THE UNIVERSITY OF SYDNEY

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Thursday, 24 September 2015

The Hon. Mr Rowan Ramsey,

Senate Standing Committee on Agriculture and Industry,

PO Box 6021

Parliament House, Canberra ACT 2600.

Dear Mr Ramsey and Members of the Committee,

Re: Technological Advancements in Agriculture

I preface this submission noting that the views expressed are mine, not necessarily those of this Faculty or University. I am quite willing to appear before the committee.

This submission contains examples of existing and developing technologies that will impact on the agricultural sector. Furthermore, a word of warning is given so that appropriate safeguards can be developed and implemented.

Agricultural technologies must be underpinned by a strong, vibrant research and development (R&D) sector to maintain competitiveness. New technologies arise from many different disciplines, frequently from basic research, and these technologies are applied into agricultural situations. Agriculture is no longer a silo but highly dependent on a very wide range of expertise outside its traditional boundaries.

Sensors are undoubtedly playing and going to play an expanding role in agriculture. For example, GPS is already widely used in agriculture but its use can be expanded profoundly. GPS will allow self-driving tractors (currently in their infancy) for agricultural operations such as sowing, application of agro-chemicals and harvesting. GPS will allow for a 'leading' tractor with offset slave tractors. GPS is fundamental for precision agriculture, a practice that is being adopted slowly by farmers. The University of Sydney has considerable expertise in precision agriculture and is delivering this expertise to farmers at grower field days particularly in the southern states.

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One of the next developments of GPS technology will be the control of many on-farm activities from remote sites. This is related to the explosion of digital devices and ability to transmit digital information quickly and in real time. Devices are already in use for irrigation scheduling and extensively in advanced dairy farms e.g. robotic milking, cow management, feed allocation, opening/shutting gates to send cows to appropriate paddock for grazing etc.

One of the outcomes of this GPS revolution is the freeing of labour for more productive activities. There can be a negative from the adoption of GPS and other technologies: low skilled labour will be required less. The societal question then becomes how to utilise less skilled workers to avoid the problems of unemployment, poor mental health and social/family dysfunction.

A large number of sensors are starting to hit the markets or about to be released over the next five years. These sensors include soil moisture sensors (use for irrigation scheduling), on-the-go pH sensors (to assess soil acidity), sensors for weed identification (judicious application of herbicides and thus minimise the potential for herbicide resistance of weeds), sensors for soil fertility, local meteorological sensors (many farm operations) etc. Radiometics is another technique that shows promise but may well be too expensive for deployment. However, it deserves further future assessment. One interesting class of development is 'non destructive techniques' to assess the state of soils, crops and agricultural products. For example, Near Infrared (NIR) spectroscopic techniques to assess such issues are near fruition. Some relatively inexpensive portable NIR sensors are now on the market for consumers to assess the ripeness of fruit or quality of vegetables – having said this, please see the warning final section below. Another non destructive technique is $^{31}P$-NMR; however, the instrumentation is largely in its development but is potentially very powerful.

To make optimum use of sensors, especially for on-the-go activities requires high-speed computer processing which may or may not be coupled to real-time remote sites. The robustness of computers for non-office activities is now very well advanced. This will allow processing of data in real time and immediate delivery of outcomes. Data transmission around properties can be from local 'towers' to a central location on the property and processed; alternatively, a central location can then transmit large bodies of data via satellite or fixed line (e.g. NBN) to major towns or cities in Australia or internationally for processing and interpretation.

Smart phones are well established in the Australian community. Development of suitable apps for agricultural operators is already occurring as evidenced by outputs from the Grain Research and Development Corporation. Large numbers of apps could be written but this is more limited by the size of the market (number of rural producers requiring an app for a specific purpose). As an aside, the number of app writers in Australia is rather small perhaps due to lack of required education especially where the app requires mathematical abilities, not simply coding/programming abilities.

Drones and robots are another technologies that will have considerable impact. There are two types of drone viz. fixed wing and helicopter. Helicopter drones currently are limited to short flights due to battery capacity. However, battery capacity is likely to improve substantially within the next five years. Fixed wing drones can carry more weight (battery or liquid fuel) – some fixed wing drones are capable of flying for hours. Drones can be used for remote sensing from very low altitude (a few metres above the ground) to hundreds of metres high. They can be equipped with mega pixel cameras to provide high resolution images. At the present time, transmission of these images to the ground in real time does not occur in agriculture. Images are downloaded on return and processed. What can be gleaned from such data? Examples include movement of stock, state of fencing, remote control of gates or electric fences, dam levels, water flows, crop monitoring for weeds, pests and diseases, pasture assessment for quality and quantity hence optimisation of livestock numbers, early detection of stress or drought, ‘drought proofing’ farms etc. Drones equipped with visible, NIR and UV etc. sensors will have great impact in improved environmental outcomes. These technologies can be applied to develop policy if used appropriately.

The above is one example of remote sensing. One should not overlook the data acquired by satellites especially as the resolution of images is improved. Its application will be in broad scale monitoring rather than small areas.

The role of meteorological observations is very important for the agricultural and agribusiness communities as well as the population at large. The Bureau of Meteorology should be given extra resources to have more observation sites across the continent. Equipment for simple measurements such as temperature, wind speed and direction and rainfall is relatively inexpensive. This equipment should be more widely deployed, data collected and transmitted; it can be powered by solar cells with battery back up. This will avoid the problems of interpolation that currently occur e.g. local weather, storm rains, and thus provide an even better service to agriculture. Agriculture depends so much on this information.

Another example where innovative technologies could be used is in the development of agriculture in North Queensland. One can easily envisage a mix of solar energy capture, hydro-electricity generation and irrigation in the one area. This would enable multiple use of the same water in cost effective ways.

Perhaps the greatest changes for agriculture will come from the ‘-omics’. This suite is genomics, proteomics and metabolomics. It is these three technologies that are likely to revolutionise plant and animal production. The time frame is genomics – already started and over the next 5-7 years; proteomics – the next 4 to 8 years; metabolomics – the next 4-15 years.

Genomics for plants or animals is already making its mark particularly for plant breeding or animal selection. The net outcome is for better adapted plants or animals, more productive plants and animals, better pest and disease resistance and lower environmental impact. Furthermore, gene transfer techniques to produce ‘genetically modified’ (GM) organisms have been available for a decade or so. Governments have produced regulations to deal with the classical gene transfer technologies. New techniques for gene transfer or expression are coming on-stream that are beyond the regulations.

Proteomics will allow more targeted information concerning genes and their expression. As enzymes are proteins and enzymes are necessary for nearly all synthetic and catabolic processes in cells, detailed expression of genes relating to specific enzymes (proteins) can be explored and utilized.

By far the most important of the ‘-omics’ for the future is metabolomics. This is a technique that will allow all the chemical compounds in a cell, blood, organism etc. to be identified. Most chemical species are synthesised in cells by enzymes but there are exceptions e.g. minerals in all organisms, vitamins in humans. As far as this submission is concerned, metabolomics will permit identification of genes related to each chemical species, regulation of gene activity, early diagnosis of abnormal concentration of chemical species, potential to rectify metabolic problems, understand how genotype and environment interact to name just a few. All these aspects will have profound influence of plant and animal performance in the future.

At the present time, the equipment needed for metabolomics is expensive and somewhat time consuming. No doubt costs will decrease and the time factor improved. It also requires ‘big data’ as do the other ‘-omics’ for optimum use of these techniques. Computing power and storage are available so this aspect of ‘big data’ is not a major issue; skilled personnel to process and most importantly use the information generated is a limitation.

Another major innovation for the Australian and agricultural economy is 3-D printing, a technology that is still in its infancy yet doing amazing things already. One of the beauties of 3-D printing is that small numbers of a product can be produced and thus ideally suited to agriculture and Australia at large. The scope for products produced by this technology is limited only by one’s imagination. To make full use of this technology, Australia will require experts in material science, design and CAD, computer programming, engineering etc. If this expertise is not developed, Australia will just become the importing house.

As all these technologies become available or are deployed to farms, the consequences are likely to include: (i) much greater farm size

(ii) a shift in the balance of capital and labour on farm (iii) greater expertise will be required to manage on-farm activities; thus farmers will have to be better educated and that a greater proportion of expertise will be sourced from regional centres or cities (iv) a shift in the rural population to regional centres and (v) more remote control of the farm.

**Warnings**. It would be remiss not to mention at least a couple of warnings. To give one example, NIR technologies offer great potential for non-destructive determinations. As NIR sensors become less expensive, they are being promoted by the manufacturers as suitable for many rapid and non-destructive analyses e.g. a hand-held NIR sensor is said to be capable of detecting ripeness of fruit or quality of vegetables and foods. These portable instruments are suitable for many analyses but must be calibrated for quality trait for every type of sample. Users who do not understand the limits of the instrument will obtain poor results and ultimately the technology could easily fall into disrepute. Support to ensure standard procedures are followed is critical.

Metabolomics can be used as non-destructive technique. For example, very high resolution nuclear magnetic resonance (NMR) machines are very expensive. Operators must be well trained and people who interpret the data highly educated. Thus it is less likely that this technology can fall into disrepute.

The technological advances mentioned in this submission as well as other technologies are dependent on having the correct expertise to interpret the information gathered. This can not be emphasised too much. The committee should consider how expertise can be trained, monitored and kept in the industry.

‘Big data’ is generated in most of the future new technologies from GPS data collected in field, to remote sensing from satellites to all the ‘-omics’ etc. The committee is urged to consider *inter alia* ‘who owns the data’, ‘to whom are the data available freely’, ‘what protections are on the data’ and ‘for what purposes can the data be used’.

Yours sincerely,

Dr Lindsay C. Campbell