Agricultural Innovation

Executive Summary

The Warren Centre for Advanced Engineering is pleased to submit this paper to the House Standing Committee on Agriculture and Industry on "Agricultural Innovation". The terms of reference for the study ask particularly for advice on the following matters:

- Improvements in the efficiency of agricultural practices due to new technology and the scope for further improvements;
- Emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals; and
- Barriers to the adoption of emerging technology

The Warren Centre for Advanced Engineering advocates for the development and adoption of digital innovation and precision agriculture techniques as emerging technologies that will benefit both viability and productivity of our agriculture industry.

Digital disruption and innovation

Digital advances like the Internet of Things, big data, advanced algorithms and robotics all promise a new wave of productivity across a number of industries. Quantifying their impact in terms of productivity or efficiency is difficult. However it is widely accepted that their adoption and impact will contribute to positive transformation and growth. The Information Era also promises to bring disruption to establishment. Industries never before conceived are spawning around the management of big data, spatial imaging, digitisation and automation with the focus of enhancing consumer preference and experience throughout supply chains. Effectively leveraging these technologies and industries to enhance growth and productivity is a challenge and an opportunity.

The challenges the agricultural industry faces include maintaining soil fertility, water shortage, pests and diseases affecting our crops and livestock, increasingly rigorous standards for the quality and safety of food and more stringent standards for the welfare and safety of those employed in the industry (Cox, 2002). In addition the variability of the industry in terms of yield and field/crop have a significant influence on

The Warren Centre for Advanced Engineering Ltd
School of Information Technologies Building J12
University of Sydney NSW 2006
T: (02) 9351 3752 • F: (02) 9351 2012

E: warrenc@sydney.edu.au • W: thewarrencentre.org.au
twitter.com/thewarrencentre • facebook.com/thewarrencentre

ABN: 27 132 821 688

production and output and lead to unique challenges (Zhang, 2002). Technology in the form of automated irrigation and remote mapping of fertile land has already been adopted into the industry and has proven to extend capacity and capability. More widespread adoption of technology and the integration of these systems into a system-of-systems is advocated as the next step. Specifically this includes the emergence and convergence of several technologies, including the Global Positioning System (GPS), geographic information system (GIS), miniaturised components, automation, in-field and remote sensing, remote computing, advanced information processing and telecommunications (Zhang, 2002). The focus of leveraging these technologies specifically for the agriculture industry should aim at gathering more temporal and spatial data, management of variability, system-level decision making and increased utilisation of automated systems.

Agriculture and technology - the combine and divide

Agriculture has historically benefitted from technology adoption (Whelan, 1997). The industrial age brought mechanisation and synthesised fertilisers; and the technology age delivered genetic engineering and automation. The information age, therefore, brings the potential for integrating technology advances into a precision agriculture that drives growth and productivity (Zhang, 2002). Adoption of precision agriculture is low, and this spawns from a lack of understanding the profitability potential. In addition as the agriculture sector is very broad, adoption is impeded by a belief that these systems cannot be widely deployed or are too capital intensive for a relatively small application. Much of the necessary technology is now available, however the environmental and economic benefits are largely misunderstood or underrepresented.

Technologies that have developed dramatically in recent years in other fields that could be applied and adopted to the next wave of productivity in agriculture growth include:

- The Internet of Things: integrated networks of sensors, actuators and wireless networks for data collection; variability management; process monitoring of crops, livestock and eco-systems
- Advanced robotics: robots with enhanced senses, dexterity and intelligence used to automate tasks or augment human labour such as harvesting fruit and controlling weeds and pests
- Autonomous farm vehicles: Vehicles that can navigate and operate safely in hazardous terrain and environments to harvest crops and herd livestock
- ‘Farms in the Cloud’: The simulation of real-time agricultural processes using data and algorithms
- Mobile broadband internet: Inexpensive and capable mobile computing devices with high-speed internet connectivity to the farmer in the field
- Decision support: intelligent software that can manage the acquisition of large amounts of information and can perform appropriate optimisation of farm operations and support decision making

Case studies from the CSIRO (Robertson, 2007) and the Society for Precision Agriculture Australia show economic and environmental benefits accompanying precision agriculture. These will be articulated further in this report. In particular, however, it is important to recognise the inherent role that technology has played in the evolution of agricultural productivity and the opportunity that the information age brings specifically to this industry and its unique challenges.

Precision agriculture – Australia and the world

Precision agriculture adoption globally is broader than what is currently applied in Australia. Monitoring and mapping of spatial variability in small-grain crop yields has been a major application in Australia. However the total number of grain yield monitors operating was below 200 as of 2002 (Robertson, 2007). At the same time in the US, there were between 5,000 and 10,000 such operating units. Similarly in Japan, there is a large investment in precision agriculture research focusing on sensing and controls for mechanisation and automation (Robertson, 2007). Most precision agriculture technologies have been concentrated on variable rate time (VRT) applications of fertilizers and herbicides. These systems allow the user to vary the rate of crop inputs as opposed to uniform rate input which does not account for variability. VRT technologies in the form of sensors which feed into a variable-rate control system to apply inputs at a precise time and/or location are being developed in Japan and the United States. More broadly, reports on precision agriculture experiments have been noted from China, Korea, Indonesia, Bangladesh, Sri Lanka, Turkey, Saudi Arabia, Brazil, Argentina, Chile, Uruguay, Russia, Italy, The Netherlands, Germany, France, UK and Canada (Zhang, 2002). Applications have been widespread and include rice and tomato production in California, banana plantations in Costa Rica, irrigation in South Carolina and cotton fibre quality in Uruguay.

Technology innovation also plays a key role in precision agriculture adoption in Australia and around the world. Sensors measuring yield (optical, weight-based and gamma-ray) and measuring field (commercial GPS and handheld systems) are maturing in technology development and are widely implemented in Australia and abroad. Soil sensors which measure soil spectral reflectance within wavebands that can predict soil organic matter and moisture content of surface and subsurface soils have undergone positive field tests (Zhang, 2002). Development of these technologies is widespread and is largely maturing. Control-system based technologies around the automation of vehicles including automatic guidance systems, robotic harvesting systems, networked systems and intelligent decision-making are areas of potential for growth (Zhang, 2002). Uniquely, these are also areas where Australia is poised to generate valuable intellectual property (IP) and deliver positive results. Harvesting robots for tomatoes, cherry tomatoes, cucumbers, strawberries, grapes and watermelons are already commercialised. Research at the Australian Centre for Field Robotics (ACFR) on robotic agricultural mapping and harvesting is developing technologies for localisation, path planning, visualisation of fruits and effective terrain mobility (ACFR, 2014). Research vehicles such as the Ladybird have been successfully field tested in onion, beetroot and spinach farms in Cowra. The system includes a robotic arm for removing weeds and autonomous harvesting. Further research into integrated decision making and systems-of-systems engineering is also an Australian research asset. The Precision Agriculture Laboratory (PA Lab) operating within the Centre for Carbon, Water and Food is another example of domestic innovation and diffusion of technology in this sector. It is important to recognise that technology innovations leading to integration and larger digital awareness are an Australian strength in precision agriculture and a capability which can build further value.

Benefits for the agriculture industry

Case studies for the benefits of precision agriculture in the industry are varied. The benefits range from optimisation of harvesting and irrigation through data collection of soil and subsoil content as well as variability in field and yield through to better mapping of arable land. Research by the CSIRO found that in six case studies across the Australian wheatbelt covering a range of agro-climatic conditions, cropping systems, soil types and production levels, benefits could be quantified ranging from $1 to $22 ha (Robertson, 2007). On a per-paddock basis, benefits ranged up to +$57/ha/yr in variable output (Robertson, 2007). The use of computer systems to help manage the land was also found to have positive effect and output. For the farmers the benefits of precision agriculture are therefore:

- Growing premium-priced products using data-intensive production systems
- Adding traceability to the farm's menu of information services and underpinning high food safety standards so that Australia can lead in global markets
- Producing organic food at near the costs of non-organic production methods
- Using less inputs on-farm but producing more outputs using intelligent machines

Working in collaboration with Australian technology researchers and innovators also proves to benefit the agriculture industry as solutions developed in the laboratory can be tailored to match specific challenges.

Benefits for Australia

The value of the agricultural industry and its potential for productivity and growth is already being recognised in the United States with a recent announcement showing that the US Department of Agriculture is investing over $150m in rural investment and entrepreneurship in an attempt to drive a level of technological innovation unprecedented (see for example Milne, 2015). According to the US Secretary of Agriculture, Tom Vilsack, 'We'll need as much innovation and creative thought in agriculture over the next 35 to 40 years as we've had in the previous 10,000 years' (Milne, 2015).

Australia is poised to benefit across its agricultural exports and output as well as its technology development. The Australian economy can benefit from a more productive and efficient output, and the increasing complexity of this digital agriculture system offers an entry to Australian university research, industry collaboration and entrepreneurship. This allows Australian innovators to engage in international supply chains as well as to develop valuable local IP which will create jobs and catalyse further growth in productivity.

The risk for Australia is that it continues to develop technologies that can be applied to agriculture in isolation from the requirements of the industry or that the technologies are not applied. For this reason the Warren Centre advocates broader research/technology commercialisation reform across the industry and innovation portfolio and invites the Australian government or interested stakeholders to engage with us in further work and output surrounding these broader issues.

The infrastructure challenge

Most importantly, there lies a significant challenge in infrastructure for the implementation of precision agriculture. This challenge is technology allocation, distribution and monitoring as well as deployment of mass surveillance and mapping technologies such as satellites. Our current infrastructure capability needs to be assessed and protocols for its update and upgrade to match the precision agriculture requirements should be implemented.

Some of the key infrastructure challenges at a glance are:

- Big data acquisition and management: there is a large systems integration challenge around managing the size and volume of datasets that are acquired through using precision agriculture technologies.
- Monitoring of technology use and implementation: ensuring the use of technology assets on the field and monitoring their relative productivity
- Reporting: Ensuring there is an independent and equitable method for reporting profit/loss in the use of these systems and that there is an effective mechanism for collating usage data and auditing the productivity improvements/losses.

Recommendations

1. Agricultural Technology Services Business Development

Australia needs to expand and promote the cluster of Australian industry and enterprise involved in agricultural technology. With the emergence of new technologies of relevance in the agricultural space, there will be new participants in the industry and expanded opportunities for revenue growth.

An effective, coherent and bipartisan Australian agricultural working group will not only underpin the basis of productivity growth in Australian agriculture, but will also ensure that research and technology commercialisation divides are managed. Further, government initiatives such as centres of excellence and clusters can be better managed through a dedicated working group.

This must be a national priority involving participants from R&D, finance and investment, and commercialisation specialists as well as farming groups. The Warren Centre believes that an appropriate business development taskforce will provide the right guidance to deliver a potentially multi-billion dollar addition to the Australian economy.

2. Digital Farms
    a. **Build awareness** of the economic and environmental benefits of an uptake in precision agriculture technologies as well as the widespread applicability of these technologies across a variety of agricultural pursuits

b. **Harness private/public partnerships around robotics research and implementation** and recognise the value driven nature of robotic applications to the agricultural industry
c. **Invest in skills and training** both in research and development and in the agricultural industry to facilitate uptake in technology development and corresponding usage and application in the field
d. **Fund demonstration projects** to assist in both building awareness and to allow start-ups to prove their technology potential
e. **Facilitate further investment from Australia and globally**. This will contribute to greater technology development and fill the knowledge gaps.

3. Approaching the infrastructure challenge

Facilitate a site-specific case study with an integration of a number of technologies and develop mechanisms to quantify the productivity output and to test the infrastructure capability and capacity.

Conclusion

By following the approach outlined in this submission, the Warren Centre believes that Australia will be well prepared to capture the benefits in the coming decade of the information era that will greatly benefit farmers.

The Warren Centre looks forward to discuss this or provide further information or analysis on any aspect of this submission.

Contacts

Ashley Brinson
Executive Director, The Warren Centre for Advanced Engineering
ashley.brinson@sydney.edu.au, (02) 9351 3752

About the Warren Centre for Advanced Engineering

The Warren Centre constantly challenges the economic, legal, environmental, social and political issues raised by innovation. We collaborate with industry, government and academia to achieve globally significant outcomes.

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