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

18 September 2015

Dear Sir/Madam,

**Re: Submission from the Rural Innovation research Group (University of Melbourne) to the Inquiry into technological advancement in agriculture**

We welcome the inquiry into technological advancement in agriculture and make this submission as a group of researchers and educators from the University of Melbourne with experience in the study of agricultural innovation systems, technology adoption and the co-development of technological opportunities with farmers, advisors, government and the private sector.

This submission draws on evidence from our research, teaching and broad experience in Australia's agricultural sector over 25 years, and on our understanding of international developments in the understanding and practice of agricultural innovation, gathered through our involvement in the international scholarly community.

Our submission addresses particularly the third point in the inquiry's terms of reference: **"barriers to the adoption of emerging technology"**. With respect to this, we provide a summary of current knowledge and highlight what we see as the key areas for government involvement in supporting continued innovation in the agricultural sector.

**1. Innovation involves more than technology alone**

We submit that agricultural innovation needs to be understood not simply as the adoption of new technology, but rather as a systemic process grounded in functioning and well-orchestrated relationships between multiple stakeholders. These stakeholders include farmers and communities, but also the developers and suppliers of technology, the people and organisations who educate and advise farmers, participants in the agricultural product supply chain, and also policy-makers and regulators. Put simply, innovation requires a focus not just on the "hardware" (that is, the new idea or technology), but also on the "software" (the skills and knowledge required to use and derive benefits from the technology) and the "orgware" (the formal and informal relationships and arrangements between stakeholders that are required to support the successful and sustained deployment of the technology). An example from another sector is the recent increased uptake of rooftop solar panels in Australia. The technology "hardware" (photovoltaic cells) had been well-developed for many years, but adoption only took off when reforms to the electricity market took place, including required legal and regulatory arrangements, that allowed householders to be paid for electricity generated ("orgware").

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This "innovation systems" view of innovation is supported by the 2008 *Cutler Review of the Australian Innovation System*, and more recently by the Australian Farm Institute. Our recent research has focused on applying an innovation systems perspective and comparing outcomes from different approaches to agricultural innovation (Klerkx and Nettle, 2013; Nettle, Brightling et al, 2013). We have found a multi-stakeholder, participatory technology development approach, that includes the private sector, consumer/societal interests and farmers co-developing options and solutions, to be an effective strategy for getting the most from Australia's agricultural RD&E system.

**2. There are many factors that influence individual farmers' adoption decisions**

As referenced in the background to the inquiry, Australian farmers have always been at the forefront of developing and adopting new agricultural technologies, however there is a large variation in adoption between farms.

In a recent meta-analysis of reasons for farmers' adoption, four key groups of factors were identified that influence adoption decisions. These factors affect both the expected peak or final level of adoption of a technology or practice within a population of farmers, and also the time taken for this peak to be reached (Kuehne et al, 2013).

These four groups of factors are:

a) Characteristics of the technology or practice (e.g. cost, level of difficulty in implementing into the farm system);
b) Characteristics of the target population (e.g. social norms in relation to the proposed change, financial capacity and debt levels, education levels);
c) Relative advantage of using the technology/practice (e.g. profitability to individuals or benefits/incentives for change);
d) Capacity to learn/adapt to generate a relative advantage (e.g. support networks to aid decision-making and learning)***.***

All these factors need to be examined with a specific technology and a specific population of potential adopters in mind. A population of potential adopters may be defined geographically, by sector, or both. For instance, satellite imaging for monitoring pasture dry mass to assist decision making in crop and pasture management, or the use of sensor networks to control livestock, will have different value propositions (that is, relative advantage in comparison to current practice) depending on whether you are a dairy farmer in Tasmania, a beef cattle producer in the Northern territory or a catchment manager in an environmentally-sensitive water catchment.

It is important to note also that the relative advantage generated for farmers from specific technologies is often worked out through experimentation, rather than being reliably knowable in advance. There is often a significant difference between the "theoretical" relative advantage of a technology or practice, as it might be identified by researchers or technology developers, and the actual advantage that a farmer is able to capture in practice.

**3. Farmers' adoption decisions are influenced by the multiple objectives they pursue**

Technology developers and policy-makers often assume that production efficiency and profitability are the only, or overriding, objectives that farmers pursue in their management decision-making. Research has consistently shown that this is not the case. Farmers pursue a range of objectives, with different individual farmers attaching different importance to them. The weighting of different objectives will also vary for individual farmers and farm families over time (Waters et al., 2009). For example, recent studies of dairy farmers' adoption of technologies have found that the benefits sought were most often related to ease of management and labour-saving rather than directly to production efficiencies (Eastwood et al., 2015). Assessments of the relative advantage offered by technologies that fail to take account of the multiple objectives that farmers pursue are thus seriously flawed.

**4. There are many and complex barriers to farmers adoption of emerging technologies**

Specifically related to emerging technologies such as use of 'smart' telecommunications, sensors and/or unmanned aerial vehicles (UAV's or drones), plant genomics or addressing complex challenges such as antibiotic and chemical resistance, research has identified a number of challenges to be addressed on-farm, in value chains and through research, development, policy and regional development practices:

- *Challenges for farmers and their supply companies*:
    - the learning challenge – adapting farm systems; developing new skills; working differently. Some technologies present high learning challenges for farmers and are not necessarily "plug-and-play", which is the way they are often described by their promotes. Farmers are rightly sceptical of technology promoters over-promising on the benefits and usability of technologies. The quality of on-going advice and support provided is also critical, and consideration of this informs on-farm decisions.
    - the management challenge: working through the costs/benefits, managing large amounts of data and information in decision-making, applying new skills, training employees.
    - the ethical/moral challenge: the extent to which the farm system will need to transform and the effects over time on family, staff, community; market or consumer consequences that can't be fully anticipated. Unknown or unresolved ethical or moral questions elevate the perceived level of risk attached to a new technology for farmers.

- *Challenges for the current agricultural RD&E system*:
    - The speed of development of technologies, such as information technology applications, big-data management and automation and the relatively large investment of the private sector in these areas, impacts on the role of agricultural RD&E. For example, there is a need to move away from developing specific technologies toward supporting adaptation at farm level, and toward "pre-commercial" RD&E which has collective industry interests in mind (such as understanding variation in farm performance; supporting good decision-making or accelerating adaptation to ensure risks are reduced and value is captured more quickly).
    - The social and economic dimensions of technological applications need to be considered very early in assessing the contribution of precision agricultural systems to innovation and the creation of value for individual farms and for society. This assists with identifying risks and socio-legal issues, with understanding potential vulnerabilities or identify unexpected benefits, and with targeting segments of a population who may gain the most or be most resistant. This means RD&E programs need to include social and economic dimensions at the beginning, not at the end, in research designs.
    - The reduction in public-sector extension services and the perception that technologies with predominantly on-farm applications reside completely in the realm of "private-good". Current policies mean that farmers and researchers are reliant on the private sector advisory system for: a) linking research efforts to farmers and b) for communicating farm-based experiences to researchers. However currently, relationships with the diverse private advisory system (often linked to particular technologies) tend to be largely informal or undeveloped. A large number of private organisations exist, and contact with research groups can be intermittent, difficult to maintain or non-existent.

- *Society and consumers need to be included in the consideration of precision agriculture applications:*
    - New technologies are not “value free” or benign in their impact. Researchers often describe precision agricultural technologies as “transformational” (e.g. genomics). This is because their application means that the “usual ways of doing things” are interrupted. Policies may not account well enough for the wider ramifications of the use of new technologies (e.g. UAV’s and the complications that arise from privacy laws and air-traffic regulations). Social norms may be seriously challenged and contested (is it better for the cow if a robot milks them rather than a human?) There can also be large social impacts or considerations. For example regional labour-markets may collapse if widespread use of labour-saving systems occurs across farms in a region, or new forms of social organisation may be required in association with new technology and management arrangements for water resources.
    - The current technology assessment process in agriculture is being challenged because many of the technological applications with potential benefit/application are not being developed or invested in from the agricultural sector but become available through “spill-over” from other markets. The ability of agriculture to know about, understand, trial and develop spill-over technologies is dependent on the degree of connectedness of the agricultural RD&E system to other networks and groups in Australia and overseas. It also requires an ability to research, trial and adapt high-potential opportunities quickly – which relies on multi-disciplinary teams with the ability to understand the range potential impacts and responses (economic/market, social, technical, organisational and institutional).

**5. Addressing the challenges**

We submit the following as possible policy responses that will help address the challenges discussed above:

- **Provide incentives to support the use of multi-disciplinary and trans-disciplinary R&D teams** to address the adaptation challenge of agricultural technologies and their interaction with sectors outside agriculture. This could include involving bio-physical scientists, engineers, social scientists, policy people, farmers, advisers, IT and knowledge management specialists, and consumers/citizens in the co-development, trialling and adaptation of systems that suit the agricultural context and the broader goals of supply chains, community or government. For instance current issues include farmer-interfaces/usability of new technologies and ‘system integration’ between paddock and value chain, yet these issues are often not included in research designs and are considered too late in the innovation process. The formation, management and performance of multi-and trans disciplinary teams in agriculture and natural resource management settings has been applied and studied in previous research (e.g. Crawford, et al, 2007; Ayre and Nettle, 2015).

- **Invest in capacity building of farmers and advisors related to data interpretation** is an important aspect of technology utilisation that is often overlooked. Whilst ‘machine learning’ and ‘autonomous decision making’ are suggested as soon to replace the need for human intervention in data analysis and interpretation, there remain numerous examples where this is not the case as yet. Further, research into the use and uptake of readily available decision support systems (DSS) suggest relatively low uptake by farmers and advisors, unless such systems strongly linked to value-chain and regulatory requirements or are integrated into the advisory services that farmers already use.

- **Invest in research to better understand the implications of the privatisation of advisory services on farmers’ utilisation of emerging agricultural technologies**: Support to farmers for the application of new precision technologies will come from the private sector in many cases. However, it is important to better understand the motivations of and benefits to private advisors for providing such support. Recent research suggests that often the support provided by the public sector does not address the learning challenges of adapting technologies into farm systems. Further, some new precision (information) technologies provided by the private sector are not wholly regulated or verified and there is a need to support farmers to adjudicate on the quality of information (for example, there are private sites forecasting weather that do not disclose their data sets or sources). This issue is linked to data access and privacy protocols as farmers and advisors share and disseminate data in new ways.

- **Explore and encourage greater opportunities for collaboration and networking** amongst farmers, researchers, private firms and public agencies (and across agricultural industry sectors) to encourage learning to address challenges and reduce duplication. On this point we highlight the important role of the newly formed research and innovation network for precision agriculture systems (RINPAS) hosted by the University of New England (UNE), to which the University of Melbourne is a committed partner. This is an example of the type of networked R&D activity that is well suited to working with the complexity of agricultural innovation processes, and which government policy should seek to encourage and support.
- **Consider establishment of a cross-sectoral research program related to the institutional arrangements and policy context** in which new agriculture technologies are deployed. Such a program could undertake research related to privacy regulation, licensing rules, social norms and the support and advisory context that is needed to support successful adoption. This research would identify the socio-legal and socio-economic implications of change, and identify the early warning signals in relation to unintended consequences and shifting societal attitudes and values. This can inform governments and industries so that conducive policies are developed and barriers addressed.

We would welcome the opportunity to provide further evidence to the inquiry on the issues we have raised.

Yours sincerely,

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