Policy*[23] provides a clear pathway for the consideration of innovations prevented by legislation or technical standards.

The NSW Government is committed to further activating our potential in critical minerals and high-tech metals. We already have a strong advantage in our resource base, record levels of

[20] dpi.nsw.gov.au/__data/assets/pdf_file/0004/1319386/pi-ccr-strategy.pdf
[21] sydney.edu.au/engineering/our-research/robotics-and-intelligent-systems/australian-centre-for-field-robotics/mining.html
[22] newcastle.edu.au/research/centre/nier
[23] resourcesregulator.nsw.gov.au/__data/assets/pdf_file/0006/850461/Innovation-Policy.pdf

investment into regional economies, access to critical road and rail infrastructure, a highly skilled workforce and a strong mining, equipment, technology and services sector.

Autonomous vehicle and drone technology

Increasingly, autonomous and remotely operating vehicles are being adopted by the mining sector. Autonomous vehicles can support efficiency and safety as well as enable operations to be undertaken in hazardous environments.

Case Study: Sandvik: Sandvik has developed mining autonomous and remotely operated mobile equipment enabling mining automation and teleoperation systems for underground mines as well as surface mining operations. rocktechnology.sandvik/en/products/automation/

Drones are used in many mining applications. Drones can be used for site monitoring, providing up to date and accurate data on stockpiles and site conditions. Drones are also used in exploration to survey and map mineral landscapes. They are being used to provide information on safety incidents, management and to provide information about on-site environmental conditions. They support monitoring of rehabilitation of mine sites and are used by industry as well as the NSW Resources Regulator to support compliance.

Case Study: Achieving Rehabilitation Completion at Westside Mine: The NSW Resources Regulator used drone and gopro360 technology to demonstrate the pathway to achieve successful rehabilitation at a former open cut coal mine. storymaps.arcgis.com/stories/807f84352a13488d8747083d40d2ee1e

Safety

Mining is undertaken within the *Work Health and Safety Act 2011* legislative scheme which provides a framework for continuous improvement and progressively higher standards of work health and safety.

Autonomous vehicles with inbuilt safety systems and collision avoidance technologies present opportunities for improvement of safety on mine sites and could mitigate the risk of human error. Switching from diesel to electric vehicles has beneficial implications for workers by minimising worker exposure to harmful diesel particulate matter.

Technology and innovation in mineral processing

The mining industry has responded to the degradation and complexity of mineral deposits through innovations in mineral processing, with a focus on minimising energy, water and environmental impact and innovations in processing plant design.[24]

Electrification, solar and low emissions technology

Technology opportunities for the mining sector include electrification of mining operations including the use of solar farms to generate power for mines and switching from diesel to electric vehicles. The NSW Government has committed to Net Zero Emissions by 2050 and emissions from mining contribute to NSW greenhouse gas emissions. Investment in research and incentivising industry

[24] ausimm.com/bulletin/bulletin-articles/technology-and-innovation-in-mineral-processing/

uptake of low emissions technologies is essential to sustain the considerable benefits of mining to the NSW economy beyond 2050.

The NSW Government has been investing funds from the Coal Innovation NSW Fund to abate emissions resulting from ventilation air methane (VAM) from underground coal mining for over a decade. Abating VAM emissions is technically challenging to implement with concerns focussed on efficiency of current technologies and safe implementation at active coal mines.

DRNSW conducted an expression of interest process in late 2021 and is negotiating an agreement with a large coal miner to implement a commercial scale demonstration of CSIRO developed VAM abatement technology. The demonstration facility aims to demonstrate efficient and safe abatement and drive uptake of the technology across the coal mining industry. An incentive scheme to drive uptake is crucial once the technology is successfully demonstrated at commercial scale.

Rehabilitation

Technology is also being adopted to support rehabilitation. Geographical Information System (GIS) technologies are improving the way mine rehabilitation data is collected, analysed and monitored. Drones are used to monitor rehabilitation progress and support compliance investigations, enabling information to be captured more efficiently and ensuring large areas of rehabilitation can be surveyed quickly and effectively.

Case Study: Mine Rehabilitation Portal: The NSW Government's Mine Rehabilitation Portal is an Australian first, allowing mining companies in NSW to submit, analyse and report on rehabilitation activities. It also assists the monitoring and regulation of mine rehabilitation activities. It includes a portal for data validation, submission, and user management as well as a map viewer for viewing, analysing and reporting spatial data. The data will be made available to the public through the NSW Government's Sharing and Enabling Environmental Data (SEED) portal to enable the community to view the progressive rehabilitation of mines in NSW. resourcesregulator.nsw.gov.au/rehabilitation/mine-rehabilitation/mine-rehabilitation-portal

Case Study: Landform evolution modelling and geomorphic design principles for mine rehabilitation landforms: A NSW Government publication on leading practice associated with rehabilitation landform design including landform evolution modelling and geomorphic design principles to support mine operators achieve long-stability of final landforms after mining. resourcesregulator.nsw.gov.au/sites/default/files/documents/g-and-a-landform-evolution-modelling-and-geomorphic-design-principles-for-mine-rehabilitation-landforms_f_9feb2021.pdf

Technological advances also support revegetation techniques and seed treatment to improve the success rates of reseeding land for rehabilitation post-mining.

Water efficiency and recycling

Mines across NSW have invested significantly in water efficiency and recycling measures used at mines to manage water use, being pertinent recently when NSW was in drought. Water is essential to mining operations. It is used in processing plants, transporting material and dust mitigation on site. Mines typically recycle about 50 per cent of water consumed onsite and the level of reuse and recycling of water is growing. More importantly, the industry is often able to use alternative lower quality sources of water, such as highly saline water or town wastewater (such as in the case of Newcrest's Cadia mine). Where required, mines have water treatment plants to ensure discharged

water is high quality. This has led to significant advancement in water treatment technologies in Australia.

Case Studies:

The Microfiltration and Osmoflo Brine Squeezer technologies used by Santos in Narrabri to treat brackish water drawn from coal seams: osmoflo.com/en/markets-water-treatment/oil-gas/leewood/

CleanTEQ's continuous ionic filtration technology: cleanteqwater.com/technology/cif/

Barriers to the take up and use of agricultural and mining technologies

Agriculture sector

Predicting how the market will grow for critical agriculture technologies is complicated by the long timeframes to develop and deploy the technologies and adapt them to an Australian context. One reason for slow rates of adoption is that the true impact is not always easily or quickly identified. Very often, adoption is a slow process even where there is a clear value proposition, and no one technology or innovation will be applicable to all farming systems or individual businesses.

There must be a whole of supply chain and whole farm business approach to developing and implementing new technologies to support the agricultural sector. It is important to understand:

- the drivers of technology adoption across the sector based on hard factors (cost, benefits) and soft factors (ease of use and more intangible impacts),
- what commercial businesses are already doing, and
- the commercial, technical, and potential regulatory challenges affecting the deployment and further development of these and other critical technologies in the Australian market.

Digital network infrastructure

Connectivity infrastructure underpins the successful uptake and use of technologies. Digital network infrastructure and connectivity in rural settings is often poor, which is problematic for accessing cloud infrastructure and complicates the design of IOT systems. The success and increased adoption of any IOT system (such as the use of autonomous vehicles) is completely dependent on quality internet access.

The NSW Government's *20-Year Economic Vision for Regional NSW – Refresh*[25] identifies technology-enabled primary industries as an emerging sector which could be rapidly developed by boosting internet capacity and extending access to mobile services to improve connectivity and lift productivity and growth in regional businesses.

[25] nsw.gov.au/a-20-year-economic-vision-for-regional-nsw-refresh

Return on investment

Economic benefit is the biggest driver of adoption across agriculture, and technology can itself be an expensive investment. The rate, scale and order in which technologies are deployed will vary from one agricultural industry to another, depending on the perception and delivery of benefit. Primary producers require evidence and strong, clear pathways towards profitability and sustainability outcomes.

Other considerations include the availability of capital and knowing the cost:benefit ratio of the investment. Returns on investment may be applicable at scale but uneconomic for smaller enterprises. Technologies should therefore preferably be scalable so that benefits can flow across the range of enterprise scales. There are also ongoing subscription-based software costs to be considered.

Capability to assess the appropriateness of an innovation or technology

There is often limited availability of independent expert advice to assess how appropriate an innovation or technology is to an individual business or to decide between multiple competing technologies. This includes a lack of advisors/consultants with whole farm systems experience.

The social and environmental benefits that can be delivered if a technology is adopted are often under-valued, hard to identify and/or overlooked. Fear of unintended consequences of new technologies can also be a significant issue.

Another barrier is low digital capability levels. This includes the capability of producers to respond to the increasing data and digital influx including a clear understanding of the ownership of data and the interoperability of data.

Social barriers and lack of community support

Understanding social structures and influences both in local communities and industry sectors is critical to accelerating adoption of new technologies. For example, lack of community support is a large threat to adoption of biotechnology. This is likely attributed to fear of the unknown and creation of plants and organisms that may present new and perhaps more challenging management issues.

Adoption fatigue

There is also adoption fatigue amongst producers where new technologies have been rapidly adopted, they have not worked or have not been suitably customised. Adoption fatigue leads to more risk aversion from producers and they are less likely to adopt new technologies.

Mining sector

Barriers to technology uptake in mining include:

- limitation on technical resources and capability
- technology readiness of electric or hydrogen fuel cell heavy vehicles
- large capital investment required
- regulation barriers
- safety and community considerations
- electricity grid infrastructure required for electrification

Regulatory barriers

In the mining sector, regulatory frameworks and regulators are often perceived to be a barrier or blockage to the adoption of new technologies and new ways of doing things. For example, regulations that do not contain sufficient flexibility to enable technology uptake to facilitate new processes or activities.

The NSW Government supports the development and use of new technologies, systems and products to continuously improve hazard control, risk management, and health and safety outcomes at mines. The NSW Resources Regulator's *Innovation Policy*[26] provides a clear pathway for the consideration of innovations prevented by legislation or technical standards.

Barriers to emission reduction technologies

The main source of emissions in the coal mining sector is mine waste gas (methane). Two opportunities which have been identified for short term emission reduction are capture and combustion of waste gas to generate power/electricity, and VAM technology. The main barriers to implementing these technologies are the cost of the technology and costs associated with assessing feasibility, long lead times and in the case of VAM, the safe implementation of the technology. Although VAM has been successfully examined in laboratory and at pilot scale, the coal mining sector has concerns regarding the performance of this technology at commercial scale.

A lack of incentives to drive emissions reduction across the mining sector is also a barrier. Emissions reduction in this sector is challenging and expensive. Long lead times for research and development is necessary. Without large scale, long term incentive or taxation schemes, the industry will only invest small amounts in emissions reduction.

Barriers to use of new technology in underground mining environments

The risks associated with the explosive environment of underground coal mines is also a barrier to adopting technology such as autonomous and electric vehicles which would need to be retrofitted with explosion protection and comply with requirements to maintain a safe environment. Similar risks are associated with underground metalliferous mines, which while not explosive environments, would still present substantial risks to workers if fires were to occur on vehicles underground.

The underground environment also presents barriers to any technology that relies on GPS or radio signals. This includes technology such as collision avoidance technology and drones. Off-the-shelf technologies are generally not appropriate in the mining context however there is work ongoing to develop solutions and applications for this sort of technology in underground mines.

Measures to support the use of agricultural and mining technologies and innovations

Agriculture sector

Farms of the Future Program

In the 2021-22 Budget, the NSW Government announced a combined $64 million over four years for the *Future Ready Regions* program - a strategy to help farmers and regional communities grow, thrive and plan for the future. This includes $48 million for the expanded *Farms of the Future*[27] program to deliver on-farm connectivity and encourage farmers to adopt ag tech to boost productivity and improve resource management, including water and drought preparedness.

The program is targeting hundreds of participating farms over high impact pilot regions and aims to seed self-sustaining ag-tech markets which accelerate adoption of tech-enabled production and monitoring methods. The program will be to construct and operate a Long-Range Wide Area Network (LoRaWAN) in eleven target locations. LoRaWAN connectivity enables communication across wide geographical areas, like farms, and complements existing IOT, mobile and broadband services.

A grants program will be run in future to enable producers in the target Farms of the Future LoRaWAN locations to purchase ag tech devices and applications. The grants will be run in conjunction with a training and support program to increase farmer digital capability and confidence to use the technology on-farm.

DPI's Global Ag-tech Ecosystem (GATE) – Ag-tech support program

The GATE hosted at the DPI Orange Agricultural Institute is a DPI initiative to fast-track adoption of agricultural R&D to increase productivity. The GATE enables greater uptake of ag-tech or digital agriculture as a key pathway for industry growth.

The GATE is open to entrepreneurs, researchers and corporate partners to deliver valuable new ag-tech products and services. It provides a unique opportunity for agricultural technology developers to access DPI R&D expertise or bring their own, and to collaborate with technology providers, business services and investors to create commercialised products for the NSW agricultural sector.

Since its establishment in 2018, the GATE partners have fostered more than 70 businesses/research teams. With the corporate partners Sparklabs Cultiv8, these teams have raised over $100 million of follow-on funding and created more than 100 Australian jobs, mostly in regional NSW.

[27] nsw.gov.au/snowy-hydro-legacy-fund/regional-digital-connectivity-program/farms-of-future

In 2022 the DPI GATE program will expand its offerings to ag tech and agribusinesses by facilitating on-farm validation of new technologies, product trials and mission-based industry collaborations.

GATE Case studies:

Solution Blue - Solution Blue based in Cowra, NSW is developing new ways to mass produce insects for fish and livestock feed. Refer: thegate.org.au/project/incubation/solution-blue

Zetifi - Providing solar powered WiFi networks for farms. Refer: thegate.org.au/project/acceleration/zetify

DPI Research Stations and Infrastructure Investment

DPI research scientists are well connected and regarded both nationally and globally, and work collaboratively in a broad range of agricultural, and public and private organisations. DPI is the largest rural research provider in Australia with over 600 scientific and technical staff and 13,000ha of trial sites.

DPI is undertaking a range of research, including to enhance sustainable resources and productive landscapes; underpin biosecure industries and the environment; drive economic growth; enhance food safety and animal welfare; support carbon neutrality and climate resilience; and strengthen response capacity to adverse events.

World-Class Food and Fibre Infrastructure Program

The NSW Government will invest almost $100 million in the State's primary industries research and innovation portfolio to help bolster on-farm productivity and protect the $15 billion sector from devastating pests and diseases. The Investment in the *World-Class Food and Fibre Infrastructure Program* will fund equipment such as new glasshouses, exotic disease diagnostic instruments, networks of on-farm sensor and data technology across DPI institutes, aquaculture and fish breeding research and plant pathology facilities. This will deliver a new generation of scientific breakthroughs like drought tolerant crop varieties, data-driven on-farm decision making, fast-tracked genetic improvements in beef and lambs and revolutionary biological control of pests.

The funding includes $4.1 million for the Advanced Gene Technology Centre at Wagga Wagga to provide advanced infrastructure to equip DPI scientists with the capabilities to be at the forefront of scientific advancements, including fast tracking new opportunities to selectively alter genes and pathways.

Other initiatives

Other NSW Government initiatives supporting the use and adoption of technologies in the agriculture sector include the following:

- **Climate Smart Pilots**[28] is a $6.7 million project as part of the NSW Primary Industries Climate Change Research Strategy, showing how digital technologies are being used to help farmers develop climate adaptation strategies. For example, in the horticulture sector, technologies have been deployed to allow farmers greater irrigation automation and convenient control, helping to deliver water use efficiency gains. In the oyster industry, mobile temperature loggers are allowing farmers to monitor stock as they move through leases providing an early warning of extreme temperature events.

[28] dpi.nsw.gov.au/dpi/climate/digital-agriculture/climate-smart-pilots

- **Farm Innovation Fund**[29] commits $1 billion through long-term, low interest rate loans for permanent on-farm infrastructure, which will assist farmers to improve farm productivity, manage adverse seasonal conditions and drive long-term sustainability.
- **Milking Edge**[30] is a three and a half-year joint initiative of the DPI, Dairy Australia and DeLaval, and aims to support industry to consider, invest and operate Automatic Milking Systems successfully.
- **AgSkilled 2.0**[31] is a $15 million investment to upskill and better prepare the agricultural workforce for fast-moving change driven by industry innovation, research and technology through vocational education and training, across plant-growing agricultural industry sectors across NSW.
- **Primary Industries Productivity and Abatement Program** (PIPAP), under the NSW Government's *Net Zero Plan Stage 1: 2020-2030* helps producers and landowners commercialise low-emissions technologies and maximise their revenue from carbon offset programs.

Mining sector

The NSW Government is taking a balanced approach to supporting responsible coal production whilst also considering the mineral opportunities that lay ahead and to support the diversification of coal-reliant regional economies.

Measures that support technology and innovation in the mining sector include:

- **Coal Innovation NSW**[32] (CINSW), an advisory council established by the *Coal Innovation Administration Act 2008*, set up to advance low emissions coal technologies R&D across the state, with the aim of reducing greenhouse gas emissions associated with the mining and use of coal in industries such as electricity generation, steel and cement. One of the key roles of CINSW is the ongoing provision of strategic advice to the Minister concerning the $100 million CINSW fund. The Fund's purpose is to support research, development and the demonstration of low emissions coal technologies for future commercial application. It also aims to increase public awareness of the importance of low emissions coal technologies in reducing greenhouse gas emissions.
- **MinEx Cooperative Research Centre**[33] (MinEx CRC), the world's largest mineral exploration collaboration, bringing together industry, government, research organisations and universities to further the understanding of geology, mineral deposits and groundwater resources in areas where rocks aren't exposed at earth's surface. Geological Survey of NSW is a participant in the MinEx CRC. The collaboration has identified three specific programs – Drilling technologies, Data from drilling and the National Drilling Initiative (NDI).
- **ARC Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals**[34] (COEMinerals), a national collaboration headquartered at the University of Newcastle, which will develop and commercialise new and more sustainable mining technologies as demand for minerals grows. The Centre builds on the research strengths of the Newcastle Institute for Energy and Resources which has over 19 research centres and 170 industry partners.

[29] raa.nsw.gov.au/loans/farm-innovation-fund
[30] dpi.nsw.gov.au/animals-and-livestock/dairy/dairy-technologies/robotic-milking-systems
[31] training.nsw.gov.au/programs_services/agskilled/index.html
[32] regional.nsw.gov.au/meg/industry-support/coal-innovation
[33] minexcrc.com.au
[34] coeminerals.org.au/about

Other measures

Other NSW Government initiatives supporting the use and adoption of technologies in the agriculture and mining sectors include the following:

- **Regional Digital Connectivity program**[35] which focuses on eliminating mobile black spots where people live and work, bringing metro-level data speeds, connectivity and infrastructure to regional NSW, and supporting agribusiness and agricultural technology.
- **Boosting Business Innovation Fund**[36] which supports tech start-ups across NSW through $18 million in funding, helping the state's universities and the CSIRO work more closely with business and industry to drive innovation.
- **Regional Growth Fund**[37] - a $2 billion fund which has committed $500 million under the Growing Local Economies Fund to unlock economic potential.
- **Turning Ideas into Jobs – Accelerating R&D in NSW Action Plan**[38] - supporting research innovation, translation and commercialisation activities for the socio-economic opportunities these generate.
- **NSW Physical Sciences Fund**[39] is a $5 million competitive development and commercialisation program for technological innovations in NSW. Recipients have included BioScout, an automated airborne crop disease tracking system and NextOre, a magnetic resonance analyser able to quickly and cost-effectively measure ore grade in the mining process.
- **NSW Smart Sensing Network**[40] which has managed some $12 million in projects to develop and commercialise sensing solutions for industry. Ag-tech is one of the NSSN's themes and mining is an identified Grand Challenge. Major agriculture and mining related projects involve use of sensing and advanced analytics to improve understanding of the relationship between mining and water; use of optical remote sensing to preserve healthy waterways; and remote soil moisture sensing.
- **Net Zero Industry and Innovation Program**[41] is the NSW Government's plan to support and partner with industry to reduce emissions and help NSW businesses prosper in a low carbon world. This includes the **Decarbonisation Innovation Hub**[42] being established by the Office of the NSW Chief Scientist & Engineer (OCSE). The Hub will support researchers, industry and government stakeholders in critical sectors to collaborate, and increase the uptake of new technologies in decarbonising NSW. Land and primary industries will be one of three key focus areas of the Hub.
- **NSW Power to X (P2X) Pre-Feasibility Study**[43] - a 2020 study commissioned by the OCSE that investigated opportunities and technology use cases. Planning for a more detailed industry study is underway. P2X technologies refers to the production of green power fuels and synthetic chemicals from renewable energy and have wide applications in the agriculture and mining sectors. These include green fertiliser and replacement of diesel for energy, vehicles and machinery for farm and mining operations.

[35] nsw.gov.au/snowy-hydro-legacy-fund/regional-digital-connectivity-program
[36] business.nsw.gov.au/innovation-and-research/programs/boosting-business-innovation-program
[37] nsw.gov.au/regional-growth-fund
[38] dpc.nsw.gov.au/publications/categories/turning-ideas-into-jobs-accelerating-research-and-development-in-nsw/
[39] chiefscientist.nsw.gov.au/funding/research-and-development/nsw-physical-sciences-fund
[40] nssn.org.au/
[41] energysaver.nsw.gov.au/reducing-emissions-nsw/net-zero-industry-and-innovation
[42] chiefscientist.nsw.gov.au/science-in-nsw/nsw-networks/decarbonisation-innovation-hub
[43] chiefscientist.nsw.gov.au/rdnsw/future-industries-reports/nsw-power-to-x-industry-pre-feasibility-study

- **Regional NSW Youth Framework**[44] which includes building links between tertiary and late-secondary education and local industry business to help young people build skills in technologies and the mining and agri-business sectors.

Impact of technologies and innovations on the past, current and future agriculture and mining workforce

Agriculture sector

The future profile of the agricultural workforce will be influenced by several factors, including:

- an aging existing workforce[45]
- growing demand for workers but less people seeking work in agriculture[46] and
- the skillsets needed to adopt modern agriculture and technology.[47]

A key component of the NSW Government's *COVID-19 Recovery Plan*[48] is equipping our students for jobs of the future. There are opportunities for people in the workforce to develop new technology, innovate food supply chains, shape sustainable environmental and animal welfare practices and explore entrepreneurship.

Science, technology, engineering and maths (STEM) skills are key to agriculture sector growth. Uptake and development of technology is a key factor that will influence the future agriculture workforce. Alongside that, accessible digital support and online training is needed to enable adoption. Increased use of technology on-farm will support, and even automate, decision-making to help improve productivity. This will see more data being produced on farm and require a workforce able to analyse it. To realise benefits of new technology the workforce needs digital literacy - the skills to integrate data sources, analyse findings and take action. New technologies have the potential to catalyse new jobs and attract a diversity of people to regional areas.

Future hi-tech industries such as robotics, advanced data analytics including AI and Machine Learning will see a changing workforce and demand for skills to service equipment and machinery. These new technologies will also require networks and data centres to be located in regional areas to enable fast processing and rapid response for automation across agricultural landscape.

The Australian Government has developed a *National Agricultural Workforce Strategy and Roadmap* that focuses on upskilling and equipping the agricultural workforce in advances in technology by recommending training, collaboration and financial support. It aims to attract, retain and upskill the domestic workforce and identify where access to overseas workers will be necessary to meet industry needs.

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[44] regional.nsw.gov.au/__data/assets/pdf_file/0004/1243912/NSW-Regional-Youth-Framework.pdf
[45] Brown A, Guttmann. 2017. Ageing and Labour Supply in Advanced Economies. Reserve Bank of Australia, Sydney.
[46] Dufty, N, Martin, P & Zhao, S 2019, Demand for farm workers: ABARES farm survey results 2018, ABARES research report, Canberra.
[47] Hajkowicz SA, Reeson A, Rudd L, Bratanova A, Hodgers L, Mason C, Boughen N (2016) Tomorrow's Digitally Enabled Workforce: Megatrends and scenarios for jobs and employment in Australia over the coming twenty years. CSIRO, Brisbane.
[48] nsw.gov.au/covid-19/covid-19-recovery-plan

Mining sector

The NSW minerals industry is a major regional employer, generating many thousands of jobs that help underpin social and economic wellbeing in regional NSW. The minerals industry positions NSW as an essential supplier to meet growing global demand for metals used in the advanced technologies of today and tomorrow—smart devices, batteries, electric vehicles and many other new and emerging applications.

In 2019, the Minerals Council of Australia commissioned *Future of work: The economic implications of technology and digital mining,*[49] a report into the adoption of digital and technological solutions by the mining industry and the impact this will have on traditional operating models, from exploration, mining operations and processing to transport and trade.

Technology provides opportunities for enhanced worker safety and efficiency but will also present new risks for the workforce that will need to be managed effectively. Different skills will be required to operate and service new technologies, such as autonomous vehicles and electric mobile plant. Ongoing workforce training and upskilling will be required to ensure mines have access to a relevant workforce as technologies are developed and adopted. While adoption may reduce the number of workers required in traditional areas of mining operations, additional workers will be required to operate and service new vehicles and plant.

[49] minerals.org.au/sites/default/files/The%20Future%20of%20Work%20-%20The%20economic%20implications%20of%20technology%20and%20digital%20mining%20-%20EY%20Report%20-%20February%202019.pdf