Thoughts on capturing opportunities and overcoming obstacles for Australian agriculture related to electronic agriculture

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Abstract

'Electronic Agriculture', a misnomer but nonetheless taken by many to mean 'gadgets and gismos' in agriculture, can make a huge, positive difference to not only the business, but lifestyle of farming, and the rural communities that farmers support. Following a survey of what electronic agriculture could mean, this paper discusses the important role of communications and education in reaping the benefits, while overcoming the obstacles, of electronic agriculture.

Key Words

Precision agriculture, national broadband network, data, digital, communication, education and training

The Farming Landscape

We all know the challenges of farming in Australia. These include the relentless growth of the world's population estimated at 1.17% p.a. (~2.2/sec) (World Population Prospects, 2005) and the conflicting demands of producing food, fibre and fuel that must be met 'sustainably' in relation to limited available water, nutrients and arable land (Hacker et al., 2007; Cowie et al., 2007; Baker 2007), increasing farm-gate cost of inputs like fertiliser (Baker 2007; Fertiliser Industry Federation of Australia Media Release 2008) and a reduction in the available workforce (Productivity Commission 2005; Agrifood Skills Australia 2011a). Also the agriculture sector must meet these needs in a way that offers maximum opportunities for carbon sequestration (Senate Standing Committee on Rural and Regional Affairs and Transport, 2008) while maintaining critical levels of biodiversity and other non-market landscape products (Cowie et al., 2007; Victoria Departments of Primary Industries and Sustainability and Environment 2006). Finally, all of this must be effected in an operating environment marked by deteriorating terms of trade, which to date have only been offset by raising productivity (Productivity Commission 2005). Sustained growth in agricultural productivity remains a key component to improving Australia's ability to compete on world markets (Andrews et al., 2003).

Facilitating innovation through improving the incentives and capability of industry to develop and adopt new knowledge and technology can accelerate productivity growth while improving sustainability (Carberry et al., 2010). Managerial skills also play a key role in productivity growth, particularly decisions regarding organisational structure, resource allocation, production scale and scope, marketing and other work arrangements. Of particular relevance is a manager's

ability to optimise these arrangements to take advantage of changes in the external environment or the availability of new technologies or information.

Electronic Agriculture and ‘SMART Farming’

A ‘mature age’ distance education student, who is also a farmer, recently lamented ‘…future farmers need to be more like technicians rather than farmers’. It is an interesting observation, but can we really say that there is a distinction? Hasn’t part of the ‘sell’ of technology been around allowing farmers to focus on what they love best; namely farming? Farming is becoming more and more electronic (and digital), and if we think the sector is being overwhelmed with the stuff, then I submit to you that it has been sneaking up on us for at least twenty years. It started with tractors with their ‘digital dashboards’ and early global positioning systems (GPS) used (predominantly by consultants) to provide more accurate paddock areas and map farm boundaries, then followed by yield monitors in harvesters. Now we have auto-steer tractors, prescription maps for on-the-go application of fertilisers and gypsum in paddocks, in-situ sensors like those used for measuring and monitoring soil moisture, gate alarms, trough water alarms, smart phones for collecting photographic records and uploading (to the web) data and information ‘on the fly’, the ubiquitous office computer with its array of hardware add-ons for connecting to that last gadget you purchased, NLIS ear-tag readers, and (now, while we are at it) walk-over weighing, auto-drafting technology and even animal-based tracking linked to NLIS records (Figure 1). The list goes on.

(a) (b)

Figure 1: (a) Electronic agriculture in action: (background) a mob of sheep, some of which are wearing tracking ear tags; (mid-ground) a telemetry soil moisture probe sending soil moisture, temperature and electrical conductivity data back to the farmhouse every 15 minutes; (foreground) a soil electrical conductivity sensor typically towed behind an ATV with a global positioning system (GPS) and a hand-held plant canopy sensor. (b) GPS-equipped smart phones are becoming a popular means of recording and uploading farm information; here being used to record and map gully-erosion.

Farming has always been about gathering intelligence, interpretation and acting on that intelligence. Today, data gathering can be done faster and often remotely. The product of intelligence gathering is data, and huge amounts of it. The reduction of data into actionable

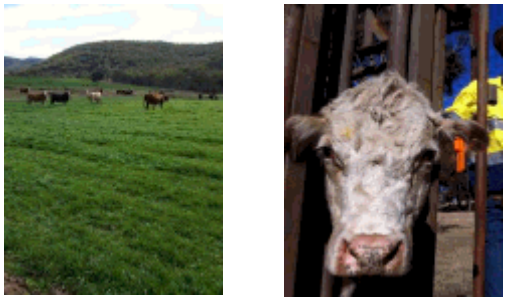
information is challenging and requires computers and fast algorithms. It is therefore not surprising that traditional (sorry, but it is) hands-on intelligence-gathering activities around pasture, crop and livestock monitoring are increasingly being handed over to commercial ‘intelligence gatherers’ and their proximal and remote sensing tools (Figure 2). And much of this ‘live’ data is ‘spatially-enabled’ (Figure 3) and this means precision agriculture comes into play. Precision Agriculture (PA) is defined as an integrated, spatially-enabled farming system designed to increase long term, site-specific (within-field) and whole farm production efficiency, productivity and profitability while minimizing unintended impacts on the environment (McBratney et al., 2005). On the back of almost 20 years of access to low-cost GPS, followed by the introduction of on- (and in-) ground sensors capable of measuring crop and soil attributes, there is a considerable volume of compelling economic evidence to spur-on widespread adoption of PA in many forms (for example Brennan et al., 2007). It is not hard to find local, ‘good-news’ stories. For example, on-farm water use efficiency (WUE) in broad-acre irrigated crops in the northern inland region of NSW (NINSW) is estimated to be between 1 and 2 tonnes (or bales)/ML across most commodities and centre pivots or lateral move irrigation systems provide labour savings of 80-90%, a 10-20% savings in fertiliser and reduce water application (ML/ha) by up to 30% (Goyne and McIntyre, 2001; Raine and Foley, 2008). Yet NINSW growers themselves estimate the potential for increased crop yields and irrigated water use efficiencies when matching application rates to actual crop requirements can be as high as 100% with significant improvements in fertiliser use efficiency (FUE) and a reduction in greenhouse gas (NO) emissions (Andrew Parkes, “Keytah”, Moree NSW, 2009). Current methods of matching water application to crop demands rely on a small number (1-2) static-point, soil-moisture probes in a paddock which are possibly inaccurate owing to the chance that they do not represent the majority of the field and the fact that they only indirectly measure plant water demand.

(a)

(b)


(c)


(d)


(e)

From this… **…to this.**

Figure 2: Increasingly, intelligence gathering operations occur remotely and the storage and manipulation of the data is being handled off-farm. Examples of data generating technologies include (a) soil surveying, (b) crop yield measurement, (c) pasture condition assessment, (d) telemetry-based soil moisture monitoring, and (e) livestock tracking.

Spatially-enabled water management can offer further improvements in WUE in irrigated fields, but biomass-based sensing, mapping and application technologies, when taken together offers the means to tackle the problem in reverse. Matching crop water demand to available water within both irrigated and rain-fed fields, via differential fertiliser management, offers increases in FUE up to 30% and input savings of up to $90/Ha based on current prices (James Hassall, “Kiewa” Gilgandra, NSW, 2009).

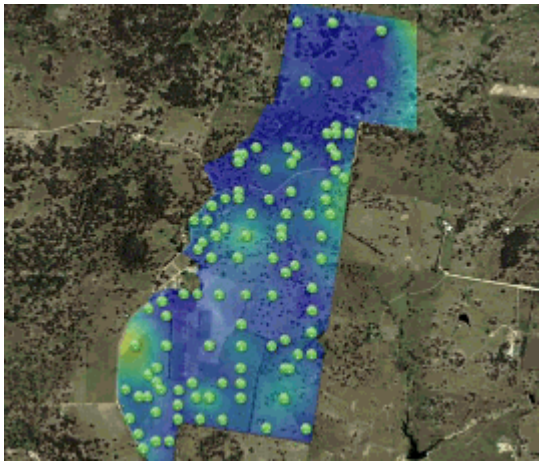


Figure 3: Sensor networks will create large spatio-temporal datasets. This figure depicts is a 'live' soil moisture map generated from 100 telemetry-based soil moisture probes distributed over 300 ha of the UNE SMART Farm (Kirby Farm, NSW; CSIRO/ACBI/UNE-PARG). The network footprint was designed using advanced geo-statistical techniques applied to plant and soil data generated by 'on-the-go' soil and plant survey technologies (EM38 soil survey, Figure 2(a); plant canopy sensors, Figure 2(b)). Live data can be viewed on http://www.sensornets.csiro.au/deployments/684.

Likewise, the productivity and profitability of many grazing enterprises in Australia can be greatly improved by increasing the quantity, quality and utilisation of pasture grown (Meat and Livestock Australia, 2009). NINSW-based Sundown Pastoral Company estimate their average utilisation at ~50% and every 10% increase equates to $64 per Ha with a gross return of $1.9 Million p.a. (Matthew Monk, "Newstead", Inverell, NSW, 2009). Managing enteric fermentation, to reduce methane production, dominates the public's perception of how the Australian cattle industries can respond to climate change. Whatever the industry response, it will be intimately connected to issues of land management, particularly the management of stocking rates in light of quality, quantity and stability of plant species within the grazing system and potential land degradation from soil and water erosion due to overgrazing. New, spatial, cattle tracking technologies are spawning spatially-enabled measurement and interpretation protocols and knowledge/data access systems for managing biomass in pasture landscapes and for matching biomass resources to stocking rates (Trotter et al., 2010); surely a key component of profitability and sustainability.

In reality, much of the spatial data generated by PA is complicated and often ends up gathering virtual dust in the hands of the service providers (Figure 4). We already know the role of spatial data in business is too important to be left to specialists (Gonzales, 2004). We also know that in the case of PA, slow industry-wide adoption has resulted from a lack of functioning decision support tools and a mismatch between products and user expectations (Lamb et al., 2008). The cost of, and capacity to manage data and information is at the heart of the problem and some of this blame must reside with the reality of Australia's rural communication capabilities (for example, a lack of reliable, high-bandwidth infrastructure). We simply must connect our farmers with the know-how to get the best out of the data being created. Who will do it and how will we enable it?

Figure 4: Spatial-based intelligence will require digital data storage and management. The future of the filing cabinet is bleak. However digital data and information management will need to be a collaborative exercise involving outside expertise and service providers.

Meeting the Challenges of Electronic Agriculture

Interestingly, the lack of reliable communications infrastructure across rural Australia has seen an enormous array of clever monitoring and tracking technologies developed by small to medium enterprises (SMEs), and large companies aimed at working around the exigencies of our rural communications networks. Here is where a national broadband communications network (NBN) comes in. Rather than being a competitor to these technologies, a (note, not 'the') NBN forms a vital link in the chain of converting data to actionable information and getting much of this off-farm intelligence back in the hands of the farmer, while at the same time avoiding the need to overload farmers with the technicalities of electronic agriculture. Ultimately mobile or wireless radio-transferred data must eventually be converted into interpretable information and actionable prompts; all of these require data rendering and collaborative interrogation by third party service providers and the end users – "the farmer". Ultimately any smart farm requires the capacity to export and import high volumes of source data and information generated through remote, collaborative interaction with experts outside the farm gate.

There is a huge degree of complimentarily between non-NBN technologies and NBN-enabled processes. Ironically, adoption of NBN in rural Australia remains a sticking point in the NBN roll-out strategy; connecting small business located in rural centres being the focal point of current thinking. NBN offers pathways to adoption of innovative technologies and processes in a sector that has a track record of cautious adoption of innovation (Lamb et al., 2008). It goes beyond the bounds of PA too. Sector-wide productivity is also affected by operational aspects such as safety. Supporting technology aimed at targeting and reducing the most common causes of farm-related death; namely tractors, quad bikes, drownings, utilities and 2-wheel motorcycles would return considerable savings to the sector. The top five causes, which account for half of farm deaths, include an estimated $21 million p.a. (Tractor fatalities), $18 million p.a. (Quad bikes) and $16 million p.a. (motor bikes) (Pollock, 2010). High-speed asset tracking and attitude (tilt, roll) sensing technologies (example tilt-roll alarms for quad bikes), NBN-enabled sentinel vision systems and immersive video conferencing capabilities, all targeting safety in hazardous locations (yards, chemical and machinery sheds, farm dams, paddocks) or supporting in-situ diagnoses and trouble-shooting (for example, machinery and a remote mechanic, sick animals

and a remote veterinarian; Figure 5) will ensure farms are safer and more efficient places to work.

Population is expected to fall in 23 regions around Australia, mainly rural areas isolated from the major cities. Yet housing demand is expected to fall in only six of these 23 regions (Beer et al., 2011). Broadband connectivity between these households, and between households and regional and urban centres, is key to ensuing the sustenance and ultimate growth of these populations. The farm is the backbone ‘small business’ of most regional communities. Without healthy, viable farms and their farming families, there is no healthy, viable local community. Electronics farms and their associated support technologies provide the platform for supporting growth, especially around management and co-ordination issues which can significantly diversify a region's industry base in a responsive and timely manner. Specific areas can include natural resource management and optimal crop and stock management in response to market pressures. Through high speed connectivity between the farm and external centres, supporting industries are no longer required to be located in major centres. Electronic, ‘connected’ farms and their use of developed and developing technologies will enable timely responses to external factors that may have a serious impact on production and sustainability. For example, the timeliness and efficiency of livestock management, specifically disease control could be improved. Many communities located within regional Australia identify the ‘urgent need’ to access new technologies, particularly broadband as part of their strategy of establishing both centralized and decentralized industries, including farm-based services (for example, agronomic, social and educational support) in regional communities.

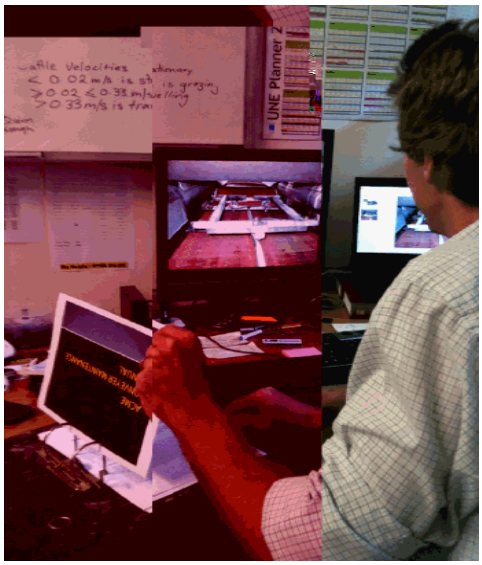


Figure 5: High quality, synchronous and immersive video links enable on-site trouble shooting without the downtime or cost associated with ‘traditional methods’ of seeking help.

Electronic agriculture has the potential to create ‘virtual service’ employment opportunities in crop and pasture agronomy, pest, disease and weed management, and livestock health, and machinery support where regionally based consultants can provide synchronous identification, analysis and management regimes. Broadband connectivity between rural communities and major cities (Australia and overseas) will ensure these farm service providers have access to the

same computing, data and technology resources as city counterparts, but with the advantages of attracting and retaining skilled ‘rural people’, with their ‘rural skills, empathies and attitudes’, in their chosen ‘rural lifestyle’.

Electronic agriculture comprises not only the hardware and software, but also technical and decision support services. The farmers’ perception of how much electronic agriculture is worth to the farm will dictate the quality of product/service on offer (Figure 6). Without valuing electronic agriculture, we are unable to create a viable market around supporting it. And, without a viable market, how do we develop a high-quality service and support culture, and with that, how do we facilitate uptake?

User expectations are largely based on considerations of sustainability, accessibility, useability and of course profitability; they will require a product or service that actually works for them. If it is valuable to them, they believe in it, and they will invest time and resources in gaining the best out of it. Ultimately it will work. The providers will consider viability (survivability) and demand (encapsulated by the 9 ‘P’s of PA described in Lamb et al., 2008), and this will influence decisions around the quality of service; including how much training to offer, infrastructure to put in place and follow-up service to offer. In Lamb et al., (2008), it was asserted that developers rather than users have stifled the adoption of, in this particular case, PA technologies. However the perceived value of the product/service plays an important role. The nature of the dependency cycle also influences the behaviour of stakeholders considered out of the loop, although they can influence the nature of the loop itself. These include those charged with ‘up-skilling’ the sector and with providing key infrastructure (for example, communications) to the sector.

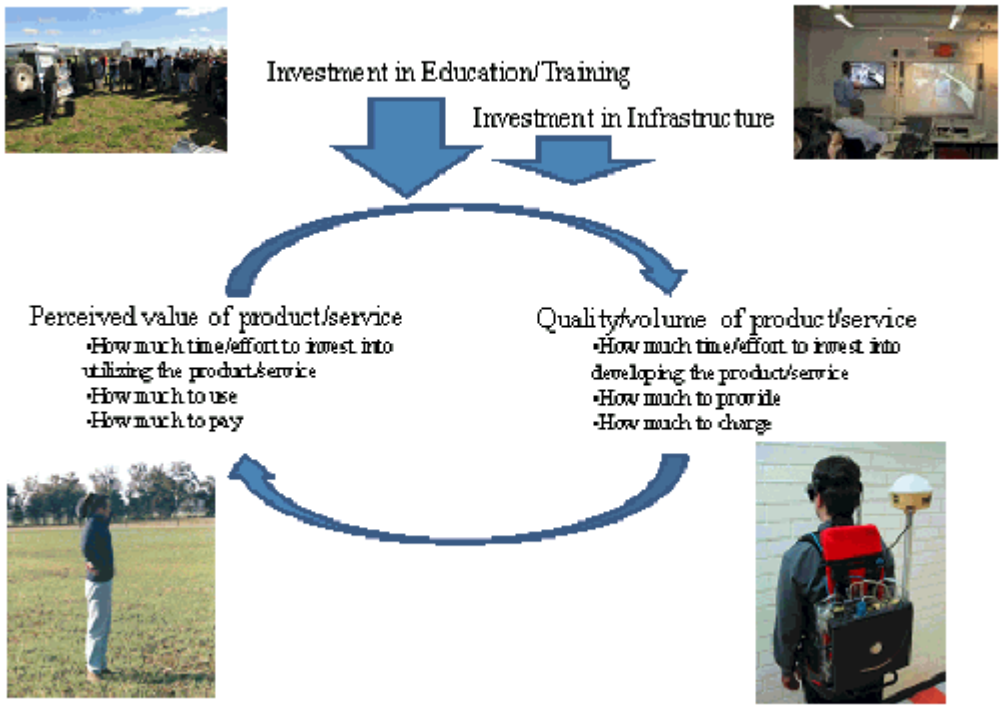


Figure 6: The 'dependency circle' of electronic agriculture. Market demand is inextricably linked to the quality of product/service on offer, and this in turn influences market demand, along with the level of outside investment in education and infrastructure, all of which feed into the cycle.

The Challenge of Meeting the Challenge

A national broadband communications capability; one that offers high quality connectivity so that farmers and skilled service providers can interact with the technology as well as 'live' intelligence, will have a positive impact on the dependency cycle ('Investment in Infrastructure' in Figure 6). It offers the means of giving farmers, and allied support services, the best out of electronic agriculture.

There is also another consideration which related to 'Education/Training' as depicted in Figure 6. Australia's agri-food industry, and in particular farming, has an ageing workforce. By 2018 more than half the agri-food workforce will be over the age of 55, and more than a third over 65 (AgriFood Skills Australia 2011b). The sector faces a critical skills shortage in rural and regional Australia, something that can only be overcome by supporting training and educational skills development and motivating industry engagement at all levels of society. "*There is potential risk that between 2013 and 2018, Australia's regional workforce will become depleted beyond critical mass*." (AgriFoods Skills Australia, 2011b). The labour challenge is probably one of the major factors set to influence the sector's ability to capture opportunities and overcome obstacles in relation to 'electronic agriculture'. If we consider that 'farmers of the future' will play a key role in the way we do our farming, be it with or without 'electronic agriculture' then we also have a second challenge, this time at what can be considered the labour 'supply' end of the chain.

"a recently released report by Universities Australia, commissioned by Australia's Chief Scientist Professor Ian Chubb highlights Australian student's growing lack of appreciation of the relevance and role of science in their lives and communities, and of its potential for rewarding career opportunities" (Universities Australia, Media Release, January 2012).

I read 'relevance of science' to mean, at least in the context of agriculture, disciplines most likely to provide the skills base to support 'electronic agriculture'. As far as our agriculture-minded students are concerned, just making them 'tech savvy' can go a long way to creating an end-user base that values 'electronic agriculture'; enough to want to pay for it. This, in turn creates the job opportunities for our technology-oriented students, hence increasing demand on training, and ultimately the trainers a viable market in which to work. It is the 'majority', rather than 'innovators' or even 'early adopters' that really need to be engaged. Bear in mind that there is likely a 'larger' shortage of unskilled labour on farms than the shortage (nonetheless) of skilled labour. So while on one hand we need to effectively engage the farmers of the present to up-skill them to handle electronic agriculture, we need to look closely at how, and who, we train to be the farmers of the future.

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