CHALLENGES AND OPPORTUNITIES FOR PRECISION DAIRY FARMING IN NEW ZEALAND

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ABSTRACT

A study was commissioned by 'DairyNZ', a dairy industry good organization in New Zealand, to identify some of the key challenges and opportunities in the precision dairy space. In New Zealand there has been an increasing research focus on the use of information and communication technologies (ICT) for precision dairy systems in recent years, and this study focused on issues for farmers and the performance of technology on-farm. A range of dairy farmers, researchers and service providers were interviewed using a semi-structured interview method. Interviews were recorded and subsequently transcribed for qualitative analysis. An open coding process was used to identify main themes across the case studies.

The information gathered from the precision dairying community provided insights which were used to identify areas of future research and development. While the technology has significant potential benefits for an industry with larger farms, scarce labor and increasing management complexity, there are a number of issues around technology and management adaption, the level of ICT skills and engagement. There was also uncertainty around how to unlock the benefits as well as problems associated with staff-technology interactions and limited backup and service level from the service sector. The analysis identified eight key questions concerning farmer expectations and experiences with precision dairy technology, along with the role of service providers, and factors involved in successful and unsuccessful adoption. These questions were used to propose a research agenda based around five themes aimed at driving a coordinated precision dairy research program. These themes were:

- Where does precision dairy technology fit in New Zealand Dairy Systems?
- Are the NZ dairy farmers ready to adopt new technologies?
- How do we build trust and confidence in new technologies while managing expectations?
- Can we clearly identify service sector roles around precision dairying?

- Where does industry engagement meet private delivery in precision dairy farming?

The paper describes the processes used in the case study work as well as farmer feedback and experiences.

Keywords: Precision dairy farming; New Zealand; Research priorities; Farm management

INTRODUCTION

Precision dairy technologies appear to offer benefits for New Zealand dairy farmers as they adapt to increasing farm and herd sizes, and as farming systems intensify (Yule et al. 2008). A 2008 survey commissioned by 'DairyNZ', the NZ dairy industry research, development and extension organization, found almost 20 percent of surveyed dairy farmers were using automation such as auto teat spraying and auto cup removal (LIC, 2008). However, other forms of precision dairy (PD) technology was less prevalent with electronic identification used by 5 percent of survey participants, and 2 percent using electronic milk meters. PD technology use was shown to be higher in rotary dairy parlors, when compared to herringbone parlors.

The definition of a precision dairy farmer is open to debate, however a potential definition involves 'the use of information and communication technologies for improved control of fine-scale animal and physical resource variability to optimize economic, social, and environmental dairy farm performance' (Eastwood et al. 2012). In practice PD relates to use of tools to gather information for farm management decision making, such as electronic animal identification, sensors for milk quality/quantity and animal performance, and smart pasture measurement devices. The challenge that PD poses for farmers is the interpretation and use of collected data, and the process of building capability in farmers, staff, and their off-farm support networks (Eastwood and Kenny, 2009).

The dairy industry lacked in-depth information regarding the use of PD on farms, and the opportunities for increasing the usefulness of PD in the context of NZ dairy systems. This paper outlines a study that was conducted with the following objectives:

- Examine the impact of precision dairy farming on farm performance, farm management practice, and farming system profiles;
- Examine the adaptive management challenges precision dairy farmers have, and are, facing;
- Develop an understanding of the role of actors in the innovation network around precision dairy farmers;
- Propose a research agenda for the precision dairy farming space.

The study was specifically focused on the farm management opportunities for PD, rather than on development of new technologies. A qualitative research approach was used, as outlined below. This paper provides a summary of the research and interim findings.

MATERIAL AND METHODS

The study was conducted using farm and dairy industry case studies and a qualitative research methodology. The case studies examined the current practices of PD farmers, and issues faced by farmers and other sectors of the industry. Semi-structured interviews, lasting 1 to 1.5 hours, were used to facilitate the exploration of relevant issues within each case study. Interviews were recorded and transcribed, with transcripts analyzed using qualitative software (NVivo™) and open coding methodology to build emergent themes (Strauss and Corbin, 1998). Data from each case study were combined to develop the main themes.

Table 1. Participant and farm characteristics of case study farms

Farm characteristics				**Animal measurements**							**Pasture and natural resource measurement**		
Farm	Farmer age	Owner-ship	Peak milk herd	EID	Milk meters	Conductivity	Auto-draft	Ind. feed	Activity	Weigh scales	Pasture meter	GPS map	Soil moisture monitoring
1	n/a	Corporate	600	Yes	Yes	Yes	Yes	-	-	Yes	Yes	Yes	-
2	n/a	Corporate	-	Yes	Yes	Yes	Yes	-	-	Yes	No	Yes	-
3	n/a	Research	600	Yes	Yes	-	Yes	-	Yes	Yes	-	-	Yes
4	40s	Family	1800	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	30s	P-Ship	1200	Yes	Yes	-	Yes	Yes	-	-	Yes	Yes	Yes
6	40s	Family	850	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-
7	30s	Sharemilk	-	-	-	-	-	-	-	-	Yes	-	-
8	50s	Sharemilk	560	-	-	-	-	-	-	-	Yes	Yes	-
9	30s	P-Ship	225	Yes	Yes	-	Yes	Yes	-	Yes	Yes	Yes	-
10	30s	P-Ship	820	Yes	-	-	Yes	-	-	-	Yes	Yes	-
11	30s	Sharemilk	360	-	-	-	-	-	-	Yes	Yes	-	-
12	n/a	Research	650	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	-	-

Participants were selected via networks of industry contacts, and through use of a snowball selection method (Bryman, 2001). They were selected to cover a range of farming systems (farm size, farm system type, irrigated and non-irrigated), a range of technologies, and a range of experience with the technologies.

During the middle of 2011 15 interviews were undertaken with commercial farmers (10), research farms (2), and precision dairy service providers (3) with more informal discussions also held with a range of technology providers at a national agricultural fielddays. Brief details of the ownership, herd size as well as the technologies used on the individual farm businesses are identified in Table 1. The technologies were categorized as being related to measurement of the cow and her performance, or related to pasture management and soil moisture monitoring.

RESULTS AND DISCUSSION

The interviews uncovered a range of challenges and opportunities for precision dairying in NZ. These are distilled as five main themes. Quotes from participants are used to highlight specific perspectives.

Integrating technologies into specific farming systems

Farmers faced challenges when integrating the PD technologies into their farm system. One issue was that many of the devices are of international origin and therefore designed for European or North American farming systems. Both the international products, and those designed within NZ, exhibited difficulties when trying to link with other devices, and in data exchange. The lack of integration led to some farmers running overlapping systems, with a degree of duplication. The ability for products to integrate proved to be a determining factor for some farmers in their investment decision making, for example one case study farmer commented:

'The thing I liked about [Technology system 1] was they had that whole package that you could bulk together, it was all integrated properly.'

Adaptation occurred on the case study farms in two ways, firstly farmers acted to adapt the technology to suit their needs, and they also adapted their management to incorporate the technology. Examples of the former were adjusting the placement of EID readers to maximize accuracy, alteration of the auto-drafting set-up, and making changes to a pasture reader to make it more robust. In terms of management adaptation, a farmer said:

'People who haven't been on an automated farm really struggle to get their heads around not just the fact that it's the gadgets that's automated, but it's the - we've linked that with our management, trying to have efficient management, planning, organizing... If that doesn't go hand in hand with the machines you've got in the shed then you're really - what you're gaining on one hand you're losing on another.'

Emergent precision dairy learning networks

Learning to use the new technologies is a vital part of the implementation process and building learning networks is a potential method to promote learning. Technology suppliers provided most of the training available to case study farmers, using a variety of approaches including one-on-one support, occasional user groups, phone support, and remote computer access. The challenge for these training activities was in empowering farmers to proactively learn and think about how to use their new systems. User groups seemed the most popular method of learning, but according to the companies these groups had variable levels of attendance. Possible reasons for this may be related to lack of perception among farmers that the groups lead to positive outcomes, or that the level of learning was pitched at early users instead of more advanced users. One farmer commented:

'The best thing about those is just finding out what other people are doing. So we learn from each other. I think they're all in the same boat in terms of actually what information is in there, but some people are obviously more computer literate and dived into a bit further and found some bits and pieces that are useful.'

There was little interaction between farm service providers, such as consultants and veterinarians, and PD systems. There is significant potential for service providers such as Vets, nutritionists, and agronomists to enhance their service offering by not only using the data collected through PD but to also help their clients get more from the systems. These service providers can add knowledge and context to data being produced through milk meters, activity sensors, or pasture meters.

Primary benefits currently occur through labor saving and task automation

The benefits that farmers identified from PD were centered on labor and skills support, and management enhancement. Larger herds and increasingly complex farming systems demand more labor and skills in managing large enterprises. PD technologies such as ACRs, auto-drafting, and calf feeders had major time saving benefits. Also heat detection in some cases saved having a dedicated labor unit looking for estrus cows. EID and the associated databases also acted as an initial risk management, especially important where many different staff are used at milking time or where staff do not have the skills to recognize certain animal production and health issues. Added to this was an ability through the technology, to see mistakes more clearly, when in the past these mistakes may have gone unnoticed.

This is perhaps different to more academic or industry good approaches that see the major benefit in increased productivity, which in turn is often in response to farmers early questioning of economic viability. Although farmers had demands on equipment they often had only vague ideas of their current performance in terms of the successful completion of tasks such as estrus detection or grazing management.

Management enhancement was derived through use of the data in decision making. Identified benefits included 'preventing surprises' by having regular and reliable data on parts of the farm production system, for example weekly measurement of pasture data enabled farmers to know where they were in terms of pasture growth. Technology such as weighing was being used to achieve an earlier response to adverse events – such as the impact of cold weather on cow condition. Farmers also learnt via the data provided to reprogram their own mental models to respond faster to similar situations in the future. The data showed them more about the actual impact of events or wrong decisions. One farmer said 'after the technology went in it was frightening to see the mistakes that were being made before'. A comment by a farmer was:

'I think that's the power of having data is that you know your system a lot better and then so you can say, okay well this is what we're currently doing and

this is what we're planning for next year. How do you fit into that? Are you going to give me more production? Are you going to save me money?'

Trust in technology

Trust and technology was a major issue amongst case study farmers as the level of trust farmers perceived had implications for their satisfaction with the technologies and extent of implementation on farm. Trust involved two aspects: whether the technology would do the job it was supposed to when it was needed, performing reliably every day even in adverse conditions, and whether the data collected was trustworthy. The building of trust appeared to be subtle and complex, depending in part on user attitudes toward technology and awareness of the expected performance of the technology. Performance expectations were often built during the sales process. Experiencing errors soon after installation without sufficient explanation also dented the confidence of some farmers in the study. A case study farmer said:

'So learning the limitations and whilst we trust it there's a couple of things that sometimes don't make bits of the technology work optimally. That's where I see a role for me or someone to come and help me. While we trust all this technology, for example the heat detection, I trust it but it's not always right and it's not always wrong either. Sometimes it's just feeding you information and some of it I'll discount based on other information it's fed me.'

The implications of lack of trust meant that systems were underutilized or full efficiencies could not be achieved due to a perceived need for back-up systems. The higher the risk associated with a wrong decision, the more likely it was that back-up systems were used – for example using tail paint and noting cows on a whiteboard where cows were treated with penicillin.

Link between precision dairy technology and farm workforce issues

As mentioned many benefits from PD came from labor and skill related areas. There was a strong link between PD and issues related to the dairy farm workforce. While some farmers saw precision tools as a means of covering a lack of staff skills, other saw it as a double-edged sword as the technology might actually lead to a 'de-skilling' of farm staff. To them, basic dairy farming skills were still important to help them interpret the information being fed to them by the system, especially as some of these people will be the dairy managers or owners of the future.

New skills were also required around interaction with ICT, entering data and having some knowledge of how to operate the software systems. Not all staff had the skills or the motivation to develop the skills. Some of the farmers specifically tried to build skills around their ICT systems, for example getting all staff to use the pasture meter, making sure the herd manager was competent with in-shed technology, and actually providing some training to staff at the start of a new lactation.

Issues for industry-good engagement with precision dairy systems

From the themes above some broader discussion points emerged based around the challenge of aligning PD within the farm management context, and the potential entry points for industry-good engagement in the PD space.

Table 2. Precision dairy in the context of the planning, implementation, and control cycle (Gray, 2001)

Processes	**Sub-processes**	**Role of precision dairy technologies and information**
Planning	- Goals for the planning period - Predictive schedule of events - Targets - Contingency plans - Decision rules	- Historical information - Information on current status and trends - Potentially predictive information/ modelling on future trends
Implementation		- Use of automation and control devices to carry out plans
Control	- Monitoring performance indicators and external environment - Data storage and processing - Decision point recognition - Control response selection - Evaluation and learning	- Real-time monitoring of animal and plant resources - Automated setting of alerts for when decision points are reached - Automated decision rules to guide actions when decision points reached - Use of data to evaluate success/failure of processes

Precision dairy represents an evolution, rather than revolution in managing dairy systems. The use of new technologies primarily provides greater information, and in more detail, for farmers making management decisions. The potential volume of new information heightens the need for farmers to have a solid farm planning process, for what is the point of collecting more data without a planning and decision-making structure to underpin its use? There is a range of farm management planning processes (Ohlmer et al. 1998) and a process described by Gray (2001) in the context of NZ dairy farming contains planning, implementation, and control phases. These phases, and the sub-processes within each phase, are highlighted in Table 2 Also shown in the table are examples of how PD was used in the case studies in relation to each farm management phase.

One of the case study farmers used a similar, but more defined approach based around steps of ‘plan, measure, manage, and review’. He applied this approach to most aspects of the business and could do so with different timelines, weekly, monthly, the lactation, the lifetime of the cow. Where he saw most benefit from PD was in rapid feedback on his planning and implementation processes as well as his management strategies.

The key is to have a defined management plan as a basis to farm decision making before investing in PD. This plan is vital for making the appropriate investment decisions and provides farmers the ability to ask 'how will this information allow me to make better decisions?'

The importance of good farm management planning practice in the successful use of PD technologies highlights a challenge when considering industry-good RD&E investment. Determining the most appropriate allocation of funding in this area can be viewed in terms of the different scales at which issues occur. Examples of these scales are highlighted in Figure 1 and involve the farm level; supply chain and service provider (near farm networks); whole of industry, and cross-sector or international scale. Industry-good organisations such as DairyNZ can have different potential impacts across these scales, as discussed below.

At the farm level industry RD&E can potentially engage with private technology companies around technology design, installation, integration, and training. It is at this scale that private companies have the strongest potential role in technology design and on-farm support, with industry RD&E organizations providing independent research, leadership around best practice, and generalized extension.

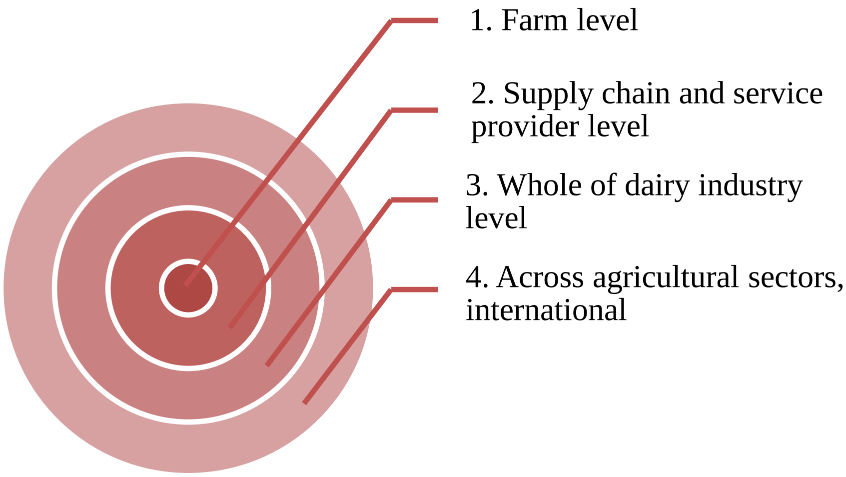

Figure 1. Differing scales of engagement for private and industry-good RD&E activities in the precision dairy space

At the supply chain and service provider level, in the networks that link with farmers, there is also significant opportunity for private organizations to build products and services focused on capturing the data from the farm level and value adding for the farmer and the industry. Industry organizations can play a role in facilitating standardization of data transfer and ensuring the rights of stakeholders are protected around issues such as privacy.

Across the dairy industry there is an opportunity for organizations to guide development of training programs aimed at building capability in the use of advanced dairy technologies, in addition to skills in interpreting the information derived. In NZ this could include more focus on training at University as well farmer training organizations. Opportunities also exist for whole of industry databases which leverage off, and value add, to the data collected on farm.

Precision technologies are increasingly being used across many agricultural sectors both in NZ and internationally. This provides the potential for learning across sectors, and collaboration around data analysis and integration. Cross-sector and international standardization of data transfer is also a priority at this largest scale. There is a strong role for industry-good involvement in these issues, as individual farmers, or even individual technology firms have insufficient leverage to enact change in this area.

From the findings of this study, five main questions were posed to form the basis of a future research agenda:

- Where does precision dairy technology fit in New Zealand dairy systems?
- Are the NZ dairy farmers ready to adopt new technologies?
- How do we build trust and confidence in new technologies while managing expectations?
- Can we clearly identify service sector roles around precision dairying?
- Where does industry engagement meet private delivery in precision dairy farming?

CONCLUSIONS

The qualitative method used in this study facilitated exploration of the challenges and opportunities faced by precision dairy farmers in New Zealand. Information gathered will be used to drive future research agendas related to the linkage of new dairy technologies with best practice on farms. We observed that the technology has significant potential benefits for an industry with bigger farms, scarce labor, and increasing management complexity. Two key observations can be made:-

First farmers must have confidence in a technology to use it. The issue of confidence becomes increasingly important as the dependency on technology increases. An increased level of automation also heightens dependency, if one component in the integrated system fails then the whole system may not work. This issue also has to be examined from the manufacturers and service provider’s perspective; in a price competitive market it would be easy to underestimate the cost of supporting such products. Once a farmer has a bad experience then there are likely to be much more hesitant about further technology adoption.

Second, the level of planning, management and review exhibited by the farm management team is crucial. If there is no planning there is no purpose to employing these new technologies. In this emergent phase for precision dairy farmers the benefits are being hobbled by issues around technology and management adaptation, ICT skills and engagement, uncertainty of how to unlock benefits, staff-technology interactions, and a paucity of capability in the service sector. This makes the design of information systems extremely important and management systems must use the data to provide useful information to “time poor” farmers or herd managers in a clear and efficient manner

Farmers and systems developers also face additional challenges into the future for development and use of new technologies which align with potentially diverse farmer needs in pasture and resource management. In addition likely new legislative and policy issues and additional market compliance demands need to be considered. Protection of the farmer's privacy and data ownership also need to be ensured.

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