Dr Michael Spence
Vice-Chancellor and Principal

25 September 2015

Ms Julia Morris
Committee Secretary
House of Representatives Standing Committee on Agriculture and Industry
PO Box 6021
Canberra ACT 2600

By email: agind.reps@aph.gov.au

Dear Ms Morris,

Inquiry into Agricultural Innovation

Thank you for your letter of 17 August 2015 inviting input from the University of Sydney to the Committee's new inquiry into agricultural innovation. We welcome the opportunity to make a submission and trust committee members will find this information useful.

The University of Sydney has an outstanding track record of contribution to agricultural innovation in Australia, our region and beyond. For more than 100 years we have been a leader in agricultural and veterinary science research, education and partnerships, forging major advances in the productivity, safety and international reputation of Australia's agricultural products, services and systems.

Our longstanding research and capacity building activities in Southeast Asia in particular, have also served to improve food production capacity and sustainability in many developing countries, with large flow-on social and economic benefits for Australia and communities in the region. For example, education and research collaborations supported by successive Australian governments have helped to maintain Australia's competitive advantage in freedom from major diseases, such as the eradication of Foot and Mouth Disease in Indonesia.

The Australian environment is a challenging one for agricultural production. As an industry, Australian agriculture has found its competitive edge not in its environment but in agricultural knowledge and innovation. Working within the resource restrictions imposed by climate and geography, we have had no option but to innovate. This has led to the development of world-leading practices and technologies, which we have successfully exported around the world.

Changes in climatic, social, economic and environmental factors have added more complexity to the way safe food is and will be produced in Australia. There are immense and complex challenges ahead for food security in our region, with competing pressures on soil, water, nutrients, and space for agricultural production. Achieving an optimal and sustainable level of food safety, animal welfare and food security in Australia and our region requires not only the application of latest technology to produce the food, but also strong capacity building for animal and plant disease management.

These challenges bring opportunities for Australian innovation and industry and the University is leading the way in multidisciplinary approaches to capture such opportunities. Technology and innovation can help through both an innovation-driven increase in efficiency and productivity (see the **attachment** for examples) and the development of new and more attractive markets

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that will allow the use of limited soil and water resources to extract the greatest possible economic benefit.

Australian agriculture has the capacity to feed some 100-120 million people, allowing us to maintain a healthy export industry in addition to feeding our own growing population. Given the restrictions of our continent and our economic environment, the challenge is to deliver a highly profitable agriculture, which at the same time continues to deliver ecosystem services for all Australians.

While Australia's current export industry is focused on the production of bulk commodities, we suggest that moving away from say 10 bulk commodities to 10,000 differentiated products is more likely to deliver greater economic benefit for our limited resources. Plant and animal products that are differentiated and targeted for niche markets can carry price premiums, and thus, especially as the middle-class in our region continues to grow, we could aim to feed 100 million middle-class people with high-value, safe, nutritious, and targeted value–added products.

To access and grow new and differentiated markets, we will need to continue to innovate and be strategic in our national approach. Developing smart and precision measurement and separation processes at all points along the production supply chain will be key. This will allow the tracking and quality measurement of products from specified locations within a paddock, or from a specific animal to the plate. We are currently developing sensing and information technologies for plant and animal products that can achieve this.

We are committed to partnering with government and industry in new ways to produce the research required, as well as the bachelor and doctoral graduates capable of developing and leading this new approach to agriculture. We strongly support the role that the rural research and development corporations and other industry-government partnership programs play in fostering agricultural innovation. These have a critical role to play in bringing industry, universities and government research agencies together to address Australian priorities. We will also continue our strong emphasis on contributing to stability and well-being in the Asia Pacific region by working closely with our partners and communities to build the safe and sustainable food production systems that are so critical to support economic development.

We are keen to discuss both the challenges and opportunities with the review committee if that would be of interest, and would be happy host committee members together or individually for briefings and site visits tailored to their needs.

Should any further information be required from the University in regards to its response, in the first instance please do not hesitate to contact Mr Tim Payne, Director Higher Education Policy and Projects in my office

Yours sincerely,

Michael Spence

Attachment University of Sydney specific comments relevant to the Inquiry's terms of reference

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THE UNIVERSITY OF SYDNEY

University of Sydney Detailed Responses

The University of Sydney's faculties of Veterinary Science and Agriculture and Environment, along with the Australian Centre for Field Robotics based in our Faculty of Engineering and Information Technologies, all undertake research and produce graduates whose skills and expertise help underpin agricultural innovation.[1] Recently we have established the Charles Perkins Centre, a $0.5 Billion investment in food, nutrition, and disease, which seeks multidisciplinary solutions to "wicked" problems in these areas. Our China Studies Centre and the Sydney Southeast Asia Centre also facilitate multi-disciplinary approaches to education and research relevant to agriculture and the environment in our region.[2]

The University's Faculty of Veterinary Science is ranked first in the Southern Hemisphere, and recognised as producing research well above world standard (Excellence in Research for Australia 2012 rating of 5 for Veterinary Science).[3] The Faculty focuses on veterinary science, animal production and wildlife conservation, and has long standing industry partnerships with the Poultry and Dairy Research Foundations.

The Faculty of Agriculture and Environment undertakes high quality research and education in crop breeding and production, soil science, livestock production and forestry (ERA 2012 ratings 3 to 5 for disciplines activities).[4] It has an extensive history of partnering for research and development with the major Australian cropping industry bodies, and has a number of well-established agricultural research facilities. These include the International Grains Research Centre, the Plant Breeding Institute, the Centre for Carbon Food and Water, the Fresh Produce Safety Centre, the Precision Agriculture Laboratory, and the Food Processing and Training Centre.

The Australian Centre for Field Robotics is recognised as one of the largest field robotics groups in the world and one of the largest robotics research organisations. The Centre conducts research in areas such as agricultural robotics and environmental monitoring, with partners including Horticulture Innovation Australia Limited.

This combination of skills and resources within the University provides a large and unique multi-industry capability platform for the continued development of data-driven decisions in agriculture across multiple industries. In particular, the University:

- conducts research across most animal species and management systems;
- holds extensive knowledge and skills in measuring and incorporating spatial soil, crop and pasture information into crop and livestock management systems;
- has extensive research experience in machinery automation and operational logistics, big data management, data fusion and analysis, and the application of this to the development and integration of robotics and IT into agricultural systems; and

[1] Faculty of Veterinary Science http://sydney.edu.au/vetscience/; Faculty of Agriculture and Environment http://sydney.edu.au/agriculture/index.shtml; Australian Centre for Field Robotics: http://www.acfr.usyd.edu.au/;
[2]Charles Perkins Centre: http://sydney.edu.au/perkins/http://sydney.edu.au/; China Studies Centre: china_studies_centre/ ; Sydney Southeast Asia Centre http://sydney.edu.au/southeast-asia-centre/
[3] http://www.arc.gov.au/era-outcomes-2012#Institution/SYD
[4] http://www.arc.gov.au/era-outcomes-2012#Institution/SYD

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- is combining skills and resources through cross-faculty collaboration to form a substantial base from which to build industry-relevant spatially- and temporally-aware decision support systems.

Addressing the terms of reference:

TOR 1: improvements in the efficiency of agricultural practices due to new technology, and the scope for further improvements.

We think of new technologies as a broad term that encompasses new physical instruments and products along with new knowledge, skills and management techniques. The latter are essential for the former to succeed.

The improvement in efficiency and impact realised will vary according to the role and areas in which such improvements are applied. In general, however, we group technologies and automation by their function, or in other words, by how they help farmers, managers or producers, as outlined below.

1. **Replacing repetitive tasks.** This includes labour-saving technologies such as robotic milking, robotic crop monitoring and automated harvesting, auto feeding in poultry, driverless tractors, automated crop harvesting and weeding, automated livestock weighing and handling. Technology intervention here will significantly raise productivity and product quality. It may also be expected that by reducing the repetitive and mundane nature of tasks, farm jobs become more variable, interesting and mentally challenging, assisting in the improved retention of staff.

2. **Increasing the accuracy of measurement of important parameters in farm enterprise operation, and measuring new operational and production variables.** By improving the measurement of these parameters, we can provide increased data for management decisions. This might include new pasture sensors, livestock activity & rumination tags, inline monitoring of animal metabolites linked to health and reproduction performance, soil property sensors, crop and food quality sensors, plant health sensors, and food safety sensors. Spectral sensing could also be used to identify individual crops, so that these can be targeted individually with fertilizer or herbicide, or to detect individual flowers to assist in guiding pollination activities.

3. **Assisting in the translation of raw 'data' into useful 'information' for decision-making.** This is useful mainly for processes and techniques that need to encompass broad systems thinking. The process will require the merging of large data streams from diverse sources, with variable structures and scales into adaptable models. These models would contain the relevant data and farm business components, allowing them to feed information into and help drive key management and operational decisions. Big-data analytics and machine learning can also be used to classify types of vegetation, allowing the individual ripeness of a fruit and its geo-location on the farm to be mapped. Automated decision software can also support pollination and spraying activities, and automated tools that can be used in conjunction with robotics for autonomous pruning and thinning. The components in the process may eventually include:

    - local data generation and capture: such as sensing product yield and quality, aerial/proximal crop, animal, disease, pest, soil, and environmental conditions;

- data dormitories: cloud-based (or local subsidiary) stores of historic and off-farm data at multiple scales (production, environment, financial, markets);
- prescription agriculture: alternative options for crop and animal business management, variable-rate application/treatment and farm logistics based on assessment of probabilistic outcomes from data-driven models of causal relationships.

All the three groups above (replacing repetitive tasks, increasing accuracy of measurement; and transforming data into information) can have large potential impact. The combination of all would of course result in the maximum impact. All roles have scope for further improvements through the development and/or refinement of new and existing technological solutions. The third group above is probably where the most individual returns can be realised, however, through the conversion of raw data into useful, processed, and automated decision-making information.

Improvements in efficiency will also come from improvements in animal health and welfare across all animal production systems. Healthy, well treated and well looked after animals are more productive as a result of early detection of health problems and improved well-being. In addition, they are better perceived and accepted by the general public, who ultimately drive demand for animal products. Advancement in technologies that allow monitoring of animal function, including “on” animal sensors that monitor behaviour, such as activity and rumination tags in dairy cows; “in” animal sensors that monitor physiological functions such as rumen probes to continuously monitor pH, temperature and pressure in ruminants; and “outside” animal sensors such as walk-over scales; body condition scorers; and inline monitoring of conductivity and health-related metabolites in milk are likely to become the dominant aspects of animal production in Australia in the next decade.

TOR 2: emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals;

Emerging technologies include all aspects of automation and robotics ranging from automated aerial and ground vehicles, drones, and associated intelligent software and data analytics for crops; automated milking, herding and sampling in animal production systems such as dairying; to cultivating, sampling, application of treatments and harvesting in agriculture and horticulture.

In animal production new technologies also include new sensors, such as those for individual animal intake like accelerometers and cameras; the application of existing and newer sensors on automated aerial and ground vehicles; sexed semen; genomics and its application to more individualised selection targets; new smartphone apps for things like chemical management and safety; machine recognition and learning, such as for biomass measurements through field scans, and new models and software that ‘learn’ from the data to optimise outcomes.

We believe the key to achieving sustained gains in the development and application of technology lies in the integration of multidisciplinary science and collaboration among national and international organisations. The University could assist through its strengths in technology-driven agriculture, which include expertise in:

- spatial statistics, soil science, agronomy, farm production, logistics and business management;
- site-specific crop and pasture management;

- spatial livestock management and herd-specific genetic management;
- animal-specific health, welfare and production management;
- robotic/autonomous sensing, control, learning and systems engineering for agriculture;
- digital data acquisition, delivery, fusion and analysis for agriculture; and
- a comprehensive range of measurement devices, platforms, sensors and operational expertise relevant to multi-scale monitoring of soil, crop, livestock and environment monitoring unique in Australia.

In addition, the University possesses world-leading skills in multi-disciplinary research, teaching and training for industry, as well as undergraduate and postgraduate education. In 2014 we introduced a Bachelor of Food and Agribusiness with a 12 week industry internship and an embedded honours year, designed to equip students with the capacity for innovation in the supply and management of food products for industry and end consumers. We have research students involved in projects across a broad spectrum of fields relevant to achieving agricultural innovation.

TOR 3: barriers to the adoption of emerging technology.

Responsible for around 4.5 percent the global agriculture and veterinary science research effort, Australia's contribution is large relative to our size, research workforce and levels of investment. In intensive farming systems in Australia, the key barriers to adoption of advances that arise from research revolve around lack of time, skills and money. Lack of time prevents farmers, managers and producers from evaluating new technologies and prioritising management actions that can result in lower costs and increased efficiency. This can often be addressed through improved communication to encourage the uptake of new skills and efficient delivery of education to build these skills. The costs of technology can also be prohibitive, though economies of scale may assist here as adoption becomes more widespread. Capability for servicing and maintaining technologies, including software and systems in remote locations must also be developed.

The significant reduction of Government-supported extension programs across the sector, requires new strategies to improve extension and local technology adoption to be developed in parallel with technological solutions. Multidisciplinary approaches and industry-research organisation partnerships are key to ensuring that any advancement in technology reaches the end-user and thus produces the desired practice change and efficiency gain.

Suggested areas for policy and funding attention

The below areas of focus to boost national capacity for agricultural innovation are suggested for consideration by the Committee.

1. **Education for innovation** – Develop programs that facilitate the recruitment of suitably skilled candidates into the field, and ensure they are trained in multidisciplinary agricultural technology innovation research and delivery. Due to its inherent multidisciplinary nature and long-track records of interdisciplinary and cross-organisation partnerships, the University of Sydney has the capability, physical and human resources to lead the development of such programs. Technological innovations are key to not only increase efficiency and productivity of food production and drive the diversification of our export industry, but also to make agricultural in general more attractive for younger generations.

2. **Research** – Improve our capacity to partner locally, nationally, in our region and globally with a range of organisations to drive innovation. This will improve our ability to undertake the multidisciplinary research that is necessary to maximise the potential impact of technological solutions.

3. **Development** – Establish new approaches to development and extension programs so that research-driven technological solutions can be demonstrated. Evidence-based demonstration informs uptake and requires local and applied field research to adapt technologies to local conditions and provide that demonstration.

4. **Extension** – Increase the skills of farmers who will implement new technologies through new and innovative programs. The current shortage of extension capacity to roll out innovation is a clear barrier to adoption and therefore is limiting the opportunity to maximise the return on Government's research investment.

5. **Collaboration** – Build on successful existing programs like the rural research and development corporations, to strengthen collaboration between industry, universities and government research organisations. Also build on existing successful agricultural aid programs such as those run by Australian Centre for International Agricultural Research, to enhance educational and research collaboration between Australia and developing countries in our region and elsewhere.

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