ATSE

SUBMISSION TO

House of Representatives Standing Committee on Agriculture and Industry Inquiry into Agricultural Innovation

SEPTEMBER 2015

AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING (ATSE)

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Recommended reading:

- ATSE 2014, *ATSE Submission: Agricultural Competitiveness Green Paper*, Australian Academy of Technological Sciences and Engineering (ATSE), Melbourne, available at: http://www.atse.org.au/content/publications/submissions/agriculture/agricultural-competitiveness-green-paper.aspx
- ATSE 2014, *Enabling Growth in Agriculture: Position Statement*, Australian Academy of Technological Sciences and Engineering (ATSE) , Melbourne, available at: http://www.atse.org.au/atse/content/publications/policy/enabling-growth-in-agriculture.aspx
- ATSE 2014, *Food and Fibre: Australia's Opportunities*, Australian Academy of Technological Sciences and Engineering (ATSE), Melbourne, available at: http://www.atse.org.au/atse/content/publications/reports/agriculture/food-and-fibre-australias-opportunities.aspx
- Daly *et al.* 2015, *Australia's Agricultural Future*, Report for the Australian Council of Learned Academies, Melbourne, available at: http://acola.org.au/index.php/projects/securing-australia-s-future/7-australia-s-agricultural-future

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ATSE Submission: Inquiry into Agricultural Innovation

The Australian Academy of Technological Sciences and Engineering (ATSE) welcomes this opportunity to provide input to the House of Representatives Standing Committee on Agriculture and Industry inquiry into Agricultural Innovation.

ATSE advocates for a future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. The Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.

ATSE considers agricultural innovation and technology to be crucial to the ongoing success of Australia's diverse agricultural sector. Next year, ATSE will be hosting *Agribusiness 2030: 2016 ATSE National Technology Challenges Dialogue* – a dialogue exploring opportunities and challenges for Australian agribusiness to 2030 through the prism of technological innovation. The dialogue will cover applications of technology in agriculture including robotics, digital technologies and data analytics, and biotechnology and molecular genetics, among others.

Summary

Australian agriculture has a long history of innovation, driving its resilience and adaptability. New technologies, including new practices, and their rapid adoption and adaption to local conditions have been central to historical increases in productivity and profitability in Australia's agriculture and food sectors.

These important sectors continue to play a crucial role in our national economy – particularly through exports and in rural and regional development and employment. Seizing unprecedented export opportunities for high quality agrifood products over the coming decades, as well as maintaining the strength of our domestic market, will require a range of new technologies to underpin continued productivity growth and international competitiveness.

The best Australian farmers are operating increasingly close to the upper limit of currently known potential yields and technical efficiency. Further growth in productivity for these farmers will increasingly require step-changes in production technology and practices. Fundamental research, and emerging technologies that arise from this research such as gene technology, robotic systems, and distributed sensor networks, make significant contributions to generating these needed step-changes. Notwithstanding the efficiency of our best farmers, there continues to be a long tail of farmers unable to access or utilise the knowledge and capital required to match these outputs.

Agricultural value chains are becoming more integrated and connected, facilitated by emerging information and communication technologies allowing real-time demand analysis and management. These are enabling changes in management practices, which are equally

important in stimulating innovation and improving efficiency. There are huge opportunities to be captured through the use of ICT to prove the provenance of high-value, high-quality produce. For example, Camperdown Dairy International recently signed a $9 billion dollar contract over 15 years to supply baby formula to China on the basis of running a fully integrated operation, tracking every cow by computer. A consumer purchasing a can of baby formula can find out which cows contributed, when it was processed, and which supermarket it should be stocked in. Significant potential exists to boost the profitability and international competitiveness of Australia's agricultural value chains through the broader adoption and application of these technologies and such provenance practices, from on-farm through to processors and export markets.

Australia should seek to use scientific and technological advances to target high-value and high-margin produce with a global reputation for food safety, not aim to be the most cost efficient producers of cheap food.

In concert with increased productivity, emerging technologies will also be fundamental for improving the sustainability and natural resource management practices of Australian agriculture, which are fundamental to the future competitiveness and ongoing operation of this sector.

ATSE considers that the competitiveness of Australia's agriculture and food sectors relies, more than ever, on strong and stable support for science, research and development, and its translation to economic advantage through the adoption of new technologies and practices. **Investment in the fundamental research which enables these technologies must be recognised as the key to future growth in Australia's agricultural sector.**

Technology also has an important role in social practice and business model innovation, as well as underpinning community health and well-being, all of which contribute to the sustainability and profitability of the agricultural sector.

Introduction

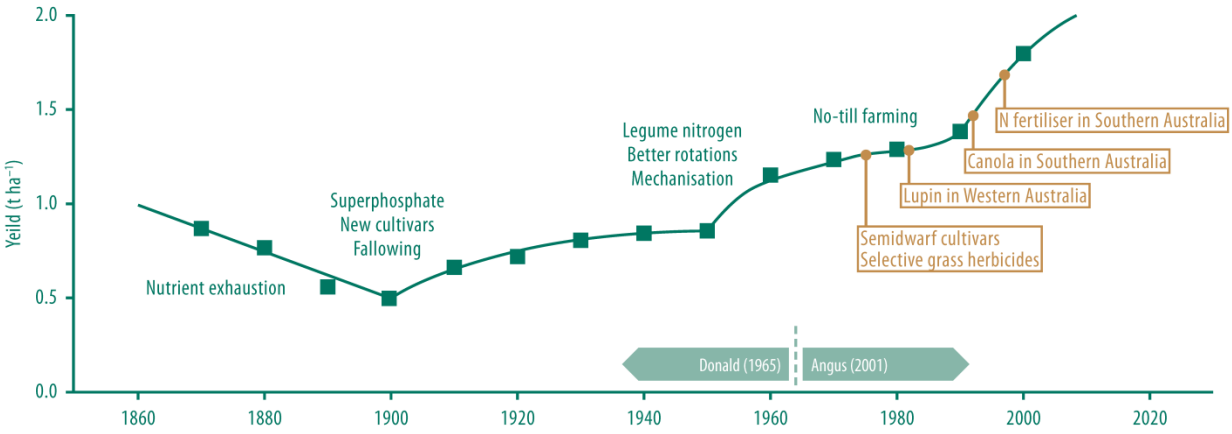
Agriculture and food production play an important role in Australia's economic and social fabric, which together form a key pillar of the Australian economy. Increasing output and seizing emerging market opportunities requires sustainably adding value, effectively producing 'more food with fewer inputs', as well as producing higher quality products. Key to this is the simultaneous increase of overall productivity and responsible natural resource and ecosystem management. The successful development of sustainably intensified production and processing systems in Australia will require innovative approaches arising from targeted research and development, and the strong participation and ingenuity of agriculturalists and agribusiness investors underpinned by a cohesive policy framework.

New and emerging technologies have a crucial role to play in achieving these parallel goals, and have historically been important in driving improvements in the efficiency of agricultural practices. Further to this, new and emerging technologies will enable the integration of agricultural and food value chains through the sharing of real-time data and information between farmers, suppliers, processors, exporters and markets – opportunities to reduce costs in supply chain logistics, as well as the use of ICT to improve market penetration and justify higher prices, should translate directly to improved profitability for farmers.

Efficiency improvements in agriculture

Technology has always played an important role in improving the efficiency of agriculture in Australia. Figure 1 illustrates the historical trajectory of wheat yields in Australia with changes owing to the adoption of important new technologies and practices.

Figure 1: Growth in Australian wheat yields and technologies driving changes[1]



The adoption of no-till farming and precision agriculture in recent decades has been important in increasing the drought resilience and profitability of farms while preserving soil health. These practices have been enabled by new technologies, most recently self-steering GPS-enabled tractors.

[1] Daly *et al.* 2015, *Australia's Agricultural Future*, Report for the Australian Council of Learned Academies, Melbourne, p. 61.

Figure 2: Progress in production per animal in Australia since 1940 – dairy cows and sheep. Data compiled from annual ABARES reports by David Lindsay.

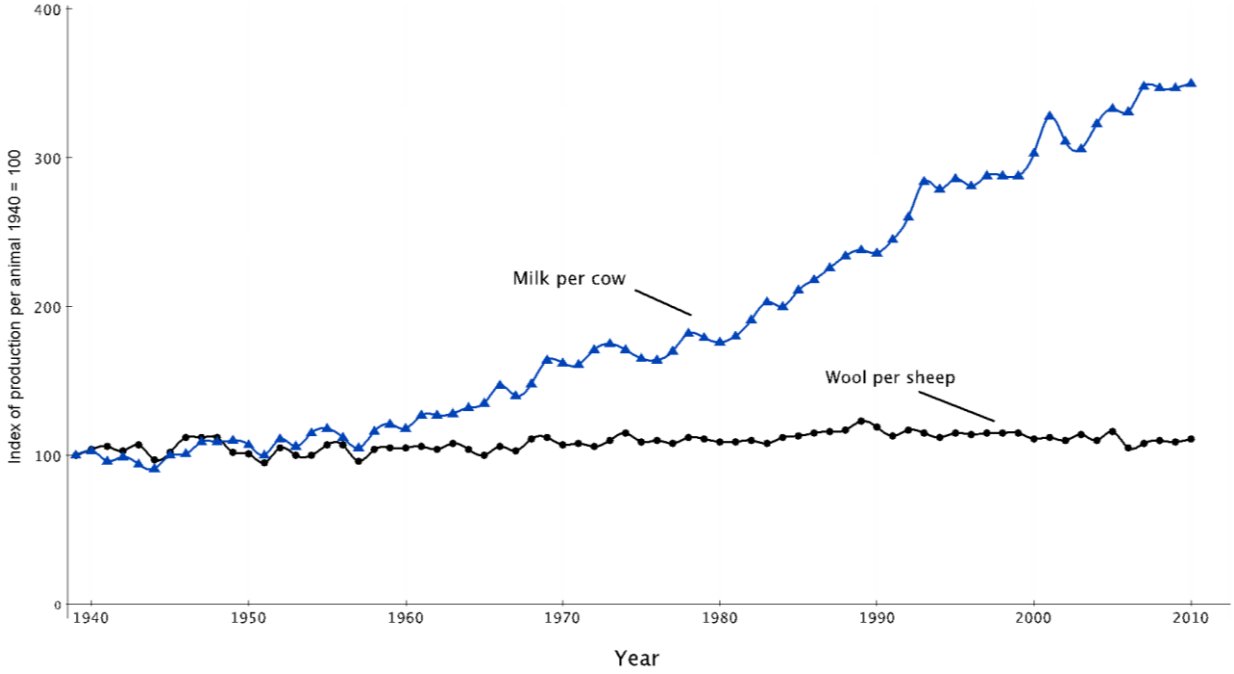


Figure 2 shows the enormous changes in productivity per dairy cow in Australia achieved in the second half of the previous century. Much of this increase is due to the wide-scale adoption of reproductive and genetic technologies in the dairy industry. In contrast, an industry that has a poor history of adopting these same technologies shows relative stagnation of the individual productivity of wool-producing sheep over the same period.

According to *Australia's Agricultural Future*[2], "since the 1960s, agriculture has benefited from increased use of agrochemicals, advances in crop and animal genetics, agricultural mechanisation and improved management practices. These technologies have driven productivity increases and will continue to provide future incremental improvements."

But in order to continue increasing efficiency, the best performing farmers in Australia will require new breakthrough technologies and practices. Broad acre cropping in particular is reaching the limit of theoretical yields using current best practices and technologies[3]. However, many cropping zones in Australia have irregular and variable rainfall patterns, which limits the capacity for advanced technologies to be effective. Many of our cropping areas could become highly reliable producers of food and fibre, adopting sophisticated technologies, if the threat of water stress could be removed.

These kinds of new technologies and advances often arise from fundamental research – whether in fields such as genomics and photosynthesis, or less obvious areas including information and communication technologies and robotics, as well as the research necessary to adapt internationally developed technologies to Australian conditions.

[2] Ibid., p. 92.
[3] Fischer *et al.* 2014, *Crop yields and global food security: will yield increase continue to feed the world?*, Australian Centre for International Agricultural Research, Canberra.

Research into the management and preservation of fundamental agricultural assets like soil and water, crucial to underpinning future increases in farm efficiency and production, is also enabled by the application of information technologies.

As discussed in ATSE's submission[4] to the Government's recent *Agricultural Competitiveness Green Paper*, "the development and delivery of novel technologies can offer benefits such as improved resource use efficiency, more reliable yield, enhanced food functionality and nutrition, while improved biosecurity outcomes can flow from research delivering pest and disease resistance, enhanced surveillance and detection, and capacity for more rapid response to incursions of exotic threats."

Investment in the fundamental research which enables these technologies must be recognised as the key to future growth in Australia's agricultural sector. Just improving the uptake of best practice and current technologies is an insufficient strategy for ongoing progress. We must use a strategic mix of development, which increases the application of what is known, with a sound investment in new research to fuel the next generation of improvements.

Beyond the farm, scope also exists for important efficiency and profitability improvements through the whole value chain. Technologies that enable better communication and coordination between farmers, processors, exporters, and markets, as well as reducing waste and transforming waste streams into valuable products, will provide important efficiency gains as well as improving profitability, and in turn relieve pressure on the environment.

Up to 30 per cent of agricultural food production can end up wasted. Appropriate technological interventions to reduce this waste will contribute significantly to food security and farm profitability in the future. Innovative food processing technologies can add value to waste streams, such as transforming edible food waste into healthy food products and ingredients, biotechnological advances reducing food loss in the manufacture of fermented foods, and separating valuable functional ingredients from food waste. There are also opportunities to apply separation technologies to extract useful and valuable chemicals from non-edible biomass streams, and to harvest energy as a product from waste streams. For example, food waste and wastewater streams may be combined to generate methane for energy.

Emerging technologies

As an important sector of the Australian economy, agriculture benefits from the application of a wide range of technologies – not just those which appear to be directly related. More scientists must be encouraged to be active participants in agriculture. Collaborations through their networks into branches of science and technology not usually associated with agriculture may trigger the next major advance.

[4] ATSE 2014, *ATSE Submission: Agricultural Competitiveness Green Paper*, Australian Academy of Technological Sciences and Engineering, Melbourne.

Increasingly, information and communication technologies have a critical role to play in improving the efficiency of agricultural practices, boosting production, minimising waste and underpinning sustainable natural resource management. These data acquisition and analysis technologies across the whole food value chain also afford the opportunity to add further value to our food through authenticating its safety, traceability, quality and environmental credentials. Proving the provenance, safety and quality of Australian produce will allow us to demand higher prices from consumers that value these attributes. This type of ICT application can produce benefits irrespective of the agricultural yield or input intensity. Advances in marketing enabled through technology will be just as important to farm profitability as advances in production techniques.

As described in ATSE's 2014 position statement *Enabling Growth in Agriculture*[5] "information technology services can revolutionise agricultural production systems. Increased deployment and penetration of ICT and high-speed internet access will enable greater use of real-time data analysis and agri-informatics, and improve the competitiveness of industries and services."

The importance of these knowledge and information technologies to the future of farming in Australia is described in further detail in Chapter 6 of the *Australia's Agricultural Future* report[6]. The following extract illustrates the emerging field of agri-intelligence, relying on these technologies[7]:

> Integrating deep agricultural knowledge with cutting-edge technologies (including sensor networks, robotics, autonomous systems, innovative mathematical and statistical models for big data sets and ICT) will be central to the next agricultural revolution. Agri-intelligence research is a springboard for agriculture into the second machine age, in which computer systems augment human perception and decision making in complex situations.
>
> Agri-intelligence is the collection of tools and techniques—from robots, unmanned airborne vehicles (UAVs) and sensor networks to sophisticated mathematical models and algorithms—that help a farmer make sense of large amounts of data (agronomic, environmental and economic) to make risk-informed decisions and run their farms more profitably and sustainably.

The *Australia's Agricultural Future* report also contains a case study on the applications of advanced robotics in agriculture[8].

> Field robotics are becoming an integral part of many farming systems, reducing labour and input costs and increasing output quality and productivity. Field robotics have the potential to: automate repetitive tasks; collect and process high resolution information to

[5] ATSE 2014, *Enabling Growth in Agriculture: Position Statement*, Australian Academy of Technological Sciences and Engineering, Melbourne.
[6] Daly *et al.* 2015, *Australia's Agricultural Future*, Report for the Australian Council of Learned Academies, Melbourne, pp. 90-97.
[7] Ibid., p. 92.
[8] Ibid., p. 93.

provide unprecedented knowledge about the state of the farm; form part of the wider farm management system to coordinate and control tasks based on intelligent data analytics and optimisation; and provide information and capabilities that benefit the wider supply chain and agricultural researchers.

Another branch of science and technology which has and continues to revolutionise agriculture in Australia is molecular genetics, genomics and biotechnology. ATSE's 2014 report *Food and Fibre: Australia's Opportunities* states that[9] "the most important breakthrough technology currently being applied in a number of industries is that of molecular genetics. This has led in some cases to the use of genetically modified organisms (GMOs) [in commercially released crops]. In reality, GMOs are only one of a suite of genetic technologies being used to improve agricultural production."

The importance of genomics to modern plant and animal breeding is difficult to overstate. Australian developed technology, including genomic selection[10], has swept through the world's livestock industries in the last decade. These techniques allow breeders to select for desirable traits, such as heat or drought tolerance, feed conversion efficiency, or disease resistance, at a vastly faster rate and greater effectiveness compared with conventional breeding. By correlating desired traits with genotypes, breeding cycles can be shortened by orders of magnitude in both plants and animals.

The suite of technologies and techniques available through modern biotechnology offer enormous potential for improving the efficiency and productivity of Australian agriculture. From *Enabling Growth in Agriculture*[11], "biotechnology, integrated with modern genetics, breeding, and other techniques, offers opportunities to improve agricultural productivity, natural resource management, and consumer demand, while offering new opportunities for bio-industries across the agricultural value chain."

The widespread adoption of genetic technologies in Australian agriculture has been slow and patchy. Despite our robust regulatory system through the Office of the Gene Technology Regulator, some Australian states still maintain moratoria on the use of genetically modified crops. The concerns of some parts of the public in regards to the use of these technologies must be reconciled, if Australia is to truly benefit from the enormous potential benefits to our agriculture and food industries. ATSE considers that the adoption of genetic technologies in food and agriculture should be supported to be simpler and faster, while maintaining appropriate regulatory oversight and working to reconcile public concerns around these issues.

The food industry is fundamentally important to the success of agriculture in Australia. If the food industry in Australia is flourishing, it acts as a market pull on agricultural production. Food processing converts perishable agrifood materials into safe, nutritious, shelf-stable and

[9] ATSE 2014, *Food and Fibre: Australia's Opportunities*, Australian Academy of Technological Sciences and Engineering, Melbourne, p. 44.
[10] Goddard, ME, and Hayes, BJ 2007, 'Genomic selection', *Journal of Animal Breeding and Genetics*, vol. 124, pp. 323-330.
[11] ATSE 2014, *Enabling Growth in Agriculture: Position Statement*, Australian Academy of Technological Sciences and Engineering, Melbourne.

palatable consumer products. Conventional and emerging food processing technologies maximise the value that can be extracted from agricultural products, and make an important contribution to food and nutrition security and sustainable food systems.

Australia should seek to use scientific and technological advances to target high-value and high-margin produce with a global reputation for food safety, not aim to be the most cost efficient producers of cheap food.

By combining modern breeding technologies with sophisticated market intelligence, Australia could develop a knowledge base to enhance the opportunities and success of our agricultural production systems in the growing markets of Asia. By characterising the particular properties, traits, and qualities valued by our target export markets, a whole set of new breeding objectives can be defined and delivered through the newest and most powerful genetic technologies. Australia's agriculture and food industries could deliberately target specific changes in the nutritional or other characteristics of particular foods to cater to the most lucrative market opportunities.

Technological advancement across the whole economy will be important to agriculture's future, including in areas such as more accurate weather and climate forecasting, a field in which Australia's Bureau of Meteorology continues to excel, and the development of new agricultural chemicals.

Climate change presents many significant challenges to Australia's agriculture sector in the coming decades. Scientific research and technological innovation in both climate change mitigation and adaptation can offer considerable opportunities to improve current production systems, develop new ones, and improve adaptation to climate change. Biotechnologies will contribute to the breeding of drought and heat resistant crops as well as reducing the carbon intensity of livestock production. Information and communication technologies can help to reduce agricultural carbon intensity by enabling more efficient farming practices and reducing the use of energy intensive inputs.

Barriers to adoption

Major barriers to the adoption of new technologies and practices exist in both common, systemic issues as well as specific technology-related issues.

Access to affordable capital can be a significant barrier to the widespread adoption of technologies by farmers. The *Australia's Agricultural Future* report found that[12] "small family farm businesses are less able to access and adopt advanced technologies due to lack of accessible capital" compared with larger farms. This report also recommended that[13] "alternative models of farm financing, such as contingent loans, need to be developed to meet the needs for farm businesses faced with fluctuating incomes and reduced capacity to borrow."

[12] Daly *et al.* 2015, *Australia's Agricultural Future*, Report for the Australian Council of Learned Academies, Melbourne, p. 20.
[13] Ibid., p. 26.

Another systematic barrier lies in the availability of an appropriately trained, skilled and experienced workforce. The kinds of technologies described above will require people with skills that are not traditionally identified as agriculture-related. Mechatronics engineers, software designers, network technicians, data analysts and other related specialisations will become increasingly important to the future of agribusiness in Australia. But these kinds of workers will also be in high demand from competing parts of the economy. Australian farmers need to be able to access people with the right skills, as well as appropriate training in these areas, to enable the adoption and application of these emerging technologies.

A related barrier to the widespread adoption of ICT and other knowledge technologies lies in access to appropriate network infrastructure. Without the ubiquitous connectivity taken for granted in urban Australia the uptake of these emerging technologies in rural areas will be severely restricted, and the well-being and education of agricultural families depends on their ability to access appropriate ICT and network connectivity.

An important but often overlooked barrier to the adoption of advanced, emerging technologies in the food and agriculture sectors is that of social acceptance of technology, or social licence to operate. There is an important role for government in helping to reconcile public concerns around the use of advanced technologies in food production. Public trust in the science and innovation that underpin the quality, safety and availability of food in Australia is paramount.

A high-profile example of social licence to operate issues is in the public backlash to the rollout of genetically modified crops, such as canola, which in some States has resulted in a complete moratorium on their use. Not all issues arising from social acceptance of technology are as high-profile or dramatic in their consequences, but if community concerns are not dealt with in a consultative and sympathetic manner there is a risk that the adoption of emerging technologies in agriculture could be needlessly undermined. The *Australia's Agricultural Future* report found in regards to this issue that "Australia needs to address the erosion of its 'social licence to operate' in the agricultural and food sectors. Scandals (animal welfare, food safety, labelling), romanticised views of agriculture that are incompatible with modern technologies, and perceptions of agriculture as damaging to the environment all contribute to that erosion."

For more information and research about public perceptions of gene technology in Australia, particularly in food and crops, see the Office of the Gene Technology Regulator's recent report *Community attitudes to gene technology*[14].

Underpinning the development, adaption and adoption of emerging technologies across the Australian economy is our capacity in science, research, development and extension. As stated above, revolutionary new technologies most often arise from fundamental research.

[14] Instinct and Reason 2015, *Community attitudes to gene technology*, prepared for the Office of Gene Technology Regulator, available at: http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/327437B632158967CA257D70008360B1/$File/Community%20attitudes%20to%20gene%20technology%20Final%20Repor%202015.pdf

But just as important is our capability to adapt technologies developed overseas to Australian conditions and applications. Most of the new technologies that will make transitional changes in agriculture in the near future were unheard of a decade ago. In the next decade, we will see more technologies that are generally unheard of today. For Australia to gain and keep a competitive edge, it is vital to keep up with our own fundamental research as well as maintain the expertise to apply current knowledge.

Australia has a strong innovation system generally, and in agriculture specifically through our Rural Research and Development Corporations (RDC) system. Recent trends towards corporatisation, and in some cases privatisation, of RDCs may be undermining effective long term innovation – RDCs should maintain a structure that ensures that they can take advantage of the best scientific advice possible, both proactive and reactive.

To maintain the strength of our innovation system and leverage the emergence of new technologies for continued success in our agricultural sector ongoing investment and support is required, both private and public.

Concluding remarks

Emerging technologies will play an increasingly important role in improving the efficiency and productivity of Australian agriculture and associated down-stream sectors such as food processing and manufacturing. Many of these technologies are the same that will be applied across the economy as a whole, and the agricultural sector must compete with other sectors for the skilled workers required to adopt these technologies successfully.

ICT and knowledge technologies will revolutionise agriculture in the coming decade, and only with reliable access to fit-for-purpose communication networks will our farmers be able to truly take advantage of these opportunities.

ATSE's Agriculture Forum comprises approximately 130 world leading experts in food and agriculture research and industry. The Forum would be pleased to make available its expertise on any of the issues raised here for the Committee's benefit.

For more information and to arrange witnesses for Committee hearings, please contact Dr Andrew Hastings (ATSE Senior Research and Policy Officer)