

# THE IMPACT OF MACHINE TO MACHINE COMMUNICATION ON THE DAIRY INDUSTRY IN NEW ZEALAND

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## 1.0 EXECUTIVE SUMMARY

This paper and the associated research sought to answer the following research question:

***What is the impact of machine to machine (M2M) communication on the dairy industry in New Zealand, and what is the likely impact in the future?***

Information and communication technology (ICT) plays a significant role in the information flow across the dairy value chain. M2M communication is a critical component of this information flow. For the dairy industry to move from where it is today, to where the benefits that can be achieved from the adoption of ICT's are maximised will take significant advances in thinking.

There were three components to the research that was undertaken for this paper. These were; a thorough literature review to identify key concepts, a survey of 64 dairy farmers, and four interviews with providers of solutions that utilise M2M communications.

A key finding from the research was that, M2M communication is currently having a limited impact on the dairy industry in New Zealand. The potential impact is much greater than what is currently being experienced. Attempts should be made to accelerate the rate of adoption in order to increase the impact.

The information flow that M2M communication enables will help add value and ensure sustainability in the increasingly competitive, and volatile dairy industry. This paper recommends that an increase in the impact of the solutions that utilise M2M communication, can be achieved by:

- **Gaining a greater understanding of why and how technological change occurs.**
- **Increasing the level of understanding of the technologies behind the solutions.**
- **Prioritising the solutions that are going to give the greatest return on investment.**
- **Industry collaboration around the direction of M2M communication.**

M2M communication presents a great opportunity to be able to gain significant control of the dairy value chain. Today the technology is emerging and its impact is limited. This relative immaturity of M2M communication in the dairy industry, will eventually be overcome by time. It is the responsibility of all stakeholders in the dairy industry to play a role in maximising what is such a large opportunity, through the acceleration of its uptake.

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## 2.0 INTRODUCTION

Machine to machine (M2M) communication, and the internet of things are radically changing the world, and its uptake is occurring at an exponential rate. Advances in cellular network technology, and its uses are occurring at a rate that could never have been predicted. This paper looks to investigate:

***What is the impact of machine to machine (M2M) communication on the dairy industry in New Zealand, and what is the likely impact in the future?***

This research found that M2M communication is not a well understood terminology. Therefore it is important to introduce a definition early in this introduction. "M2M generally refers to ICT able to measure, deliver, digest, and react upon information in an autonomous fashion, i.e. with no or really minimal human interaction during deployment, configuration, operation, and maintenance phases." (Anton-Haro, and Dohler, 2014). This definition is restated in the literature review.

Machina Research (2015) estimates that there will be one billion devices utilising M2M communications through a cellular network, by 2020, at the current annual growth rate of 25%. This number could be closer to two billion, if certain upside growth scenarios occur, and a 40% annual growth rate can be achieved.

Similar research was conducted in 2012 by Machina Research. This research forecast that by 2015, globally, there would be 36 million devices in land based agriculture that utilise M2M communication, and that by 2020 there would be 88 million connected devices. In New Zealand, the same research estimated that there would be 360,000 connected devices in land based agriculture with by 2020.

According to these predictions the impact of M2M communications on the dairy industry in New Zealand should already be significant. Is this the case? The research suggests not.

Technology transfer in agriculture has been a well research subject. In 1962, Rogers first published his theory of diffusion of innovation. In this he argued that innovations were adopted at different rates, depending on social groups. His research was born out of having watched his father, an agricultural innovator, create innovations that were not taken up. It is this rate of adoption that will determine the impact that M2M communications can have on the dairy industry in New Zealand.

The dairy industry exists in a volatile time. Being able to critically analyse the current situation in order to become more sustainable will determine its future success. How ICT's and in particular M2M communication plays a role in this is an important questions. This research paper seeks to link the two worlds of technology, and dairy farming, to help each understand the critical role that each plays.

### 3.0 LITERATURE REVIEW

There was little research found looking specifically at the research question. The literature review was used to define M2M communications and expand on the concept of technological change. These key concepts were used to shape the survey of dairy farmers and case study interviews.

#### 3.1 DEFINING M2M COMMUNICATION

The central concept of M2M communication is the most critical to define. Several definitions have been sought of M2M. The first of which comes from Burkholder, Peter, Palisca, Grout, and Donald (2012) in their book, "M2M Communication – A Systems Approach."

"Perhaps the most basic way to describe M2M is shown in Figure 3.1. The role of M2M is to establish the conditions that allow a device to (bi-directionally) exchange information with a business application via a communication network, so that the device and/or application can act as the basis for this information exchange." (Burkholder et al, 2012)

"In many cases, M2M involves a group of similar devices interacting with a single application, as depicted in Figure 3.2. Fleet management is an example of such an application, where devices are, for example, trucks, and the communication network is a mobile network. In some cases, as shown in Figure 3.3, the devices in the group may not directly interact with the application owing to having only limited capacities. In this scenario, the relationship is mediated by another device (e.g., a gateway) that enables some form of consolidation of the communication. "Smart metering" is an example of such an application where the devices are smart meters and the communication network can be a mobile network or the public Internet." (Burkholder et al, 2012)

*Taken from M2M Communications – A Systems Approach (Burkholder et al, 2012).*

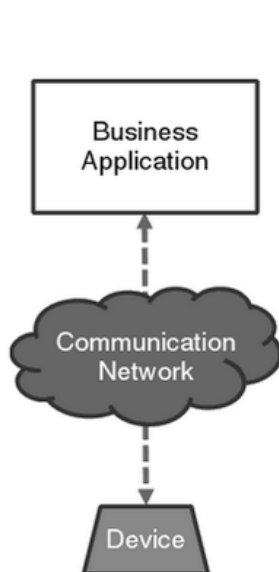


Figure 3.1

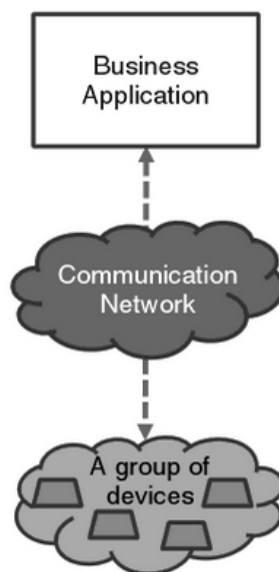


Figure 3.2

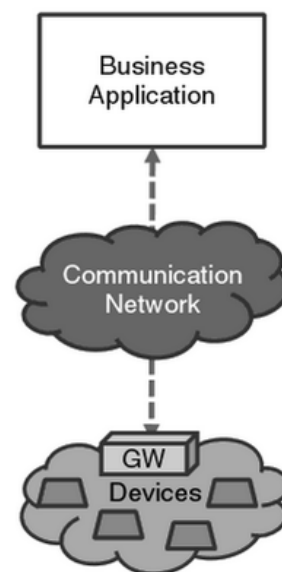


Figure 3.3

The second definition of M2M communication comes from Anton-Haro, and Dohler (2014) in their book, "Machine-to-machine (M2M) Communications: Architecture, Performance and Applications."

"M2M generally refers to information and communications technologies (ICT) able to measure, deliver, digest, and react upon information in an autonomous fashion, i.e., with no or really minimal human interaction during deployment, configuration, operation, and maintenance phases." (Anton-Haro and Dohler, 2014)

"While machines do not excel humans in writing poetry, they are definitely industry favourites when it comes to (i) repetitive jobs, like delivering water meter data once a day, and (ii) time-critical jobs with decisions taken within a few milliseconds based on the input of an enormous amount of data, like the real-time monitoring of rotating machinery parts." (Anton-Haro and Dohler, 2014).

Finally Anton-Haro and Dohler (2014) offer an important insight into the components of M2M communication. "Machine-to-machine (M2M) communication is essentially composed of three key ingredients: (i) a wireless end device, (ii) an infrastructure-based or infrastructure-less wireless carrier network, and (iii) the back end server network."

When defining M2M communication it is also important to define the internet of things, and the difference between the 2 concepts, although the terms are often used interchangeably.

Cox (2015) in an article published in the M2M Magazine defines the difference between M2M technology and the internet of things as, "M2M is almost synonymous with isolated systems of sensors and islands of telemetry data. In contrast, the internet of things is trying to marry disparate systems into an expansive system view to enable new applications."

In the 2015 edition of the annual publication the Vodafone M2M Barometer, the similarities, and differences, between the terms M2M, and the internet of things are highlighted:

"It's clear that there is significant overlap between M2M and the internet of things, and for many purposes it's possible to use the terms interchangeably without real confusion – nobody disputes that both terms are about connecting objects in the world to share data and communicate. But we see a qualitative difference between M2M and internet of things." (Vodafone M2M Barometer, 2015)

"M2M is primarily about remotely connecting an organisation's assets and machines; Internet of things is about all types of assets, machines and 'things' becoming connected together, to benefit a broader range of parties. As M2M evolves into internet of things, we see increasing:

- Connectivity: Organisations will use a wider range of network types to connect a wider range of “smart” assets and products. Highly customised solutions will be complemented by more standardised and off-the-shelf solutions that function at scale.
- Data gathering: More data will be gathered for analysis, and it will be shared beyond functional silos, and beyond the organisation’s four walls.
- Sharing: Projects will not just deliver value within departments, but span whole ecosystems of companies across multiple industries and multiple regions. Solutions will be delivered direct to consumers, not just corporates — for instance, wearables.” (Vodafone M2M Barometer, 2015).

### 3.2 M2M IN AGRICULTURE

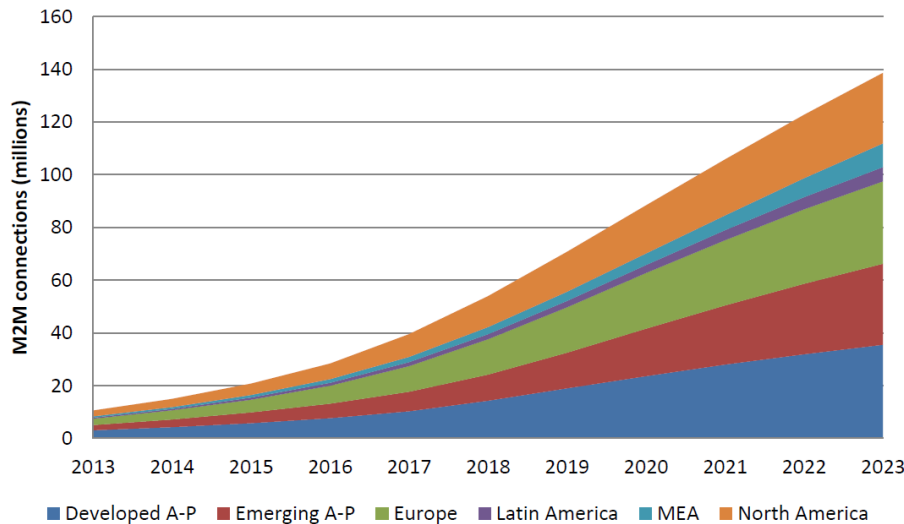
Throughout the literature review no previous research was found that was specific to the research question of the current and future impact of M2M on dairy farming in New Zealand. By broadening the search to research publications on the global use of M2M communication in agriculture, one piece of research was found, that will be referred to.

Berthelsen and Morrish (2013) completed a report for Machina research titled “M2M Communication in the Agriculture & Environment Sector 2012-22.” This report focussed on:

1. The drivers to adoption of M2M applications on crop and livestock farming on a global basis. These included:
  - Requirement for increased productivity which is linked to cost savings (fuel, electricity, water, and labour)
  - Requirement to monitor food chains to increase traceability and promote public health
  - Compliance to regulation to improve the monitoring and management of the environment
2. The barriers to adoption of M2M applications on crop and livestock farming on a global basis. These included:
  - Low wages in the developing world
  - Existence of few standardised M2M solutions owing to the fragmented nature of farming
3. The applications of M2M in agriculture citing examples of; crop and greenhouse monitoring solutions consist of a wide range of connected sensors, animal health and nutrition management applications, livestock tracking, and irrigation management. Irrigation management was seen as a key area where M2M can provide rapid returns. Fleet management was given as a key application not directly associated with agriculture.
4. The forecast for growth in the M2M market. The findings were that globally M2M connections in Land Agriculture will grow from 10.5 million to 139 million between 2013

and 2023. This is shown in Figure 3.5. This growth is mainly forecast in low power wide area (LPWA) networks and short range connections in farm networks.

Figure 3.4: Global M2M connections in Land Agriculture Application Group 2013-2023 (Source: Machina Research, 2014)



### 3.3 TECHNOLOGICAL CHANGE

To understand the impact that M2M communications is having now, and in the future, previous research on technological change was sought.

Hendy and Callaghan (2013) in their book, “Get off the Grass: Kick-starting New Zealand’s Innovation Economy,” state that, renowned, and often cited, economist Joseph Schumpeter, envisaged technological change in three steps: invention, innovation, and diffusion.

“The first step is the invention process, which involves the generation of new ideas or new knowledge. The second stage, which Schumpeter called innovation, occurs when new ideas or knowledge are converted into marketable products or improved processes. Schumpeter’s third step is diffusion, in which these products and processes spread to potential markets.” (Hendy and Callaghan, 2013)

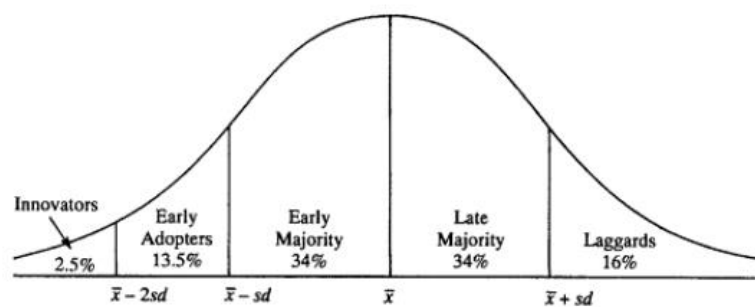
They argue that New Zealand should be looking to grow through increasing public expenditure on research and development. “Our government will need to increase its spending on research and development to stimulate private-sector innovation and to build diversity in our innovation ecosystem. Government must also assume a role as a connector and facilitator of knowledge transfer. It must find smart, scalable ways that allow innovators and ideas to find each other. It must reduce contestability at the researcher level, which can hinder collaboration, while increasing it at a strategic level to foster diversity and connectivity.” (Hendy and Callaghan, 2013).



They see that collaboration is the key to building growth into New Zealand’s economy. “This highlights perhaps one of biggest barriers to collaboration in New Zealand: the innovation system’s lack of openness and a consequent absence of self-awareness.” This statement is backed up by a simple anecdote of, “Building a ‘dating’ service for innovators and entrepreneurs is a key step in building the city of four million people.” (Hendy and Callaghan, 2013).

Rogers’ (1962) theory of diffusion of innovation offers a method of characterising how innovation is adopted. Rogers hypothesised that, the population fell into five major segments relative to their adoption of innovation. These being; innovators, early adopters, early majority, late majority and laggards. The distribution of these individuals is represented by Figure 3.5.

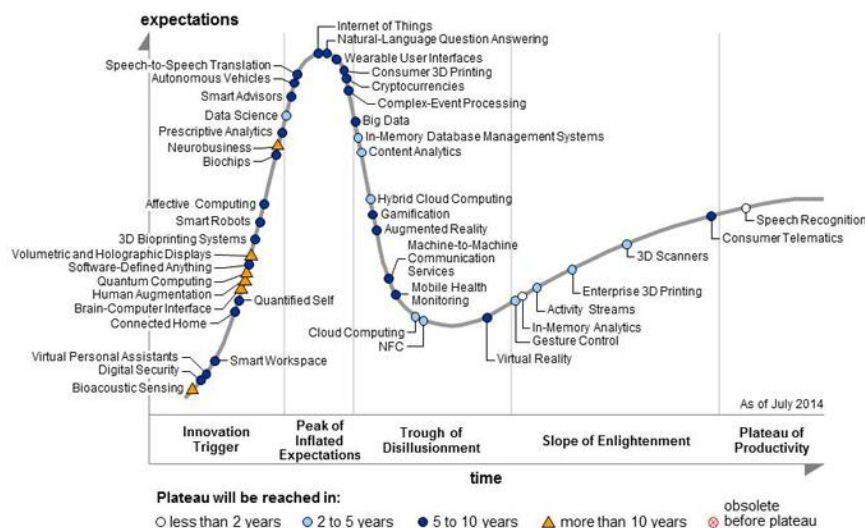
Figure 3.5: Adopter characterisation on the basis of innovativeness (Rogers, 1962)



On an annual basis, the research firm, Gartner, publish what is known as the Gartner Hype Cycle for Emerging Technologies. Gartner theorise that over time emerging technologies move through a cycle that is measured by expectations. This is a recognised measure of the maturity of an emerging technology.

There are 5 stages to this cycle. These are: innovation trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and the plateau of productivity. According to Gartner, M2M communication is currently in the stage known as the trough of disillusionment. This is illustrated in Figure 3.6.

Figure 3.6: Gartner Hype Cycle for Emerging Technologies 2014 (Gartner, 2014)



## 4.0 METHODOLOGY

Alongside the literature review there were two more components to the research conducted on the question “What is the current and future impact of M2M communication on dairy farming in New Zealand?”

### 4.1 SURVEY OF DAIRY FARMERS

A survey was conducted of dairy farmers in New Zealand asking them a series of questions around M2M communications, and technology uptake. The survey was created and responses were collected via the cloud software Survey Monkey. The following questions were asked:

1. How do you rate your understanding of the following terminology? Telemetry, machine to machine, internet of things, big data, cloud technology, precision agriculture.
2. What M2M technology do you currently use in your dairy farming operation?
3. What M2M technology will you look to adopt in the next 5 years in your dairy farming operation?
4. What has been the impact of the following technologies on your dairy farming business? Smartphone, tablet, broadband, machine to machine technology, internet of things, cloud technology.
5. How would you describe yourself when referring to your tendency to take up new technologies? Innovator, early adopter, early follower, late follower, laggard.
6. What are the barriers to you adopting M2M technologies?
7. What are the drivers to you adopting new M2M technologies?
8. Can you provide any further comment of M2M technology and the impact that it is providing on your dairy farming business?

The sample size was 64 which allowed for 4 quartiles of 16 respondents to be grouped together. Analysis was conducted to see if there were any differences between the quartiles and the responses that they gave to the questions.

### 4.2 SOLUTION PROVIDER INTERVIEWS

There are a large number of solution providers that utilise M2M communication in the dairy industry. Not all of these could be interviewed. Four solution providers were chosen to be interviewed because of the perceived impact of their solution. The following organisations were interviewed.

1. Waterforce Limited – water management solutions
2. Blackhawk Tracking – fleet management solutions
3. Regen Limited – nitrogen, water, and effluent management solutions
4. Livestock Improvement Corporation – dairy shed automation solutions

The intention was to gain an insight into the various impacts that their solutions are having on the dairy industry. The interviews investigated three areas. These were:

1. The commercially available solutions that the solution provider had in market, including the cost, the number of units, the function, and how it utilised M2M communication.
2. The impact of the solution, including any economic, environmental, or social impacts, and how the solution provider articulated these to the dairy market.
3. The uptake of the solution and what the barriers and drivers of uptake were, including any changes that the solution provider saw in the future that would affect uptake.

Three of the four interviews were conducted over the phone with the exception being the interview with Regen Limited which was conducted face to face.

## 5.0 ANALYSIS OF SURVEY RESPONSES

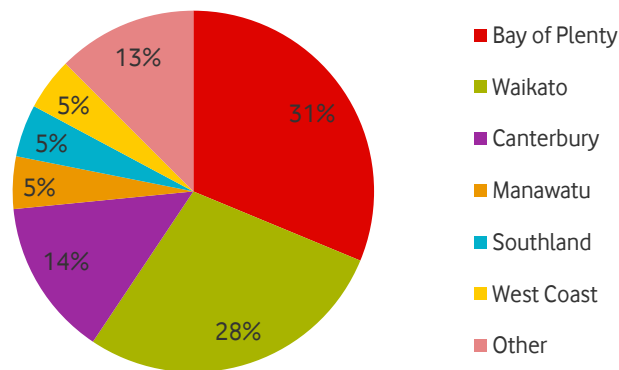
### 5.1 SNAPSHOT OF RESPONDENTS

64 dairy farmers responded to the survey. Several questions were asked about their dairy farming operation in order to ascertain whether there were any particular differences in the characteristics of their businesses.

#### 5.1.1 REGION

The majority of respondents were from Bay of Plenty, Waikato and Canterbury. With a spread across other dairying areas in New Zealand. Figure 5.1 shows the geographic spread of respondents.

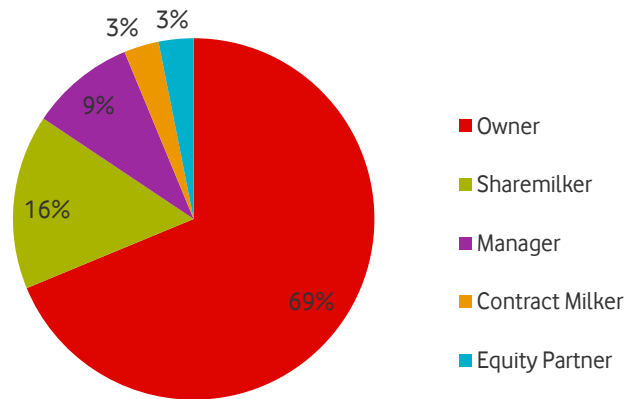
*Figure 5.1 Geographic spread of the respondents*



#### 5.1.2 POSITION

The majority of respondents considered themselves as farm owners. This is important as farm owners have direct responsibility for the decision to use technology or not. The other positions would have various levels of influence in the decision making process. Figure 5.2 shows that 69% of the respondents were farm owners.

Figure 5.2 Role of the respondent in the dairy operation



### 5.1.3 OPERATION SIZE

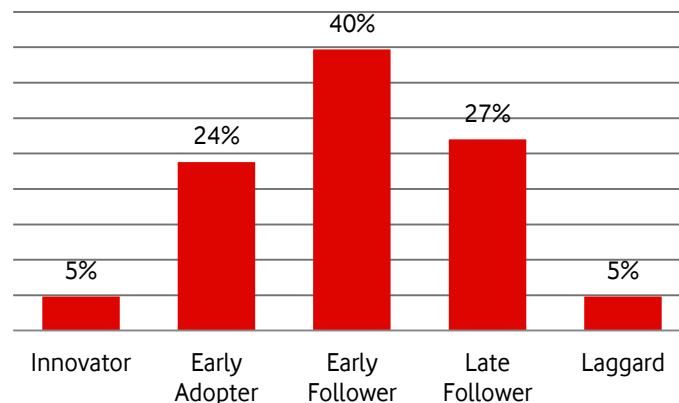
Three different details were collected in relation to the size of the dairy operation. These were; area (hectares), herd size (cow number), and employee number (full time equivalent). The indicator of size of operation that was chosen to conduct further analysis was herd size.

The largest operation surveyed was 16,000 cows and the smallest was 140 cows. The median herd size was 535 cows and the average herd size was 940 cows. The raw data has been broken into quartiles by herd size in order to analyse the effect that the size of the operation has on the use of M2M technology.

### 5.1.4 TENDENCY TO TAKE UP TECHNOLOGY

An important detail that was asked to assess the characteristics of the sample was their tendency to take up new technology. Rogers theorised that the distribution should follow the curve shown in Figure 3.6, in the literature review. The sample taken in the survey followed a similar distribution but there was a skew to the left of the diagram suggesting that the sample was more likely to take up technology than the general population. This is illustrated in Figure 5.3.

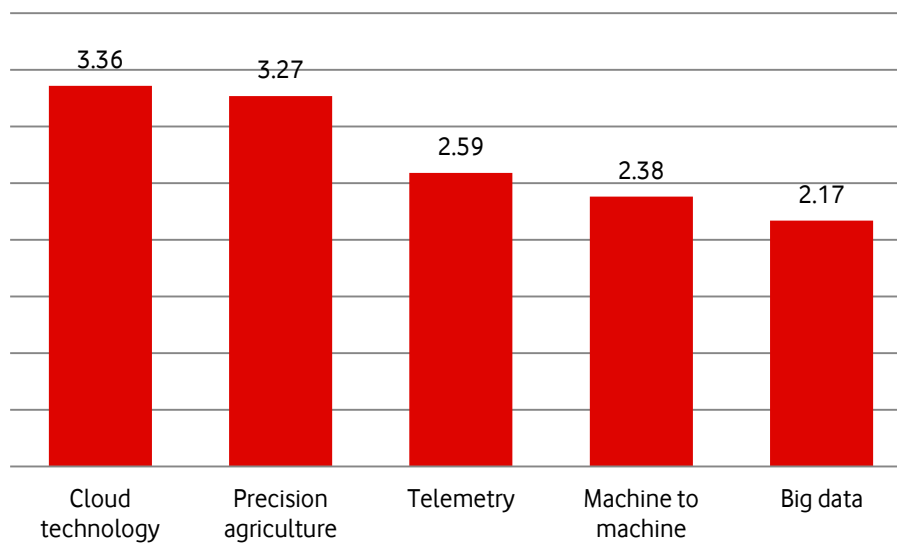
Figure 5.3: Responses to the question, "How would you describe yourself when referring to your tendency to take up new technologies?"



## 5.2 UNDERSTANDING TERMINOLOGY

In order to assess the understanding of the terminology the following question was asked. "How do you rate your understanding on the following terminology?" The terms, none (1), little (2), some (3), good (4) or very good (5) were used to describe their understanding. Each was then assigned a numerical value (in brackets). A mean value of these has been used to determine the relative understanding of the terminology. Figure 5.4 shows the results of this question.

Figure 5.4: Responses to the question, "How do you rate your understanding of the following terminology?"



Of the terminologies the term "cloud technology" was the most understood. The understanding of "cloud technology" was as high as "precision agriculture." "Machine to machine" is not a well understood technology from the survey results. 56% of respondents had "no" or "little" understanding.

The terminology "internet of things" was also included in the survey. It became clear that some respondents had confused this term for "the internet" when comments were asked for. This assessment would not be presented in the report due to this confusion. There was no difference between herd size quartiles when it came to the understanding of terminology.

## 5.3 CURRENT M2M SOLUTIONS

Figure 5.5 shows the solutions that respondents are currently using in their dairy farming operation. Of the respondents, the most common solution was, "fertiliser and effluent proof of placement" solution with 42% of respondents utilising this solution. Livestock monitoring was the second most popular M2M solution with 39%.

Fleet management solutions (engine diagnostics, vehicle fleet management, and machine operation compliance) were the least popular of those that were offered as options. In relation to

herd size and the popularity of the particular solution there was no difference between the quartiles

Figure 5.5: Percentage of respondents currently utilising a particular M2M solution

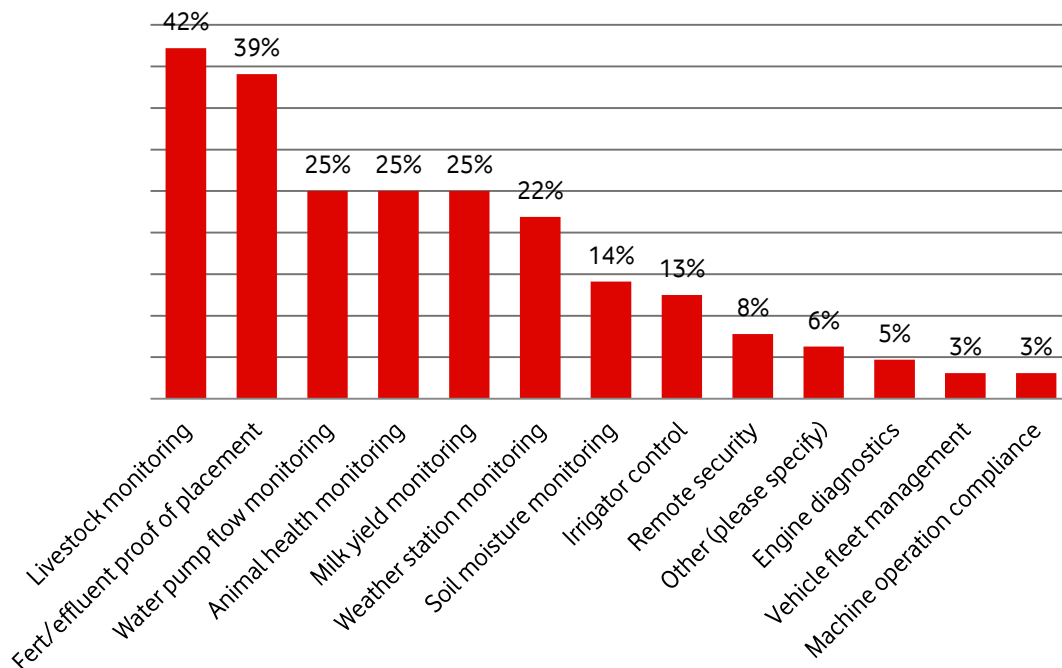
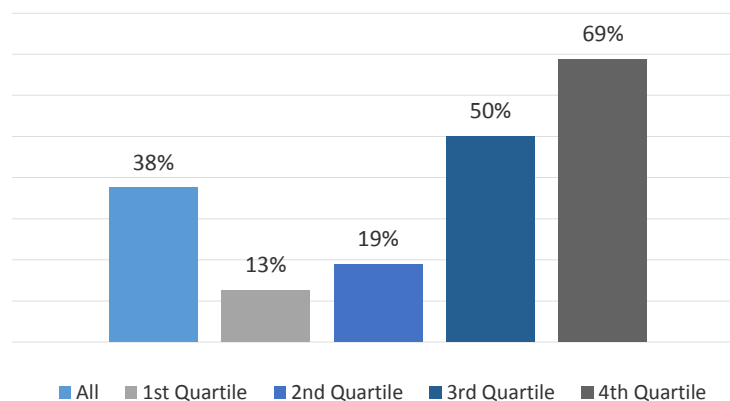


Figure 5.6 shows the relationship between herd size and likelihood to employ M2M solutions on farm. In total 38% of respondents had no M2M solutions on farm at all. This number increased as the size of the herd reduced. Of those surveyed in the bottom quartile of herd size 69% had no M2M solutions on farm at all. In comparison of the top quartile of respondents by herd size only 13% did not employ M2M solutions.

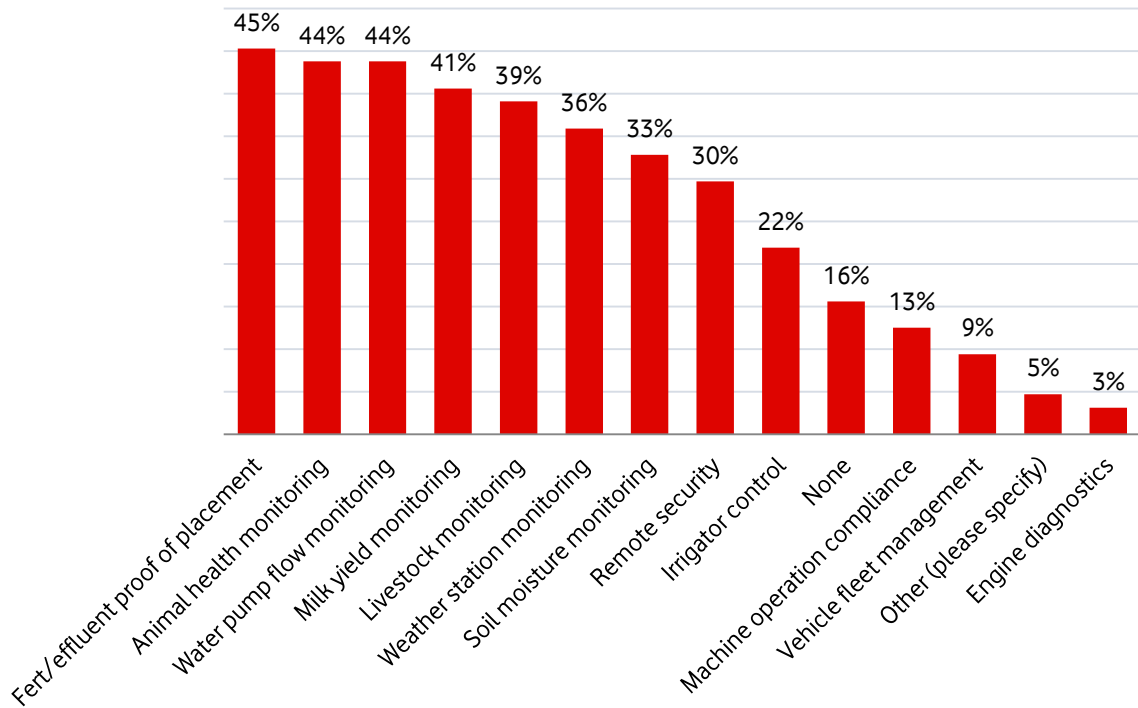
Figure 5.6: Percentage of respondents with no solutions utilising M2M on farm by herd size quartile



## 5.4 FUTURE M2M SOLUTIONS

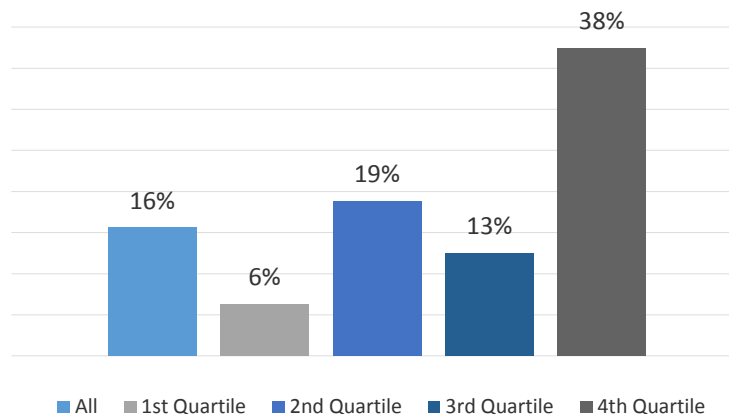
The question was asked, "What M2M technology will you look to adopt in the next 5 years in your dairy farming operation?" There was a wide range of solutions that the respondents intended utilising in the next 5 years. Figure 5.7 shows this wide range of solutions.

Figure 5.7: Percentage of respondents intending on using a particular M2M solution in the next 5 years



Significantly the number of respondents that would use no solutions dropped from 38% that are currently using M2M solutions to 16% that do not intend using M2M solutions in the next 5 years. A similar pattern in the intended solutions across the quartiles by herd size and the future usage of M2M solutions (Figure 5.8) as was seen in the current solutions by herd size (Figure 5.6).

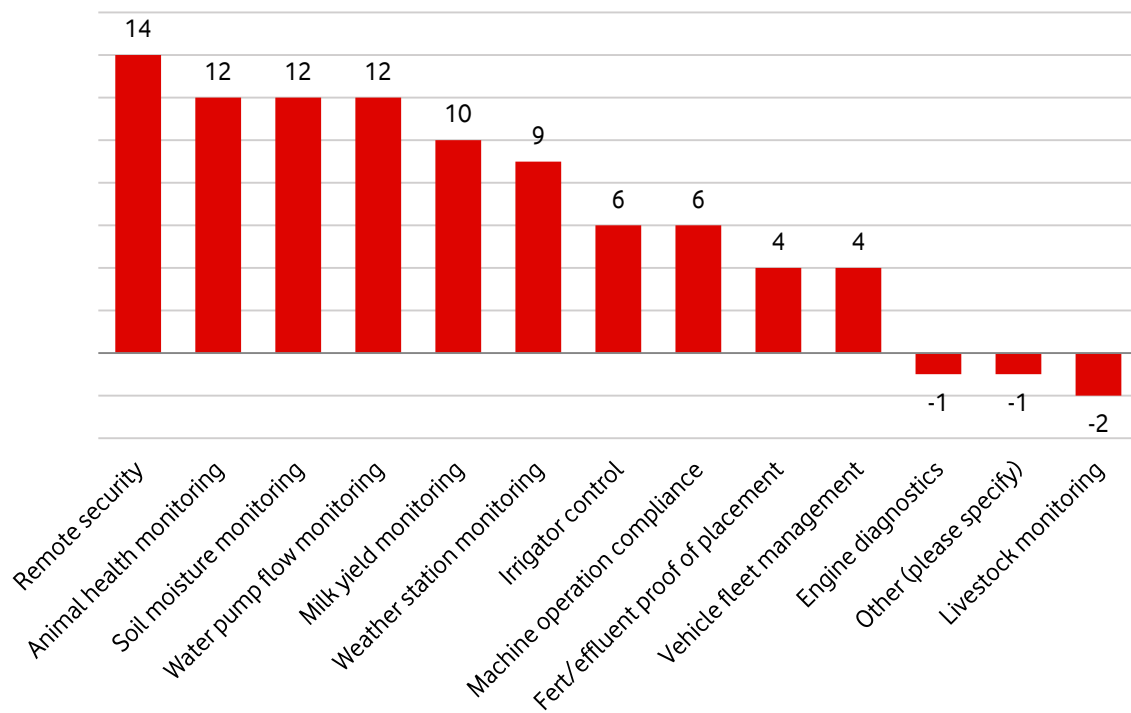
Figure 5.8: Percentage of respondents intending on utilising no M2M solutions in the next 5 years by herd size quartile





Remote security was the area that will see the most growth in the next 5 years by number. This is shown in figure 5.9. In contrast by percentage growth the area of greatest growth will be in machine operation compliance at 300% growth. This growth in respondents was from 2 current users to 8 future users.

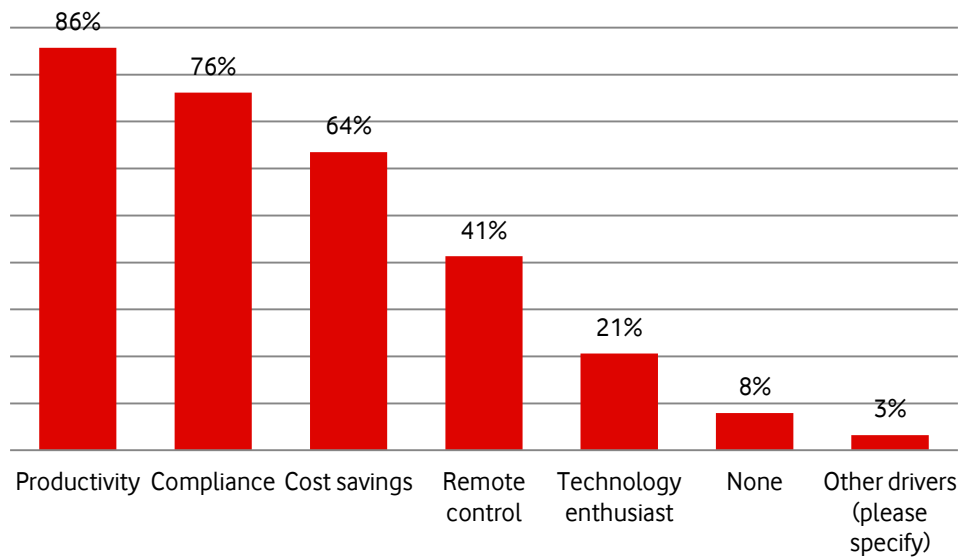
Figure 5.9: Growth by number of respondents answering positively to their intent to use a particular M2M solution in the next 5 years



## 5.5 DRIVERS OF UPTAKE

There are 3 clear drivers of uptake of M2M solutions. Productivity, compliance, and cost savings are the most commonly cited reasons for employing M2M technology. Figure 5.10 shows this. There was little difference between the herd size quartiles.

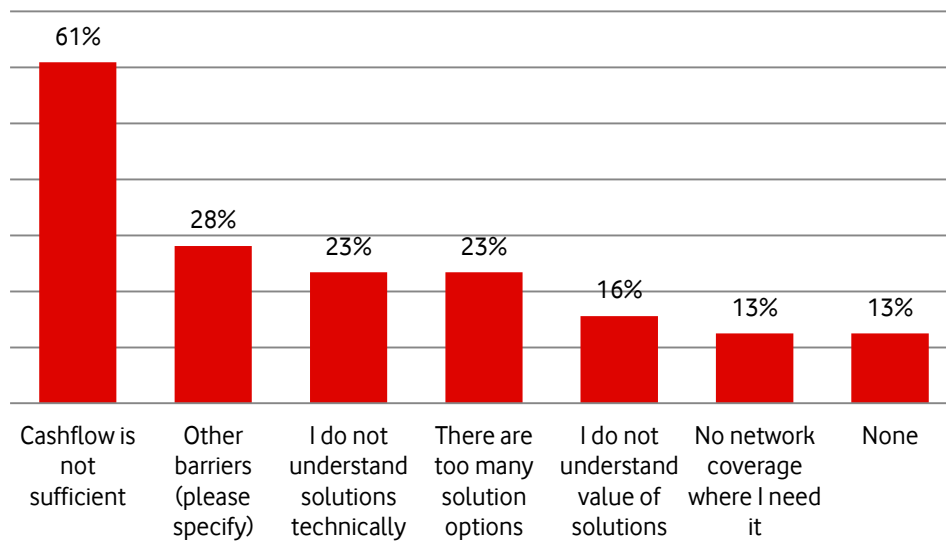
Figure 5.10: Responses to the question, "What are the drivers to uptake of M2M solutions?"



## 5.6 BARRIERS TO UPTAKE

The greatest barrier to uptake of technologies utilising M2M technology is the lack of cash flow with 61% of respondents citing this as an issue. Figure 5.11 shows that this is overwhelmingly the primary barrier to uptake.

Figure 5.11: Responses to the question, "What are the barriers to uptake of M2M solutions?"



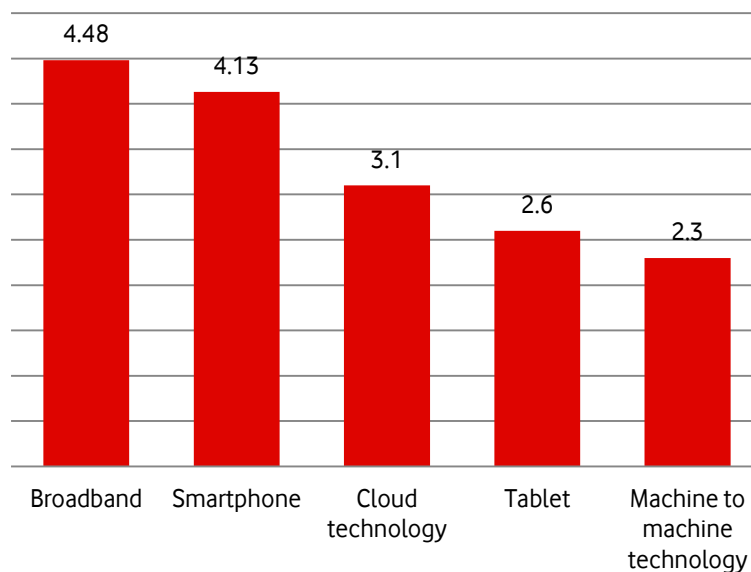
Network coverage does not seem to be the limiting factor across the dairy sector with only 13% of respondents stating this as a barrier. There were a number of other barriers identified. These can be seen in the raw data. There was no differences between the herd size quartiles and their barriers.

## 5.7 IMPACT OF TECHNOLOGY

The survey asked what the impact of a number of technologies was. The terms unknown (1), none (1), little (2), some (3), handy (4), and essential (5) were used to describe the impact. Each was then assigned a numerical value (in brackets) and the mean value of these has been used to determine the relative impact of the technology.

Conclusions can be made on the impact that M2M technology has had relative to other ICT's. Figure 5.12 illustrates the impact that these various technologies have on dairy farming.

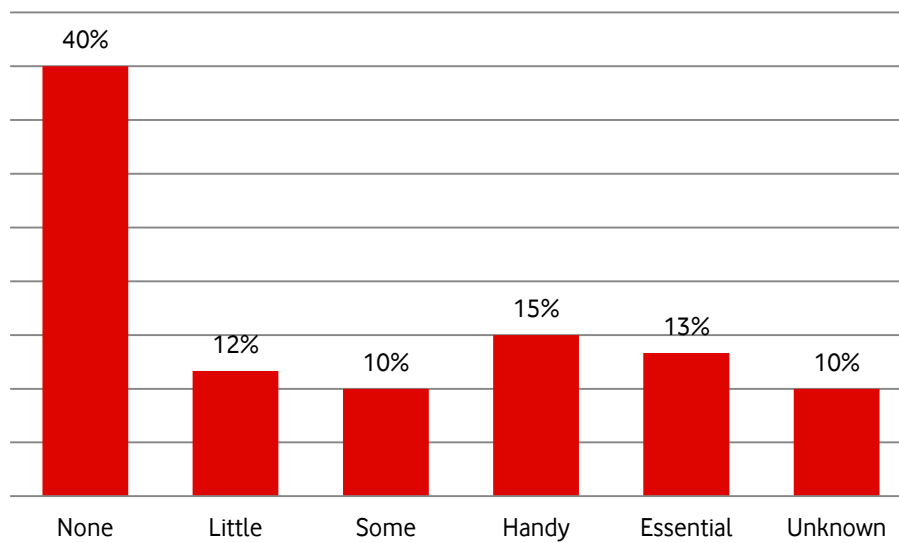
*Figure 5.12: Responses to the question, "What has been the impact of the following technologies on your dairy farming business?"*



It is clear that broadband and smartphones have had significant impact on those surveyed. With 70% of respondents rating broadband and 59% of respondents rating the smartphone as "essential" to their dairy farming operation. When asked for comment on the impacts a large number of applications for broadband and smartphones were mentioned. These included; Fencepost, MINDA, internet banking, weather, Google and many more.

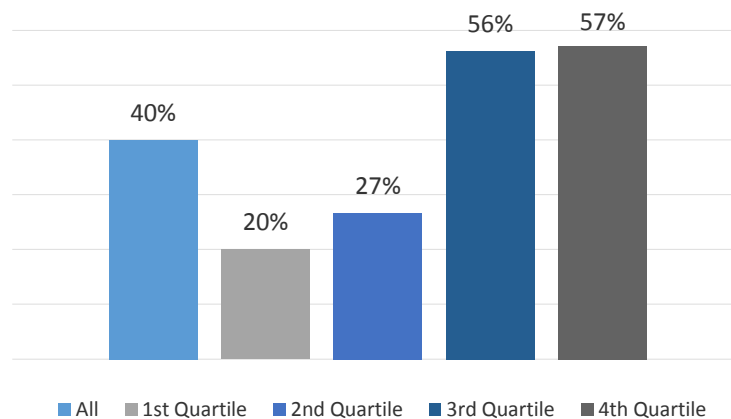
In contrast only 13% of respondents rated M2M technology as "essential" to running their dairy operation. 40% of respondents rated the impact of M2M technology as "none" to their dairy farming operation as is shown in figure 5.13. When asked for to comment on the impact that M2M technology a number of solution providers and solutions were mentioned. These included; C-Dax, Milkhub, and TracMap. Specific impacts mentioned were; reduction in labour requirement, easier compliance, and time savings.

Figure 5.13: Responses to the question, "What impact has M2M technology had on your dairy farming operation?"



When the impact data is broken down into herd size quartiles it can be seen that the smaller the operation the lesser the impact that M2M technology has. Figure 5.14 illustrates this. 20% of the top quartile by herd size indicated that M2M technology is having no impact on their dairy farming operation. In contrast 57% indicated in the bottom quartile that M2M technology was having no impact on their operation.

Figure 5.14: Percentage of respondents that indicated that M2M technology is having no impact on their dairy farming operation.



From the results of the survey it can be concluded that the impact of M2M communications is not as high as other ICT's. The larger the farming operation by herd size the bigger the impact that the technology is having.

## 6.0 ANALYSIS OF SOLUTION PROVIDER INTERVIEWS

Four solution providers were interviewed as case studies. Each has solutions that utilise M2M communications to transfer data in order for the dairy farmer to be able to make decisions.

### 6.1 CASE STUDY – WATERFORCE LIMITED

Waterforce are a water management solution provider based in Hastings, New Zealand. “Waterforce supply, install and service a complete range of water management and irrigation products. Products include centre pivots, irrigators, sprinklers, drip & fixed irrigation, pumping systems, filtration & treatment, effluent systems and monitoring devices.” (Waterforce, 2015). Ron McFetridge, the Managing Director was interviewed.

#### 6.1.1 DESCRIPTION OF SOLUTIONS

Waterforce’s portfolio of solutions includes 4 that utilise M2M communications. These are illustrated in Table 6.1.

*Table 6.1: Waterforce solutions utilising M2M communication*

SOLUTION NAME	BRIEF DESCRIPTION	COST
Scadafarm	Pivot irrigator monitoring solution. Variable rate irrigation tool.	\$3000-\$5000 (\$480 per year)
Flow metering solution	Measuring flow volumes for irrigation/water/effluent.	\$1000-\$3000 (\$180 per year)
Soil monitoring	Soil moisture and temperature monitoring	\$2000-\$6000 (\$240 per year)
Bore level monitoring solution	Measuring aquifer levels using bubbler technology	\$5000-\$6000 (\$300 per year)

#### 6.1.2 IMPACT OF SOLUTIONS

There are a number of impacts that the Waterforce solutions provide that Ron McFetridge cited in the interview:

Through soil moisture, and soil temperature monitoring, better decisions can be made around when and when not to apply irrigation. A significant operational cost of applying irrigation is electricity. A reduction in this operational expenditure will have a direct economic impact.

Scadafarm technology gives the ability to remotely operate irrigators. There are labour costs associated with having staff travelling to manually turn the irrigator on and off. McFetridge quoted the fact that there is a 20% saving in water using variable rate irrigation, a technique that Scadafarm enables. The water saved can either be stored, or utilised in other irrigated areas.

The environmental impact of proper water management can also be significant. Over watering will create an impact by degrading soil structure and by using fresh water that could be utilised elsewhere in the eco system.

The impacts that customers of Waterforce have seen outside of those directly related to productivity are related to lifestyle. The Scadafarm product allows the irrigation infrastructure to be controlled from anywhere there is an internet connection available. This allows managers or owners the ability to leave the farm and still have control over its operations.

The impact of the flow meter and bore level monitoring systems are primarily linked to compliance with the requirements of water schemes and Regional Councils. The economic impact of non-compliance is significant. Regional Councils are monitoring water flows using the flow meter product.

### 6.1.3 UPTAKE OF SOLUTION

- Uptake of the solutions is highest in larger dairy farming operations, by younger decision makers, and in regions that have greater pressure for Council compliance.
- The major drivers for uptake are compliance and productivity when it comes to water management solutions. Another important driver stated was lifestyle.
- A barrier to uptake stated was not only the capital expenditure required but also an understanding of the ongoing subscription model.

## 6.2 CASE STUDY 2 – REGEN LIMITED

Regen are a water, nitrogen, and effluent management solution provider based in Wellington, New Zealand. Their solutions utilise weather stations, soil moisture monitors, and effluent pond level monitors in order to deliver recommendations to dairy farmers on input application. Bridgit Hawkins, the CEO and Founder of Regen was interviewed.

### 6.2.1 DESCRIPTION OF SOLUTIONS

There are 3 solutions that Regen provides. These are described in Table 6.2:

*Table 6.2: Regen solutions utilising M2M communication*

SOLUTION NAME	BRIEF DESCRIPTION	COST
Regen Nitrogen	A tool that shows what response rate can be expected from a planned nitrogen application. With time-specific environmental data collected from the farm utilising M2M technology, along with a small data input the Regen	\$3000 - \$5000 (\$1980 per year)
Regen Water	A tool that calculates what the optimum irrigation amount is for the next five days. Based on current soil	\$3000 - \$5000 (\$4000 - \$6000 per year)

	moisture levels transmitted by M2M technology and the forecast weather. The mobile app shows a five day irrigation recommendation.	
Regen Effluent	A tool that provides daily measurements specific to individual farm parameters including rainfall, effluent pond levels, soil moisture, and soil temperature. This information is all transmitted using M2M technology to a secure database.	\$5000 - \$8000 (\$1980 per year)

## 6.2.2 IMPACT OF SOLUTIONS

Better management of nitrogen, water and effluent all have a positive impact on the environment.

The environmental impacts described were:

1. Regen Nitrogen gave the ability to ensure that the right amount of nitrogen is being applied to the right areas which will reduce the risk of nitrates getting into waterways.
2. Regen Water will reduce the risk of over or under watering which will have a negative impact on soil structure and therefore increase the risk of erosion.
3. Regen Effluent is designed to manage risk of effluent getting into waterways which will have a negative impact on the environment.

The economic impact of the Regen Nitrogen solution is significant in dairy farming considering the expenditure at an on farm level on nitrogen inputs. Nitrogen use efficiency can be greatly improved through applying fertiliser when the pasture is going to maximise its response to the applied nitrogen.

Bridgit Hawkins stated that on a typical dairy farm \$5,000 to \$10,000 can be saved by not applying fertiliser when it shouldn't be. She gave an example of a dairy farming operation that had recently applied urea by helicopter when it was too wet to apply by ground spreader. The use of the Regen Nitrogen solution would have clearly indicated that the ground was too wet to get any uptake of the nitrogen applied and that the entire application had effectively been wasted.

The economic impact of the Regen Water solution is related to maintaining soil moisture levels at an optimum level to maximise pasture growth. Decisions are able to be based on real time information. The correct irrigation regime has a twofold economic impact by reducing the costs of electricity by only operating irrigation infrastructure when required and by increasing the pasture production by applying water when maximum response will be achieved.

The application of effluent in an irrigation round on a dairy farm is a common practise in New Zealand dairy farms. There is an economic impact here from better placement and utilisation of

the nutrients in the effluent. Economic impact also comes from the reduction of risk of non-compliance to Regional Council regulations. The incorrect use of effluent that results in discharge into waterways can result in fines of up to \$200,000 if the operation is found to be negligent.

### 6.2.3 UPTAKE OF SOLUTIONS

- The majority of those that utilise the solutions are innovators and early adopters. Larger enterprises have a tendency to take up solutions as they have a need for systems to monitor and manage.
- Compliance is seen as a key driver to uptake but end users want to know that the solution will achieve their objective. Adopting the solutions gives the end user piece of mind that they will not face large fines for non-compliance.
- An important part of uptake is validation through referrals.
- A major barrier stated to getting the end user to adopt the solutions is to get them to recognise that they can improve their current systems. The technology is new and there is often scepticism around the ability of the solutions to achieve their objectives.

### CASE STUDY 3 – BLACKHAWK TRACKING

Blackhawk Tracking are a fleet management business that provides a solution called Farm Angel. Farm Angel is a safety and communications solution designed to make the farming sector safer. Andrew Radcliffe the CEO and Founder was interviewed.

#### 6.3.1 DESCRIPTION OF SOLUTION

The Farm Angel solution is a device that is attached to an All-Terrain Vehicle (ATV) that primarily monitors the movement of the vehicle in order to track and send alerts if a rollover occurs. The device contains a gyroscope and location sensor that transmits via cellular and satellite networks. Table 6.3 provides a brief description.

*Table 6.3: Blackhawk Tracking solutions utilising M2M communication*

SOLUTION NAME	BRIEF DESCRIPTION	COST
Farm Angel	Safety and communications solution built to make farming sector safer. Utilising GSM and iridium (satellite) connectivity so device is always connected.	\$849 (\$19-\$60 per month)

The 4 pillars of the Farm Angel value proposition are:

1. Safety – an alert function will notify the appropriate parties in crisis situations such as rollovers.
2. Security – the position of the ATV is monitored so if it has been stolen it can be found easily.



3. Communications – the device also enables communication with the user of the quad bike via SMS.
4. Performance – a record is kept of how the vehicle is being driven in order to increase safety through being able to proactively make changes to driving behaviours.

### 6.3.2 IMPACT OF SOLUTION

The social impact of making the dairy farming workplace safer is considerable. 850 people are injured on ATV's and 5 people die per year as a result of accidents (Worksafe, 2015). Ensuring that all employees of dairy farm's return home each day to their families alive and uninjured should be paramount to the dairy industry.

The economic impact of this is well documented. Since 2008, the Accident Compensation Corporation has paid \$29 million on 11,084 claims for injuries and 26 claims for accidental deaths involving ATV's (Sharpe, 2013). Andrew Radcliffe believes that this could be halved through the use of the Farm Angel device. This is a result of the elimination of accidents due to stupidity by utilising the tracking components of the solution and making behavioural changes.

Other economic impacts that the device can have are around the performance of the asset. A generally accepted figure in the fleet management industry is that tracking of vehicles and staff will increase productivity by 30%. These productivity gains could be made on farm by a decrease in down time and a reduction in the costs of running the vehicle.

Changes to the health and safety laws in New Zealand due in November 2015 will make the value proposition much more compelling. To a point where manufacturers will potentially be embedding the device in all new ATV's sold and becoming the channel to market. It is feared if the ATV industry is not proactive in reducing harm then these vehicles will not be able to be used in New Zealand without a device such as Farm Angel having been installed.

### 6.3.3 UPTAKE OF SOLUTION

- There has been limited uptake of the Farm Angel solution, so it was difficult to isolate a particular demographic that has taken up the technology.
- Some generalisation was able to be made about why particular segments. Corporate farms would utilise the solution because of a duty of care to do provide a safe working environment. Smaller farms would consider the impact of injury and fatality on the family unit.
- A barrier to the uptake of the Farm Angel solution is cost. The uptake of the solution is such that there are not enough end users to be able to reduce either the device cost or ongoing subscription costs.
- A major driver is the cost to ATV manufacturers of non-compliance. If significant steps are not taken to improve the injury and fatality rate the sale of ATV's will be dramatically under threat in New Zealand.

## 6.4 CASE STUDY – LIVESTOCK IMPROVEMENT CORPORATION (LIC)

LIC are a dairy co-operative in New Zealand providing, shareholders with, “genetics and information to create superior livestock; information to improve decision making to enable superior livestock; hardware and systems to improve productivity and decision making.” (LIC, 2015). Rob Ford, LIC’s General Manager of Information and Automation was interviewed.

### 6.4.1 DESCRIPTION OF SOLUTIONS

LIC provide a number of solutions utilising M2M communication through their subsidiary LIC Automation. LIC Automation specialises in manufacturing integrated and innovative in-shed farm automation and sensor technology systems. Table 6.4 describes the commercially available solutions that LIC Automation offers.

Table 6.4: LIC Automation solutions utilising M2M communication

SOLUTION NAME	BRIEF DESCRIPTION	COST
Protrack Vantage	Fully integrated system that utilises in-bail identification, event recording and audio & visual alerts to help make livestock management decisions. Integrated with farm software MINDA.	From \$79,500 (\$100 per month)
Protrack EZ Heat	Automatically identifies cows on heat via patch captured on an in-shed camera and automatically drafts the identified cows for further inspection and artificial insemination.	\$20,000 (\$300 per annum)
Yield Sense	Milk sensor provides real time data on results for yield, fat, protein, lactose and conductivity as well as monitoring plant performance.	
Cell Sense	Automated at bail somatic cell count (SCC) sensor that provides real time data that can be used to sense clinical and sub-clinical mastitis.	

### 6.4.2 IMPACT OF SOLUTIONS

The impacts of the LIC solutions are generally related to economic impacts. The productivity gains that are achieved through better measurement and management of milk output create greater profitability.

Protrack Vantage provides a platform that is integrated with the LIC’s MINDA product and electronic identification (EID) of the cow in the bail. Impacts from installation of this solution are; associated data collection in real time, being able to manage livestock issues in the dairy shed, and drafting livestock of interest off automatically. The average increase in productivity can be expected to be 20%.

Protrack EZ Heat can have a significant impact on ensuring pregnancy occurs in a timely manner. Rob Ford estimates that a productivity gain of 10-15% can be expected through benefits such as improving calving spread, and greater days in milk.

Monitoring yield of individual cows through the Yield Sense solution will impact by giving the farmer the ability to make decisions in real time whilst the cow is in the dairy shed. Over time trends can be seen in the yield of individual cows and ongoing decisions made. Cell Sense impacts by being more responsive to high somatic cell counts and reducing incidence of mastitis. This in turn increase milk production.

With the amount of data being generated on farm it is important that this data can be translated into information that can be utilised to make decisions. The accuracy of this data is also paramount for the farmer to be able to trust the information provided. In the absence of this LIC's solutions do not have the same impact.

#### 6.4.3 UPTAKE OF SOLUTIONS

- Uptake of LIC solutions is increasing as the average herd size has increased. Multi farm operations and operations with a herd size of greater than 600 cows are where the greatest uptake is occurring.
- Post-sales support and training by LIC is a key driver of uptake. If this function is unavailable the product is underutilised and undervalued, therefore uptake will be limited.
- As labour becomes scarcer and less skilled, there is a real need that drives value in automation that utilises M2M communication.
- The National Animal Identification and Tracing (NAIT) scheme has provided the EID system in order to be able to identify cows in the bail therefore the transition has become much easier to in dairy shed automation.
- The recent ability to be able fit LIC's automation equipment into herringbone sheds has improved uptake as 70% of New Zealand's dairy sheds are herringbone versus rotary.

## 7.0 DISCUSSION

Undoubtedly M2M communication and the internet of things are globally having a massive impact on businesses and consumers alike. Healthcare, retail, automotive, logistics, energy, and manufacturing are all industries that are being transformed by M2M communication.

There are a number of different purposes that M2M is being adopted for. These include; automating processes, measuring service delivery, gathering data to support manual processes, enabling new business/operating models, enabling new products and services, safety and security, and transforming business processes (Vodafone M2M Barometer, 2015)

The question remains though, what is the impact that M2M communication is having on the dairy industry in New Zealand?

### 7.1 CURRENT IMPACT OF M2M ON DAIRY FARMING

A number of conclusions can be drawn on the impact of M2M communication on dairy farming in New Zealand from the research conducted:

M2M communications, in dairy farming are having some impact with only 38% of farmers surveyed indicating that they do not employ any solutions that utilise M2M communications. The areas of livestock tracking and nutrient proof of placement were the 2 most utilised. Clearly the larger the farming operation the more likely they were to employ M2M solutions with only 13% of the top quartile by herd size not using and 68% of the bottom quartile by herd size not using.

It was indicated though that the impact of M2M technology was less than that of other ICT's being employed on dairy farms. Broadband, smartphones, cloud technology and tablets were on average rated as having a greater impact on dairy farming operations than M2M communications. The impact although less than other technologies again was impacted by the size of the operation. 20% of the top quartile by herd size indicated that M2M technology had no impact on their operations. In contrast 58% of the bottom quartile by herd size had no impact from M2M technology.

The solution providers interviewed were able to clearly articulate the impact that their solutions have on dairy farming operations. The impacts are classified into 3 categories. These being; economic, environmental, and social impacts.

#### 7.1.1 DRIVERS OF UPTAKE

The rate of adoption of these technologies determines their impact now and in the future. Overwhelmingly compliance, and productivity, were the two areas that featured across all the research conducted. 86% of respondents stated "productivity" and 76% stated "compliance" as drivers of uptake. All four case studies also referred to these drivers of uptake.

There are two types of compliance that M2M communications enables. The first of which is regulatory compliance which is a result of local and central government using levers to be able to determine outcomes that are related to common good. These are usually focussed on environmental and social outcomes. Water usage is one of these highlighted by both Bridgit Hawkins and Ron McFetridge in their case study interviews. Health and safety legislation is an issue of compliance that the Farm Angel solution is able to address.

The second form of compliance is customer driven compliance. As the market determines how and what is produced through the dairy chain, visibility of this is able to be achieved through the information flow that M2M communications enables. Traceability is a key outcome from the NAIT programme in the case of a disease outbreak. This tool is able to give confidence that their dairy product is being produced in a manner that they demand.

Productivity is the other key driver of the uptake. All of the case studies were able to provide examples of increased productivity. Andrew Radcliffe stated that the Farm Angel solution brings efficiency gains of 30% in regards to the vehicle being utilised better. Rob Ford stated that a key driver to uptake of LIC's solutions was not only the shortage of labour available to dairy farming but also the shortage of skilled labour.

### 7.1.2 BARRIERS TO UPTAKE

The clear barrier to adoption of M2M technologies indicated by respondents to the survey was cash flow. This may be a reflection of the current forecasts for milk pay outs. The Fonterra pay out figure forecast, on the 31<sup>st</sup> of July 2015, for the 2014/15 season, was \$4.40/kilogram of milk solid (kgMS). On the same date, the forecast Fonterra pay out figure, for the 2015/16 season, was \$5.25/kgMS (Fonterra, 2015). Capital expenditure on items such as M2M solutions are being delayed due to the limitations placed on cash flow in tight times.

Other barriers indicated in the survey related to the understanding of the solutions utilising M2M communication. Some of these included; understanding the value that the solutions can bring, understanding the solutions technically, and the large number of solutions in the marketplace. This gap in understanding was also borne out in the understanding of the terminology "M2M technology." With this terminology being rated well behind other ICT related terminologies.

It was not the cellular networks that were seen as the barrier to uptake of these solutions. Only 13% of respondents indicated that they had no network coverage where it was required. The flatter topography of the dairy industry results in a greater ability to put cellular networks across farms than in other sectors such as the red meat industry.

## 7.2 FUTURE IMPACT OF M2M ON DAIRY FARMING

Huawei state that today's fourth generation (4G) cellular network is designed to enable 3000-4000 connections per square kilometre. They state that the fifth generation (5G) cellular network

will have enough capacity to enable up to one million connections per square kilometre. (NZ Herald, June 2015). The next generation of networks to be built will be ideal for M2M communication in the dairy industry in New Zealand.

It is important to recognise that the solutions utilising M2M communications that will be employed in 2020 may not have even been invented yet. As forces such as regulation, economic cycles, and consumer demands continue to drive changes in the dairy industry, innovation will continue either, in solutions that already exist, or in completely new inventions.

It was clear from the survey that the use of solutions utilising M2M communication is going to increase over the next five years. The areas where uptake will be greatest are in larger dairy farming operations, and where the areas of productivity and compliance are being addressed. Nutrient proof of placement, animal health monitoring, water pump flow monitoring, milk yield monitoring, and livestock monitoring, were the top five solutions that will be employed in the next five years.

As the M2M industry continues to mature, there will be a more measured view of the expectations that these solutions can bring to dairy farming. The 2014 Gartner Hype Cycle of Emerging Technologies, indicates that M2M communications has entered the “trough of disillusionment” after the initial hype of this technology. As the transition to the “plateau of productivity” occurs the impact will continue to increase into the future.

We are already seeing evidence of this maturing in the dairy industry. The large number of small providers of M2M solutions are reducing through acquisition. Examples of this are Tru-Test Limited’s acquisition of Milkhub, and LIC’s acquisition of DAL in 2014. This consolidation will continue to occur into the future as larger organisations look to add more services to their portfolios.

### 7.3 THE WIDER IMPACT OF M2M ON THE DAIRY INDUSTRY

The research focussed on the impact of M2M technology behind the farm gate. There are potentially significant impacts that can be made beyond the farm gate. M2M communication plays an important role in information transfer across the entire dairy value chain. The data that is being generated and transferred across the value chain should be able to be used to create greater value to the wider dairy industry.

The value chain concept was first popularized in 1985 by Michael Porter, who used it to illustrate how companies could achieve, “competitive advantage” by adding value within their organization (Porter, 1998). In this case a value chain analysis can be conducted to identify where M2M communication is having an impact on the dairy industry. Figure 7.1 illustrates this.

Figure 7.1: Areas in the dairy value chain where M2M is adding value



It is in this environment that isolated solutions utilising M2M communications will evolve into the internet of things. The internet of things is about remotely connecting all types of assets and machines for the benefit of all parties (Vodafone M2M Barometer, 2015). Without this common goal amongst stakeholders it is going to be difficult to maximise the impact that M2M communication can have.

The data being generated by M2M communication can be used to give visibility through the value chain in both directions. If consumers are able to see where the product has come from, then they will potentially see value in provenance, as well as information on the food safety of the product. Likewise looking the other way down the value chain the dairy industry is able to measure the impact changes in farming systems have on the demand of the consumer.

A key concept to consider for this evolution to occur is interoperability. Interoperability allows a number of different information systems and software applications to be able to communicate. In an anonymous response to the survey it was clearly articulated that this would need to occur before widespread adoption could take place. "Too much on-farm technology is stand alone, we need whole farm solutions, a dashboard view of this on-farm technology, so that it all can brought together in one digital location."

#### 7.4 CURRENT EFFORTS TO INCREASE IMPACT

Currently there are some organisations worth mentioning that have an involvement in increasing the impact of new technologies on the dairy industry. Dairy NZ and Fonterra are leading a Primary Growth Partnership (PGP) titled, "Transforming the Dairy Value Chain." This PGP programme is aimed at creating new products, increasing on-farm productivity, reducing environmental impacts, and improving agricultural education.

A key outcome from this PGP is the formation of the organisation Farm Data Standards Ltd, which has been established to administer the Farm Data Code of Practice. These common standards will allow uptake to occur with the confidence that the data being generated by technologies, such as M2M communication, can be shared appropriately across the industry.

There is funding available and mentoring for start-up businesses focussed on agri-tech from the venture capital and incubator communities. The Callaghan Institute, Soda Inc, and the BCC are examples of organisations that have a focus on agri-tech start-up organisations. Many inventions as they move through to the innovation phase of their life cycle don't have the capital to grow. It is important that this support network exists in order to fill a pipeline of solutions that will continue to increase the impact of solutions utilising M2M communication.



## 8.0 RECOMMENDATIONS

This report seeks to make a number of recommendations based on the evidence gathered throughout the research. The research has uncovered a number of findings but it has only scratched the surface. Any further research into the use of ICT's in the primary sector should be supported as there are significant gains to be made from understanding where these technologies will create areas of competitive advantage.

The recommendations that come out of this research into the impact of M2M communications on the dairy industry in New Zealand are:

1. A thorough audit of solutions utilising M2M communications should be compiled both locally and globally. At present there are a large number of solutions available without any clear guidance on what solutions should be adopted in what situations. These solutions should be rigorously tested in the dairy industry in New Zealand and return of investment figures made available to the industry in order to find a clear order of prioritisation of the adoption of these solutions.
2. There is a gap in understanding of M2M communication, and the internet of things that needs to be addressed. This was highlighted by survey responses. The network providers alongside the solution providers need to provide education to dairy farmers in order to increase the understanding of the how these technologies work. This education programme should focus on early and late followers as they are the majority.
3. Solution providers should be focusing on larger farming operations, innovators, and early adopters to implement solutions. It is these segments that are more likely to take up solutions utilising M2M communications and therefore should receive the sales focus of solution providers. By targeting these segments that are most likely to adopt technology, increased revenue will allow critical mass to further develop solution offerings. This approach will also show followers the return on investment opportunities available through adoption.
4. A clear path of commercial development and investment support should be available to start-up organisations that are looking at developing on-farm technology solutions. An opportunity exists for this network of incubators, investors, and other interested parties to work to ensure capital is available for development of solutions that are going to provide solutions to dairy farming. The idea of a physical hub or virtual hub of these start-up organisations should be considered. This would allow for idea flow and physical demonstration of solutions.
5. An eco-system of organisations that have interests in on farm technology should be created and common objectives sought. This alliance will have the ability to provide direction on these common objectives around interoperability, increasing uptake, and areas of research and development. Representation across the entire dairy value chain is required in order to make this alliance successful and relevant.

6. There is a link that exists between uptake of M2M solutions and compliance requirements. These compliance requirements have been able to deliver productivity outcomes. An example of this is the compulsory requirements of electronic identification (EID) tags through the NAIT programme having delivered the ability to track productivity in dairy cows through solutions like Protrack. The value of productivity that compliance tools can bring should always be considered when undertaking changes for compliance sake.
  
7. It is critical for network providers to deploy emerging network technologies as soon as possible across dairy farming areas in order to maximise the impact of these M2M capable networks. Low power wide area networks are a network opportunity that will be well suited to dairy farming due to the low power requirement for devices connected. It is estimated that in 2020, 5G will start to be rolled out in New Zealand. Although 5G standards have not been defined at this point it is predicted that 5G will not only increase data speed again but also dramatically improve capacity.

It is recognised that these recommendations are only a start to the work that should be done on M2M communications in the dairy sector. There is much to be learnt from other industries locally and globally to bring together a comprehensive piece of work on the impact of M2M communications on the dairy industry in New Zealand. The gains in value that can be brought to the dairy industry through technology are too great to ignore.

## 9.0 CONCLUSION

Rate of adoption, and the value of the individual impact of solution are what determines the overall impact of solutions utilising M2M communications. Understanding these two factors is critical to taking advantage of a technology that can provide sustainability to an increasingly volatile industry.

The factors that determine rate of adoption are the drivers and barriers of uptake. Productivity, and compliance, are the two drivers of uptake. Cash flow, and knowledge, are the two barriers to uptake. Being able to identify, and manipulate, these is a key factor in increasing rate of adoption.

The characteristics of the dairy farming businesses that are most likely to adopt solutions utilising M2M communications are; large herd sizes, innovators, and early adopters of technology. Targeting these dairy farming businesses in the first instance is what is going to build a critical mass that will accelerate impact.

The value of the individual impacts of the solutions are often articulated in economic terms. The environmental, and social impacts of these solutions should not be overlooked. The key to being able to demonstrate this value is to be able to quantify the value that each solution brings. Network and solution providers should do this in terminology that the dairy industry can understand.

As M2M technology in the dairy industry matures and a sustainable commercial model evolves significant benefits will be realised. There will be a point in time where the internet of things just surrounds us and no consideration needs to be given to the technology that enables the gains that will be achieved. Until this point in time it is in the dairy industries best interest to maximise the impact of M2M technology on the dairy industry in New Zealand.

The recommendations borne out of this paper will be the basis for ongoing work on increasing the impact of M2M communication in the dairy industry and wider agricultural industry in New Zealand.

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