Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

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Dedicated to my Family and Partner

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy.

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New Zealand dairy farming is a primary industry suppling 3% of the world's milk. One of the primary tasks in traditional herringbone and rotary milking systems is to milk the cows. As milking can occur up to three times a day, this is a very labour-intensive task. In pastoral-based farming systems, this task accounts for up to 33% of the total labour input. Milking often occurs outside traditional work hours which makes it difficult to attract and retain workers.

The Automatic Milking System (AMS) almost eliminates the labour associated with traditional milking systems. While this system has been widely used in European countries where the dairy cows are kept indoors, there has been a much lower rate of adoption in countries like New Zealand practicing pastoral-based systems. This study investigates the characteristics of the farmers who have and have not adopted AMS in New Zealand pastoral-based dairy farms and the factors which facilitate or hinder AMS adoption.

This study included two stages of interviews. Three farmers who had adopted AMS participated in the first interview. The results from this stage, along with a review of the existing literature, were used to develop the second stage interviews. This second stage used the Theory of Planned Behaviour (TPB). A further seven farmers who had adopted AMS and 13 who had not adopted AMS participated in the second interview.

The results showed that adoption is not necessarily linked to high levels of education. The interviewed farmers, however, did have long-term experience in dairying. Most had no identified successor. Factors related to the farm (location, production level and system, and cow breed) were found to have little or no influence on AMS adoption. The animal health and welfare factors that had the greatest influence on AMS adopters and the highest potential for non-adopters were better animal welfare, more relaxed cows, treating cows as individuals, enabling a farmer to make better decisions about individual dairy cows, and reducing rates of lameness. The social factors that had an influence were having a new experience and challenges, providing a more relaxed operation system, providing a better lifestyle, improved work conditions, and flexible work hours. In terms of who influenced the decision to adopt AMS, the interviews revealed that only publicity materials provided by AMS suppliers were found to have an influence on farmers' decisions to install this system. While the AMS requires changes to farm layout, infrastructure, grazing systems, 24/7 monitoring, skilled labour, and support from AMS suppliers, the farmers did not find it difficult to institute these changes or meet these requirements.

The farmers who had not adopted AMS had similar levels of education as those who had adopted AMS. Six had possibly and definitely identified a successor. While these farmers had positive attitudes towards AMS' social and animal health and welfare benefits, they were not convinced that the system would provide greater economic benefits. They were not influenced by others' opinions on AMS adoption, stating that they only considered it after reading printed and online articles. Despite believing that AMS provides social and animal health and welfare benefits, these farmers believe that it is complex to install, it has high capital costs, and requires major changes in the farm layout and operation system.

Farmers who had adopted AMS wanted a better lifestyle and were interested in improving animal health and welfare. They saw AMS as a way to work with more flexible working days and hours. After installation, they confirmed that AMS improves animal health and welfare and does not prevent them from observing the cows or spotting problems. They also noted that the improved profits and financial returns and reduced milking shed operation and maintenance costs do not necessarily outweigh AMS' high capital costs. While these economic factors, including the high capital cost, were not prohibitive for them, this was not the case for the farmers who had not adopted AMS.

In this study, AMS farmers found AMS as an information-intensive technology complex to install. It took one of them almost two years to learn the system. The information-intensive technologies have a lower adoption rate as compared to embodied technologies. Similar to this study, non-AMS farmers found that it is complex to install AMS and this was one of the barriers to AMS non-adopters.

Keywords: Automatic Milking System (AMS), milking robots, technology adoption in dairy farming, pastoral-based dairy farming system, AMS in pastoral-based systems, technology adoption in pastoral-based dairy farming system, characteristics of New Zealand dairy farmers.

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Chapter 1
Introduction to global dairy production

Over the last three decades, there has been an increase of more than 59% in global milk production, from 530 to 843 million tonnes in 1988 to 2018 (FAO, 2020). Dairy cows are the main source of milk for dairy products. In 2018, 81% of the milk came from cows, 15% from buffaloes and a total of 4% from camels, goats, and sheep. Globally, in 2020 there were more than 270 million dairy cows, producing 748,346,036 tonnes of fresh milk (FAO, 2020). In 2019, the value of milk exports produced by dairy cows exceeded US$28 billion globally (International Trade Centre, 2019). There are a number of dairy companies which are responsible for milk production and exports. In 2019, the New Zealand dairy company, Fonterra, was the fifth largest dairy company in terms of turnover (USD) (Dairy Industries International, 2019).

There are a wide range of milk production systems practiced in different regions of the world. These include grazed pasture, grazed pasture for specific seasons, and cereal grains (Holmes, Brookes, Garrick, Mackenzie, Parkinson & Wilson, 2007). Rotary, herringbone, and Automatic Milking System (AMS) are some of the systems used to perform the milking task (Andrews, Davison, & Pereira, 2016).

In the developed world, the hired labour force plays a major role in ensuring competitiveness, particularly today where the farm and herd sizes are expanding despite declining family interest. This is challenging as the dairy industry is not seen as a particularly attractive career choice and the industry is plagued by high turnover rates (Nettle, 2018). In this sector, attracting employees is important not only for effective dairy farming, but also for succession and for improvement in innovation (McKillop, Heanue, & Kinsella, 2018). Labour issues have raised the interests of agricultural advisors and research scientists in the field of human resource management (Brasier, Hyde, Stup, & Holden, 2006; Hyde, Cornelisse, & Holden, 2011). Experimental studies recommend a diverse series of approaches to attract and retain employees including offering an attractive pay rate and monetary incentives in accordance with the employee's performance (Przewozny, Bitsch, & Peters, 2016), ensuring a safe working environment, increased social benefits for employees (Dumont & Baret, 2017), and providing an appropriate work atmosphere (Kolstrup, Lundqvist, & Pinzke, 2008). However, these approaches have not been successful to eliminate labour turnover. Besides, the attractiveness of dairy farming can also be affected by other factors including the long work hours, the physical types of tasks that an employee must perform (Deming, Gleeson, O'Dwyer, Kinsella, & O'Brien, 2018), a farm's distance from the urban area, and negative perceptions of labour about dairy farming (Eastwood, Klerkx, Ayre, & Rue, 2019). In accordance with human resource management literature, carrying out repetitive tasks and continuing in the same job position for a long time may have a negative impact on an individual's feeling of job satisfaction, resulting in turnover (Foong-ming, 2008).

In the conventional dairy system, one of the main tasks is to milk the cow. This task is labour intensive; it requires workers to milk the cows between one and three times a day. Milking can take up to six hours a day, every day (Jago & Woolford, 2002). In a pastoral-based dairy farm, this task accounts for up to 33% of the total labour input (O'Donovan, O'Brien, Ruane, Kinsella, & Gleeson, 2008). In addition, milking task occurs at unappealing hours and outside traditional work hours which can make it difficult to appeal and retain skilled labour (Tarrant & Armstrong, 2012). Dairy farmers work the longest hours in the agricultural sector; they spend an average of 48 hours on the farm per week (Morrison, 2016). In other words, the labour force must perform the repetitive milking task for long hours every day; this can result in high turnover rates and/or labour shortages in the dairy farming sector. Similarly, in New Zealand there are both micro and macro environmental factors which contribute to labour shortages, particularly when it comes to skilled workers (Callister & Tipples, 2010; Tipples, Trafford, & Callister, 2010).

In New Zealand, the conventional milking systems are mainly herringbone and rotary. Both require a labour force to operate them to perform the milking task (DeLaval, 2020). One alternative system is the Automatic Milking System (AMS) which almost eliminates the labour involvement in milking (Driessen & Heutinck, 2015). This system has been widely used in European countries where dairy cows are mostly kept indoors (John et al., 2016). There have been much lower rates of adoption in countries practising pastoral-based dairy farming systems, including Australia (Greenall Warren, Warren, Meijering, Hogeveen & de Koning, 2004), New Zealand (Woolford et al., 2004), and Ireland (O'Brien, 2012). The social, economic, and animal health and welfare reasons for AMS adoption include having a better lifestyle (Molfino, Kerrisk, & Monks, 2014e), more flexible working hours (Wagner-Storch & Palmer, 2003), less physical tasks and workload to contend with (Hogeveen, Heemskerk, & Mathijs, 2004), the desire to experience new technology (Brown, 2014), ensure better labour management, decreased labour unit and costs (Griekspoor, 2018; Rodenburg & House, 2007; Rushen, 2017), increased milk production (Rushen, 2017), improved profit (Rushen, 2017; Tse, Barkema, DeVries, Rushen, & Pajor, 2017; Tse et al., 2018), better manage of dairy cow's health, welfare, and efficiency (Common, 2014; Rushen, 2017; Tse et al., 2017; Tse et al., 2018). These reasons help to explain farmers' decisions to introduce this system despite the high capital cost (Common, 2014; Geleynse, 2003).

1.1 Research aims and objectives

This study aims to identify the critical factors influencing to the successful adoption of Automated Milking System (AMS) in New Zealand pastoral-based dairy farms. In addition, it identifies the factors preventing dairy farmer from adopting Automated Milking System (AMS) in pastoral-based dairy farming.

The objectives of this study are as follows:

1. To determine the characteristics of dairy farms and farmers who adopt and those who do not adopt Automated Milking System (AMS) in New Zealand pastoral-based dairy farms

2. To identify the factors that facilitate or are barriers to Automated Milking System (AMS) adoption in New Zealand pastoral-based dairy farming systems

3. To categorise the perceived impact of Automated Milking System (AMS) on farmer lifestyle and farm operations management

4. To categorise the perceived impact of Automated Milking System (AMS) on animal health and welfare, including cow behaviour

5. To determine the perceived impact on milk production, milk quality, investment and operating costs of Automated Milking System (AMS) for New Zealand dairy farmers

1.2 Thesis structure

This thesis is composed of six chapters. The first chapter provides an overview of dairy production in the world and issues related to dairy farming, specifically the task of milking the cows. In addition, the chapter also outlines the aim and objectives of this study. This chapter is followed by the literature review which reviews the literature on three interrelated topics: dairy production around the world and New Zealand, technology, and the Automatic Milking System (AMS). The third chapter describes the methodology and methods which were applied to conduct the study, including the data collection and analysis. The following two chapters provide the results from the study. The last two chapters provides a discussion of the results and the conclusion on how these meet the study's aim and objectives.

Chapter 2

Literature review

This chapter, a review of the literature, consists of three broad sections. The first section focuses on dairy production around the globe, before considering New Zealand. It considers the ranking and contribution of this sector in terms of dairy farmers, herds, production methods, operation structures, changes in the industry over time, strengths and weakness of popular methods, and labour issues. This section is followed by a discussion of different types of technology in both the agricultural industry in general and the dairy farming sector in particular. It also considers their adoption rates and the reasons for adoption. The last section describes milking machines and the Automatic Milking System (AMS) along with its requirements, implications, and the reasons behind the low adoption rates.

2.1 Dairy production around the world

There are more than 270 million cows in the world. Of the top 20 countries with the highest number of dairy cows, India is number one: it has more than 52 million dairy cows (see Table 2.1). Brazil and Pakistan are second and third with more than 16 and 13 million dairy cows, respectively. With more than 5 million dairy cows, New Zealand sits in 16th place (FAO, 2020).

Dairy products (fresh milk, mild solids, cream, ice-cream, butter, and cheese) are made primarily from cow, buffalo, camel, goat, and sheep milk. In 2018, more than 192 million tonnes of cow's milk were used in dairy products (FAO, 2020). In 2019, dairy cows produced 748,346,036 tonnes of fresh milk globally. In the list of the top 20 countries with the highest levels of milk production, the United States of America which has a smaller number of dairy cows than India had the highest level of milk production in the world. India was ranked second, in terms of milk production, producing more than 89 million tonnes. New Zealand was ranked nineth. These statistics show that some countries are more efficient in terms of milk production; they produce more milk with a lower number of dairy cows (see Table 2.2).

Table 2.1: Top 20 countries with the highest number of dairy cows
Source (FAO, 2020)

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Table 2.2: Countries with the highest level of milk production
Source (FAO, 2020)

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In 2019, the value of milk exports produced by dairy cows exceeded US$28 billion globally. In the top 20 countries with the highest milk exports (in monetary value), New Zealand is ranked first (see Table 2.3). From a continental point of view, Europe sold more than half of the global milk exports, approximately 54%. New Zealand sold one-fourth of the worldwide milk exports (approximately 25%). This was followed by Asia (9%), North America (7%), Latin America (4%), and Africa (0.5%).

Table 2.3: Countries with the highest milk exports (monetary value)
Source: (ITC, 2019)

"Table removed for Copyright compliance"

Globally, there are a number of dairy companies which dominate milk production and exports. In 2019, the top three dairy companies were European companies, Nestle, Lactalis and Danone (based on turnover). This was followed by Fonterra, a New Zealand based company (Dairy Industries International, 2019). Figures are provided in Table 2.4 below.

Table 2.4: Biggest dairy companies in the world
Source (Dairy Industries International, 2019)

"Table removed for Copyright compliance"

There are a wide range of milk production systems practised in different regions of the world. Holmes et al., (2007) provides an overview of New Zealand milk production from pasture farming systems which are still relevant to current practices. These systems vary due to climate and other physical conditions associated with location, and financial constraints (Holmes et al., 2007). These factors influence the availability of feedstuffs. The dairy production systems can be categorised as follows:

- Grazed pasture which is common in New Zealand, Australia, South America, and South Africa.

- Cereal grains, hay, horticultural, and arable by-products used in the countries such as California and Israel where there is no pasture.

- Grazed pasture for particular seasons, including spring and summer, and conserved pasture with cereal grains, for the colder seasons like winter. This system is used in countries such as Ireland where the winter conditions mean that dairy cows are unable to graze outside (Holmes et al., 2007).

Grazed pasture is a significant element of the total diet for 10% of the world's dairy cows; however, it is more common in areas with sufficient rainfall and a moderate climate. This production system is widespread in New Zealand, Australia, South America, and South Africa. In order to produce 1kg of milk, cows must consume 1kg of Dry Matter (DM). For this reason, the viability of the feeding system is affected by factors including milk price and feed costs (Holmes et al., 2007).

2.1.1 Dairy farming in New Zealand

Dairy farming is a key industry in New Zealand. This section provides a timeline of significant developments in this industry. It examines dairy trends, the distribution of dairy herds around New Zealand, the value of the industry, its operating structure, the country's dairy production systems, seasonal dairy production, the strengths and weaknesses of the industry, and labour issues.

In New Zealand, dairy farming has existed for more than a century. Over this time, the industry has undergone substantial changes, with the transition from hand milking to machine milking. In addition to changes to farm and herd size, dairy farmers' expectations have also changed. Table 2.5 presents a history of New Zealand dairy farming which is provided by New Zealand dairy industry organisations (DairyNZ., n.d.c; Fonterra, n.d.) and scientists and science learning hub (Holmes et al., 2007; LearningHub-PokapūAkorangaPūtaiao, 2019; Stringleman & Scrimgeour, 2008).

Table 2.5: Timeline of New Zealand's dairy farming sector

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The dairy industry organisations, Livestock Improvement Corporation (LIC) and DairyNZ (2019) indicate that over the last 35 years, the total effective hectares of dairy land grew by 58%, from 1 to 1.7 million hectares to allow approximately five million dairy cows to graze. Similarly, as Table 2.6 shows, the average effective hectares increased by 42%, from 64 to 153.

The statistics show that over the last 35 years, the number of cows increased by 47%, from 2.3 to 5 million cows, which resulted in a 34% increase in the average herd size, from 147 to 435 (see Table 2.6). Today, there are 11,372 herds with an average herd size of 431. The herd size ranges from 10 to more than 1500 cows (see Table 2.7). This increase in the number of cows resulted in a rise of 35% in the milk processed, from 7 to 21 million litres (LIC & DairyNZ, 2019).

Table 2.6: Dairy trends in New Zealand
Source: LIC & DairyNZ (2019)

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Table 2.7: New Zealand herd size
Source: LIC & DairyNZ (2019)

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DairyNZ (2019) reports show that most of the dairy herds are located in the North Island; 72% of New Zealand's dairy herds are located there and 59% of the country's total number of dairy cows. The North Island also produces 56% of New Zealand's milk solids. The Waikato region of North Island has the most herds (33%) in New Zealand (DairyNZ, 2019). About 27% of New Zealand's dairy herds are located in the South Island. Similar to the North Island, dairy farming in South Island is of substantial importance. As can be seen in Figure 2.1, 41% of New Zealand's dairy cows live in the South Island and they produce 44% of the country's milk solids.

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Figure 2.1: Distribution of dairy cows in New Zealand
Source: LIC & DairyNZ (2019)

Dairy farming makes a remarkable contribution to the value of New Zealand merchandise exports. The dairy farming contribution to merchandise exports between the years 2017 and 2018 was 28%. This figure is 2.5 times more than the meat sector, more than three times the wood sector, and ten times greater than the wine sector (DairyNZ, 2019).

In 2017 – 2018, 3% of the world's milk was produced by New Zealand. The country holds a striking position amongst the world's largest dairy exporters, with a revenue of $NZ15.1 billion. This is surprising given that New Zealand is ranked as the ninth largest milk producer worldwide (DairyNZ, 2019). The dairy industry also provides employment for many people in the country. There are currently 46,000 people employed in the New Zealand dairy industry. This figure includes 34,000 employed on dairy farms and 12,000 working in processing and wholesaling (DairyNZ, 2019).

In terms of farmers, in 2018 there are 380 farm owners and 3,159 sharemilkers (DairyNZ, 2019). There are three primary operating structures: owner, sharemilker, and contract milkers. The term owner operator refers to dairy farmers who own their own farm and run it or employ a manager to run the dairy farm in return for a salary. This type of operator collects all the income earned from the dairy farm but must also pay all of the farm staff their salaries. Most New Zealand farms are run by their owners (57%). This type of farm structure accounts for more than half of the country's dairy herds (LIC & DairyNZ, 2019).

The sharemilking operating structure is considered one step below farm ownership. A sharemilker runs the dairy farm on behalf of the farm owner in return for an agreed portion of the farm's income. There are common types of agreements: a 50/50 contract or a variable order sharemilking agreement. In a 50/50 split, the sharemilkers bring their own herd, crop, and gear which they use to run the farm. The sharemilker is liable for all the expenses related to labour, harvesting milk, and anything stock-related, as well as overall farm work and maintenance. The farm owner must pay the costs related to the farm's upkeep. The portion stated in 50/50 sharemilking agreement normally refers to the percentage of income earned from milk which the sharemilker receives. The portion in the sharemilking agreement can vary from 45% to 55%. In this type of agreement, the farm owner's involvement in farm management is minor.

In a variable order sharemilking agreement, the farm owner is involved in more farm management tasks. In this type of agreement, the farm owner may hold all or some of the herd ownership and bears more expenses related to the farm, namely animal health and breeding. In accordance with the terms stated in the agreement, the sharemilker's responsibilities can vary, from managing the herd to managing the entire farm. The most common type of sharemilking agreement in New Zealand is 50/50 sharemilking which is practised by more than half of the farm owners and sharemilkers (LIC & DairyNZ, 2019).

Contract milkers who milk the herd are paid at a fixed rate per kilogram of milk solids. The rate can vary based on the amount of work which must be completed. Contract milkers are the smallest group in New Zealand and represent approximately 13% of all the herds (LIC & DairyNZ, 2019). However, contract milkers tend to have higher average herd sizes (471) than the owner-operators (428) and sharemilkers (430). The same is true for the average of effective hectares for the contract milkers. They tend to work on farms with an average of 160ha, compared to the owner operators (154ha) and sharemilkers (149ha) (Holmes et al., 2007).

In New Zealand, dairy production systems vary greatly. They have also undergone rapid change over the past decade (DairyNZ Limited, 2015). Farmers have also increased the amount of supplement they provide to dairy cows. They must grow more pasture to meet production expectations. New Zealand dairy farming today is very different from previous decades. As both the number of dairy farms and herds have grown, dairy production systems have changed (Mounsey, 2015). The other reasons for changes in the production systems include improving milk production, higher prices of feed and milk, changes in seasonal weather patterns (especially during droughts), public pressure related to animal welfare, improving cow's condition, and advice given by feed consultants. This advice has led to the successful implementation of intensive input systems on many farms; however, farmers must carefully manage the pasture to ensure that they receive the ultimate benefits (DairyNZ Limited, 2015; Mounsey, 2015).

In New Zealand, dairy production systems can be divided into five categories based on the use of imported feed. These systems vary depending on the amount, the timing, and purpose (for dry or lactating cows) (DairyNZ Limited, 2015; Mounsey, 2015). In a pastoral-based system, supplements mean supplying dairy cows with additional feed with the aim of improving revenue, and developing the business (Mounsey, 2015). In the five production systems, the grazing policies of young stock are not included. These categories are listed below (DairyNZ Limited, 2015; Mounsey, 2015):

- System 1 – all grass, self-contained:

  In this system, the farmer does not purchase supplement feed. In other words, this system is completely based on grass; therefore, dairy cows do not graze off the milking area.

- System 2 – feed purchased to feed dry cows:

  In this system approximately 4 – 14% of the total feed is purchased to feed dry cows. Dry cows also graze off the milking platform.

- System 3:

  In this system approximately 10 – 20% of the total feed is purchased to feed dry cows and to extended lactation which is mainly in autumn.

- System 4:

  In this system approximately 20 – 30% of the total feed is purchased to feed dry cows and extend both ends of lactation.

- System 5:

  In this system, a minimum of 30% of the total feed is purchased to feed dry cows over the whole year.

In New Zealand, the primary components of dairy farming, including feed which is eaten and converted into milk by well-bred, fertile, and healthy dairy cows, are the same. These primary components of dairy farming are integrated into the pastoral based system which is only viable due to New Zealand's physical environment and climate. The pastoral based system is based on the assumption that the cows will eat the pasture and then convert that food into milk at a low cost. These low-cost pastoral based systems are essential due to the moderately low global milk price. These systems are feasible due to the moderate climate conditions of New Zealand's dairying regions (Holmes et al., 2007; Silva-Villacorta, 2005). Recently, there has been substantial debates surrounding the provision of additional feed on New Zealand dairy farms. While some studies indicate that low feed input can generate higher profits (Armer, 2000; Kuriger, 2002), other studies show that if a high feed input is managed effectively, it can also result in a higher profit (Roche, 2002).

The quality of pasture is dependent on the season and growing conditions (Roche et al., 2009). In most of New Zealand's dairying regions, pasture grows faster during springtime compared to wintertime (Holmes, 2001). Therefore, the seasonal production system attempts to synchronise the cows' feed requirements with the level of pasture growth. Subsequently, the dairy cows must get pregnant between October and December and calve during July to September which covers the end of winter and the beginning of spring. This means that they will produce milk during spring, summer, and the beginning of autumn. In this system, the cows do not lactate before winter. As a consequence, the non-lactating period occurs when the pasture has its lowest growth (DairyNZ, 2019a). However, in some regions of the North Island many cows calve during autumn time so they will be non-lactating over the hot season when pasture growth is at its lowest. In this scenario, lactation occurs during wintertime, the time when dairy farmers should be able to obtain a premium price for their milk solids (Holmes et al., 2007; NZ Farm Life Media, 2019).

The primary purpose of seasonal dairy production is to ensure that grazed pasture supports more than 90% of the herd's required feed and also to store a small portion of hay or silage (Blackwell, Burke, & Verkerk, 2010; Holmes et al., 2007). In this system, the cows are kept outside year-round. They have access to the pasture for feed and are able to spread their urine over the pasture. This system has substantial savings in terms of buildings, machinery, labour, and feed costs (Holmes et al., 2007).

In accordance with this system, the need for synchrony between pasture growth and feed demand results in a shorter lactation period (between 220 and 240 days in a year). However, if farmers incorporate supplementary feed into this system, then they can extend the lactation period. This type of system is dependent on good weather conditions to ensure and/or increase pasture growth. Therefore, milk production might fluctuate over the years (Holmes et al., 2007).

The primary strengths and weaknesses of the New Zealand pastoral dairy production system are provided in Tables 2.8 and 2.9.

Table 2.8: Strengths of New Zealand pastoral dairy production system
Source: (Holmes et al., 2007)

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Table 2.9: Weaknesses of the New Zealand pastoral dairy production system
Source: (Holmes et al., 2007)

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Dairying is of substantial importance to New Zealand and the performance of this industry plays a critical role in the country’s employment rate, economy, and exports. However, there are both micro and macro environmental factors which contribute to skilled labour shortages in the New Zealand dairy industry (Callister & Tipples, 2010; Tipples et al., 2010). These factors include long working hours, the type of tasks that must be performed (Deming et al., 2018; Taylor, Van der Sande, & Douglas, 2009) the distance of many dairy farms from urban zones, and negative perceptions about dairy farming which affect the attractiveness of dairy farming (Eastwood et al., 2019).

Similar to many dairy farmers around the world, New Zealand farmers struggle to attract and retain a skilled workforce (Eastwood, 2019). Even though there have been substantial efforts in the New Zealand dairy sector to improve human resource management practices, to ensure wage compliance and leadership, and health and safety rates, dairy farmers still experience difficulties in hiring and retaining their workforce. Therefore, it is necessary to make changes in New Zealand dairy farming workplaces (Eastwood, 2019).

Dairy farming may be unattractive due to the long hours of work, which means insufficient time away from the farm and little free time where one is not engaged in farm activities. The consequences of long working hours can lead to an intensive workload, more stress, fatigue and depression, and isolation. Other factors, including changes in work flexibility and the urbanisation of labour, have made it challenging to source local workers (Eastwood, Greer, Schmidt, Muir, & Sargeant, 2020). In recent decades, the New Zealand dairy industry has also witnessed substantial structural changes because of a rise in corporate farm ownership and the conversion of beef and sheep farms and forests to dairy farms (Poulter & Sayers, 2015). Increasing herd and farm sizes, and technological developments all mean that there are more dairy cows which need to be milked (Poulter & Sayers, 2015; Trafford & Tipples, 2012).

Eastwood et al. (2020) have identified factors, such as the recruitment and retention of labour, labour productivity and wages, skillsets and learning, financial returns, and structural issues as high-level issues which make it challenging to attract and retain workers in the New Zealand dairy sector. Strategies to overcome such issues include providing modern accommodation with proper facilities (such as high-speed internet), offering social and community activities to bring workers from different farms together, providing workers with clear expectations, utilising social networks such as Facebook and WhatsApp for the purpose of communication, automating farms tasks (such as milking using automated cup remover and teat sprayers), recruiting employees during off-peak time rather than during the peak season. Other strategies include taking care of new workers by enabling them to have access to family support, ensuring workers have sufficient food and sleep, providing new workers with proper instructions and guidance, supporting workers whose native language is not English, providing new workers with proper and effective inductions, giving workers opportunities to participate in decision making processes, and flexibility during peak periods (Eastwood et al., 2020).

Labour shortages may have a negative impact on the dairy sector's performance, productivity, and growth (Trafford & Tipples, 2012). Attracting individuals to dairy farming sector is necessary for a successful succession process and dairy farming, and also innovation development (McKillop et al., 2018).

The New Zealand dairy system and seasonal dairy production results in peak times which makes dairy farming labour-intensive and time-consuming. Therefore, there is a need for innovation to make milking task easier and less time consuming, and solve issues related to labour shortages.

2.2 Agricultural innovation

Innovation is an extensive concept which includes creating and accepting innovations which are new to an organisation, market, and/or the whole world (Läpple, Renwick, & Thorne, 2015). In other words, innovation refers to the effective use of creative ideas (Knickel, Brunori, Rand, & Proost, 2009). An Irish study indicates that in the case of the dairy sector, it involves an acceptance of procedures and practices which will lead to better performance and farm profitability (McKillop et al., 2018). Innovations can be divided into product, process, market, and organisational innovations. Product innovation suggests changes in a product by applying new or existing technologies. Process innovation focuses on making changes in the production or delivering of a new product (or a substantially enhanced product). In short, it refers to improvements in the production of an existing product. Marketing innovation focuses on launching a product to the market in accordance with the user's need by making changes in the context. Organisational innovation refers to the application of new and different organisational practices in an organisation (Ganzer, Chais, & Olea, 2017).

Precision agriculture (PA), known as smart farming, digital agriculture, and digital faming, has been established for the effective management of land, animal, and farm staff members (Tey & Brindal, 2012; Wolfert, Ge, Verdouw, & Bogaardt, 2017). PA technologies can be divided into two main categories: embodied knowledge technologies and information intensive technologies (Fernandez-Cornejo, Daberkow, & McBride, 2001; Lambert et al., 2004). Embodied knowledge technologies are those which do not require the users (in this case, farmers) to have a particular skillset in order to use the technology. In other words, the user does not require extra training and knowledge to benefit from the technology. Information intensive technologies are ones which provide a considerable amount of data and information which can be applied for future decision-making purposes. In contrast to other technologies, users (farmers) must have a particular skillset in order to interpret the data correctly. In short, it is necessary for the users (farmers) to gain extra skills or attend trainings to leverage the generated data completely (Fernandez-Cornejo et al., 2001; Winstead, Norwood, Griffin, Runge, Adrian, Fulton & Kelton, 2010). Prime examples of embodied knowledge technologies are automatic guidance and section control.

Computerised sensors and automation, including the global positioning system, vision machines, and laser-based sensors, have become increasingly embedded in the agricultural sector, including dairying. They have been developed with the purpose of organising autonomous systems which enable a user to spend their time on other activities (Emmi, Gonzalez-de-Soto, Pajares, & Gonzalez-de-Santos, 2014; Sejal, Smruti, & Shruti, 2016). In the agricultural and forestry industries, automatic systems play a role in the whole production process, where handling and automated sensing are commonly utilised in both crop and livestock systems. For instance, in Australia, vehicles with automatic guidance are often used to limit damage to growing crops (Billingsley, Visala, & Dunn, 2008). A review by Huhtala, Suhonen, Mäkelä, Hakojärvi, & Ahokas (2007) suggests there are numerous different types of robots which assist farmers in the feeding and cleaning process, and milking. In Australia, they are also used in shearing sheep and the slaughter process (Billingsley et al., 2008).

Globally, the agriculture sector has experienced precision farming in its utilisation of global positioning systems. Devices have transformed many manual farm tasks into automated ones. Some of these are used to evaluate crop and animal performance in New Zealand and other developed and developing countries (Busse, Schwerdtner, Siebert, Doernberg, Kuntosch, König & Bokelmann, 2015; Jago, Eastwood, Kerrisk, & Yule, 2013; Kutter, Tiemann, Siebert, & Fountas, 2011; Tey & Brindal, 2012). In smart farming, a farmer can use a variety of sensors, advanced equipment, and information systems and management to collect data related to farm management and the supply chain with the purpose of monitoring animals, soil, water, and plant growth/health (Eastwood, Chapman, & Paine, 2012; Eastwood et al., 2019; Jago et al., 2013; Scholten, De Boer, Gremmen, & Lokhorst, 2013). This technology allows them to control agricultural quality and quantity and maximise their production level by accounting for uncertainties and variabilities in agriculture systems (Gebbers & Adamchuk, 2010). The data is used to understand past performance and to forecast the future to enable timely and precise decisions within the supply chain and on-farm (Carbonell, 2016; Wolfert et al., 2017). Scientists consider smart farming as a solution to the social concerns of farming, such as animal welfare in the livestock sector (Yeates, 2017) and the environmental impact of various farming approaches (Busse et al., 2015; Carolan, 2017; Wolfert et al., 2017).

Despite the fact that smart farming brings benefits, such as increasing agricultural performance and efficiency, positive environmental impacts suggested by a review study and studies in Greece and the UK (Kaloxylos et al., 2012; Rutten, Velthuis, Steeneveld, & Hogeveen, 2013; Wathes, Kristensen, Aerts, & Berckmans, 2008; Wolfert et al., 2017), reduced production costs, improved flexibility and convenience suggested by a study in India (Thompson, Bir, Widmar, & Mintert, 2019), there are also negative results. These include socio-ethical implications (Driessen & Heutinck, 2015; Millar, 2000) occurring at a farm level, within the broader farming community, and at a societal level. In Australia, smart farming reforms farming practices by being more dependent on data-driven methods rather than hands-on management (Eastwood et al., 2012).

While there has been a swift increase in the adoption of PA on-farm technologies over the past two decades, the adoption rate of particular types of technologies are still unknown (Miller, Griffin, Ciampitti, & Sharda, 2019). Amongst PA technologies, automatic section control has been the most popular in America and Canada (Mitchell, Weersink, & Erickson, 2017; Schimmelpfennig, 2016), perhaps because of the reduction in required labour units (Fernandez-Cornejo et al., 2001). In Canada, automatic guidance technology is a popular type of technology which has been quickly adopted, mainly by service providers and farmers (Mitchell et al., 2017). An American study indicates that farmers have been more willing to adopt embodied knowledge technologies and automatic guidance in comparison to other types of technologies (Miller et al., 2019). Globally, amongst information intensive technologies, those which enable a farmer to monitor production have been used as the benchmark to judge the adoption rates of the other technologies (Lambert et al., 2004).

Today there are a wide range of farm practices, new technologies, and organizational and management methods which can be categorised into agricultural innovations. These innovations and their adoption have been driven by a range of factors including increased farm sizes, farm owners having access to credit, agricultural education, and innovative agricultural policy. A study by Läpple et al. (2015) indicates that increasing agricultural profits, whilst preserving the environmental sustainability of agriculture requires improved productivity and performance of the agriculture industry. Continuing innovation is needed to achieve this. Deavoll (2018) highlights that the development of technology, innovations, and applications can assist farmers to make more precise decisions which enable them to farm in a more sustainable way. Moreover, the adoption of innovative farming practices helps raise productivity and ultimately provides a competitive advantage (Sumberg, 2005).

In the agriculture sector, continuing innovation is essential to ensure sustainability (Leaver, 2010). The United Nations (UN) has estimated that the global population will increase from two to nine billion by 2025. Agricultural consumption will increase by 60% (when compared to 2005 figures). In order to cope with this population increase, the agricultural sector will need to be smarter and more efficient (Deavoll, 2018).

2.2.1 Technology adoption in agriculture and dairy farming

The dairy farming sector has experienced the growing availability of technology, including electronic animal identification, robotics, and data collection devices (Berckmans & Bocquier, 2008; Bewley, 2010). Previous studies by Jensen, Jacobsen, Pedersen, & Tavella (2012) and Schlageter-Tello et al. (2015) show that precision dairy farming is known to have economic and environmental benefits. However, Borchers & Bewley (2015) and Edwards, Rue, & Jago (2015) find that there has been a low adoption rate. Studies conducted by Kutter et al. (2011) and Schewe & Stuart (2015) conclude that factors contributing to the low rate of precision farming adoption include complications and possible unintended effects related to the usage of such technology. Studies in Australia by Eastwood & Kenny (2009) and in New Zealand by Nuthall (2012) find that the complication of precision farming results from shifting from experimental decision-making to a data-driven process which may affect a farmer's typical style of working. Kutter et al. (2011) adds that this shift leads to uncertainty about the possible expenses and benefits of the technology. A study by Meijer, Hekkert, & Koppenjan (2007) shows that there is a robust relationship between dairy farmers' (as technology users) uncertainty and technology providers. Eastwood, Jago, Edwards, & Burke (2016) find that the developers and manufacturers of precision farming technologies are from the private sector and they often have insufficient farm knowledge and skills to adequately support on-farm adoption and usage. There is thus uncertainty relating to the operation of the technology both on and off the farm (Hay & Pearce, 2014; Kamphuis, Rue, Turner, & Petch, 2015). Consequently, Bewley & Russell (2010) and Hoes, Beekman, Regeer, & Bunders (2012) emphasize that it is essential to simplify the learning process and decrease uncertainty related to the adoption and operation of such technology.

In America, dairy farmers seeking to expand their business must consider effective approaches to herd management, processes, their finances, their workforce, and strategic management (Hadley, Harsh, & Wolf, 2002). In New Zealand, when the size of dairy processes keeps expanding, managing and monitoring dairy cows becomes a challenge; thus, it is necessary to improve their management (Edwards et al., 2015). In countries like New Zealand and America, the use of PA has enabled dairy farmers to decrease their required labour force and better manage large herds (Bewley, 2010; Eastwood et al., 2012; Eastwood et al., 2016). In New Zealand, there are different types of precision technology, namely automatic cup removers, automatic gates, calf feeders, post milking disinfection, and milk plant wash systems, have all been developed to decrease the reliance on human labour and increase farm productivity (Edwards et al., 2015). Other types of technology, including Electronic ID (EID), milk meters, automatic oestrus detection and herd management systems which capture data for individual dairy cows, are designed to improve dairy farm productivity and performance. Studies from different countries indicate that despite the obvious benefits associated with such technologies, only a small portion of dairy farms around the world have adopted data-capture technologies (Bewley, 2010; Borchers & Bewley, 2015; Edwards et al., 2015; Rutten et al., 2013).

In the dairy farming sector, service providers from both public and private sectors (consultants, scholars, farm equipment technicians, veterinarians, agronomists, and nutritionists), play a crucial role in dairy farmer networks. They also influence decision making processes (Eastwood et al., 2012; Klerkx & Jansen, 2010; Murphy, Nettle, & Paine, 2013). There is an opportunity for these service providers to apply precision technology in their own businesses and introduce precision technologies to the dairy farmers they work with. For instance, service providers could provide computer generated reports for animal health and feed (Eastwood, Chaplin, Rue, Lyons, & Gray, 2016a; Eastwood et al., 2016).

In recent years, several research studies have shown that technology can decrease the costs of production and increase efficiency within pastoral-based systems. Irish studies show that technologies can be used to estimate how much pasture and feed need to be budgeted for (O'Donovan, Connolly, Dillon, Rath, & Stakelum, 2002), more effectively manage finance (Shalloo, Dillon, Rath, & Wallace, 2004), and a study in New Zealand suggests that technologies can enhance animal breeding NZ (Harris, Pryce, & Montgomerie, 2007), and. Studies in Ireland show that the technologies with the highest adoption rates in the pastoral-based system are related to grazing, animal breeding, and financial management (McDonald, Heanue, Pierce, & Horan, 2016).

2.2.1.1 Technology adoption in the pastoral-based system

This section focuses on the different types of technology adoption in New Zealand dairy farming, before examining the same in the Australian context. Both countries favour a pastoral-based farming system.

Understanding the factors that contribute to technology adoption assists in the prioritisation of research and development of future technologies (Rue, Eastwood, Edwards, & Cuthbert, 2020). In dairy farming, milking is the primary task. It not only impacts upon the business and its financial performance, but also the wellbeing of the workers and animal. In pastoral-based dairy systems, this task occupies up to 57% of the annual farm labour time (Taylor et al., 2009). As the herd size increases, so too does the need for on-farm labour (DairyNZ Limited, 2012). In the case of larger herd sizes, there is a continuous need to ensure milking productivity and data which will underpin any business decisions. It is also difficult to identify the cause-and-effect relationship between an increase in herd size and the adoption of technology. Milking facilities have undergone significant improvements which have affected labour productivity positively. In the early 1940s, the back-out-type of dairy farms where dairy and non-dairy cows were housed together was replaced with the walk-through-type. A shortage of labour is one of the primary factors which has contributed to growing milking machine adoption (Hamilton, 1942). Therefore, this model was designed to improve working conditions (Hamilton, 1942). Likewise, in 1960s, the adoption rate of herringbone dairy sheds increased dramatically. This resulted in the batch milking of more dairy cows using less labour units. It also led to better ergonomics and facilitated better herd/farm management. In the year 1963, only a small portion of New Zealand dairy farms (10%) had installed a herringbone system; by 1974, this figure had grown to 70%. As shown in Figure 2.2, from 1963 to 1974, the average herd size grew by 51%, from 74 dairy cows to 112. Currently, there are different types of technology, including Automatic Cluster Removers (ACR), automatic teat sprayers, and automatic drafting. These three technologies have improved labour productivity, especially in the dairy farms utilising a rotary system. Over the years, dairy farmers have been more inclined to adopt technologies which increase labour productivity (Edwards et al., 2015). Improvements in labour productivity have enabled each worker to manage 140 cows as opposed to 50 cows. (DairyNZ Limited, 2013). Consequently, farm workers need to milk more cows that they have less time to check dairy cows' health and detect oestrus during milking. Different types of technology, including activity and milk meters, weigh scales, and Automated Mastitis Detection (AMD) have been developed to help dairy farmers with on-farm decisions (Kamphuis, DelaRue, Burke, & Jago, 2012;

Kamphuis, Rue, Mein, & Jago, 2013). The development of EID, in which signals are coded and transferred (either by radio frequency or infrared light), amongst components of the system, might potentially encourage dairy farmers to adopt technologies such as automatic weigh scales (Edwards et al., 2015).

“Figure removed for Copyright compliance”

Figure 2.2: Increase in herd sizes and labour utilisation
Source: (Edwards et al., 2015)

On dairy farms using either herringbone or rotary systems, the technologies related to data-capture have had the lowest rates of adoption. In contrast, automation technologies have higher rates of adoption rates (Rue et al., 2020). Having sufficient knowledge and the necessary skillset to interpret data is essential in data-capture technologies; automation technologies are less dependent on the operator (Edwards et al., 2015). Dairy farmers operating data-capture technologies are less satisfied compared to those who have adopted automation technologies. The lower level of satisfaction might be due to dairy farmers not having sufficient knowledge about how to use and interpret the data or difficulties in determining the benefits at a farm-level. Data capture technologies, namely automatic heat detection systems, are most suitable for dairy farmers in the future when using diverse and novice labour (Eastwood et al., 2020).

Automation technologies can mostly be found in dairy farms with rotary sheds (Edwards et al., 2015; Rue et al., 2020). They are more likely to be found in dairy farms with larger herd sizes, as such technologies benefit dairy farmers in terms of labour costs. They also enable them to make better decisions. In New Zealand, farmers prefer labour saving technologies. The technologies which benefit dairy farmers with herringbone systems the most are automatic plant, vat, and yard washing systems: these technologies reduce the workload associated with cleaning after milk harvesting. Farmers who have rotary systems benefit the most from automatic drafting systems, teat sprayers, and cluster removal (Edwards et al., 2015). Dairy farmers who have herringbone systems favour automatic drafting systems over automatic teat sprays (Edwards, 2013; Edwards, O'Brien, Lopez-Villalobos, & Jago, 2013).

There is the potential for an increase in technology adoption when the herd size gets larger. When the herd size is large, a farm worker has more jobs to perform and more cows to milk and they will have less time to spend with each cow; therefore, it is less likely that a worker would notice problems related to the dairy cow’s health. In this case, technologies which monitor the cows’ health, including activity and milk meters, AMD, and weigh scales would be helpful. Technologies which are used for the purpose of monitoring a herd's health can be adopted to lessen the workers' stress levels and/or decrease the difficulties associated with working with a less experienced workforce. Reducing stress levels and fatigue might be prime factors for the adoption of technologies such as ACR which do not contribute much in terms of productivity in herringbone systems. So, apart from labour efficiency and savings on hired labour, there are other factors like more effective milking, decreased stress levels, better flexibility in terms of milking task, and effective animal monitoring which can be considered in the adoption of these technologies (Edwards et al., 2015).

Reports from dairy industry bodies including Agriculture and Horticulture Development Board (AHDB) (2016) and Livestock Improvement Corporation Limited & DairyNZ Limited (2016) show that while most of the primary dairy regions in the world have seen declines in the number of dairy farms, the average herd size and milk yield of each herd have increased. In Australia, dairy farms that have herd sizes of more than 500 cows have adopted two to five times more precision technologies. Technologies such as Electronic Identification (EID), automatic milk plants, automatic cup removers, herd management systems, and milk plants are found primarily in larger dairy farms. Service providers in the dairy farming sector have predicted a greater adoption of AMS and walk over weighing systems. The most popular technologies are those which save farmers money on labour costs and increase productivity. Farmers are also more likely to purchase those technologies which do not require a high level of skills and those which are readily available. But it is found that the adoption of data-capture technologies which are designed to monitor farm systems will increase by the year 2025 (Gargiulo, Eastwood, Garcia, & Lyons, 2018).

Automatic cup removers are the most commonly used form of technology. They enhance milking consistency and labour productivity (Tarrant & Armstrong, 2012). They also alleviate the occurrence of over-milking, help to preserve the teat condition, and ensure a high quality of milk (Jago, Burke, & Williamson, 2010). Other factors that contribute to the high adoption rates include the lower cost of this technology and the ease of use (Gargiulo et al., 2018). In Australia, the use of automatic cup removers has been increasing over the years. This type of technology is mostly used in herringbone sheds rather than rotary ones (Gargiulo et al., 2018; Watson, 2009).

Most Australian dairy farmers have increased the portion of concentrates and grains in bail. Automating this task can potentially enhance labour productivity during the milking event. The adoption of automatic feeding systems has been higher in rotary sheds than herringbones due to them being inexpensive and easy to install (Gargiulo et al., 2018).

Automatic milk plant wash technology helps to save on labour, ensure that the processes are followed consistently, and alleviate health and safety concerns related to the management of hot water and chemicals (Reinemann, Wolters, Billon, Lind, & Rasmussen, 2003). This type of technology is popular in Australia and has mainly been adopted in rotary sheds rather than herringbone ones (Gargiulo et al., 2018; Watson, 2009).

EID was introduced to Australia in 1999. This technology makes it possible to manage individual dairy cows as data is sent to a computer. It is essential for dairy farmers who need to shift their dairy cows between properties. The adoption rate of this technology has been much higher in dairy farms which have a larger herd size (more than 500 dairy cows) compared to small dairy farms (Gargiulo et al., 2018). Most of larger dairy farms which use EID also use automatic sorting gates. The adoption rate of both types of technologies has been growing over the years (Gargiulo et al., 2018; Watson, 2009).

Regardless of herd size, there has been a similar rate of technology adoption for animal or feed monitoring systems (Gargiulo et al., 2018). The issues associated with these technologies include not being compatible with specific conditions such as the grazing system, being available to dairy farmers lately, to some extent unknown to the dairy farmers, costing dairy farmers more, and dairy farmers do not know how to operate them. There is a lower adoption rate for these technologies (Borchers & Bewley, 2015). For instance, walk over weighing technologies provide comprehensive information about breeding and variation that can be applied in decisions about health management, feed, and reproduction (Maltz, 2015).

In Australia, although the adoption rate of AMS has been slow (with approximately 40 dairy farms by 2017), experts predict that in the next decade it will become one of the top five technologies. This is due to growing labour shortages and increased recognition of the importance of managing and monitoring dairy cows at an individual level (Jacobs & Siegford, 2012; Lyons, Kerrisk, & Garcia, 2014). However, dairy farmers do not expect the rate of AMS adoption to increase as much as the service providers (Gargiulo et al., 2018).

2.2.1.2 Characteristic of dairy farmers who adopt technology

In New Zealand, dairy farmers can be categorised into two groups dependent on their adoption of technology: fast and slow adopters (Edwards et al., 2015). Both groups have positive perceptions about the impact of technology and its ability to make life easier. Fast technology adopters tend to be younger, work on bigger dairy farms with a larger herd, and have newer milking sheds (most often rotary sheds). (Edwards et al., 2015; Rue et al., 2020). Fast technology adopters mostly favour complex types of technology (for instance, AMD) since they have already adopted simpler types of technology, including automatic yard washing systems (which are more favourable to slow technology adopters). A dairy farmer’s attitude and his/her particular requirements can affect their decision on whether to invest in technology or not (Edwards et al., 2015).

Globally, there are numerous studies showing that there are individual factors which contribute to the successful adoption of technology. These factors include the farmer's age (Connolly & Woods, 2010; Edwards-Jones, 2006; Gloy & LaDue, 2002; Solano, León, Pérez, & Herrero, 2003), their years of experience (Paudel, Gauthier, Westra, & Hall, 2008; Rezaei & Bagheri, 2011; Shahin, 2004), their financial position (Mishra, El-Osta, & Steele, 1999), their level of education (Edwards-Jones, 2006; El-Osta & Morehart, 1999; Mishra, Wilson, & Williams, 2009; Paudel et al., 2008; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008; Shahin, 2004), their gender (Edwards-Jones, 2006), the financial position of the farm (Boz, Akbay, Bas, & Budak, 2011; El-Osta & Morehart, 1999; Mishra et al., 1999; Paudel et al., 2008; Prokopy et al., 2008; Shahin, 2004), their involvement in advisory programmes (Howley, Donoghue, & Heanue, 2012), mass media exposure (Shahin, 2004), their level of interaction with third parties, including veterinarians (Shahin, 2004), their access to sources of information (Prokopy et al., 2008), their use of social networks (Prokopy et al., 2008), how complicated the technology is to use (Douthwaite, Keatinge, & Park, 2001), environmental awareness (Prokopy et al., 2008), and the existence of a successor (Howley et al., 2012; Paudel et al., 2008). Young farmers are recognised to be more innovative, farm at a higher level of intensity, have greater holdings, and have higher levels of education (Prokopy et al., 2008; Wilson, Lewis, & Ackroyd, 2014). In addition, technology adopters have often identified a successor to carry on the farming business and thus are concerned about providing their successor with a profitable business (Howley et al., 2012).

It is important to understand the factors affecting farmers' adoption of technology. For example, the results from an American study show that the older a farmer is, the less likely s/he is to adopt innovation and technology (Barham, Foltz, Jackson-Smith, & Moon, 2004). Apart from economic factors, both farmer and technology characteristics can encourage a farmer to adopt technology. For this to occur, the technology should be simple to adopt, have transparent economic benefits, be simple to use, and avoid further complication to the pre-existing system (Rogers, 2010).

2.3 Automatic Milking System (AMS)

In the western world, the milking process has evolved from using hands and buckets to automatic milking machines (Driessen & Heutinck, 2015). A milking machine consists of a pump which is attached by tubes to teat cups. It replicates the milking process completed by the dairy farmer and/or farm staff (De Koning & Rodenburg, 2004; Driessen & Heutinck, 2015). Milking commonly takes place twice a day; one session early in the morning and another one in the late afternoon. This labour-intensive task involves cleaning each cow's udder, attaching the milking cups to the cows, observing and checking each cow's condition and then harvesting the milk. In smaller farms, milking is mainly undertaken by farm staff or family members; however, in larger scale dairy farms, milking is often undertaken in shifts by farm staff (Driessen & Heutinck, 2015). The most common milking machines are herringbone and rotary. Much less common is the Automatic Milking System (AMS). In the herringbone or fishbone system, there is an elevated platform and a central sunken pit to give the cows space to stand whilst they are being milked. The milking machine is placed within or above the pit and a set of milking cups are attached manually by the staff to the cow's udder (from the back or front) for the purpose of harvesting the milk. In the rotary system, the cows enter a stall in a large circular elevated platform. Similar to the herringbone system, staff attach the cups to the cow's udder. Unlike these two systems, in the Automatic Milking System (AMS), cows voluntarily move to the milking shed at any time and the milking robots work all day. Without staff involvement, the milking robot attach the cups to the cow's udders and milk the cows (Dairy Australia, 2019).

Over the years, automatic milking machines have been developed to milk the cows automatically. These robotic milking machines present an alternative to the conventional milking parlour system (Driessen & Heutinck, 2015). Robotic milking machines form part of an overall automatic milking system (AMS). AMS has become more common on dairy farms around the world, particularly for those farms with small herd sizes, and in barn-based systems (Dairy Australia Limited, 2014). There are differences between the conventional parlour milking system and AMS. American and Australian studies conclude that the differences include the need for the voluntary movement of the cows, and potentially, the opportunity for 24-hour access to milking, which is referred as distributed milking (Deming, Bergeron, Leslie, & DeVries, 2013; Kerrisk, 2008a). The voluntary movement of the cows refers to the fact that the dairy cows have the freedom to voluntarily visit the milking stalls, decide when to be milked, and move around the farm (Driessen & Heutinck, 2015; Jacobs & Siegford, 2012; King & DeVries, 2018). In other words, there is no specific milking time so milking can take place during the day or night, depending on the system's capacity, cow traffic, and the milk permission settings (Kerrisk, 2008a). The AMS allows the dairy farmers to select the most suitable or preferred operation system for their needs. For instance, if the farmer prefers batch milking at certain times, the cows can be brought to the AMS to be milked by the robots (Kerrisk, 2008, February). In contrast, in the conventional parlour milking system, the farmer or the staff brings the cows to the waiting area at specific times and they are forced to enter the milking parlour (Halachmi, Adan, Van Der Wal, Van Beek, & Heesterbeek, 2003).

An Australian dairy industry body shows that AMS is suitable for various herd sizes and dairy farming systems. The AMS is not only a new method for milking dairy cows, but also represents a new way to run a dairy farm. When converting from conventional to automatic milking systems, most of the dairy farms require modifications (Dairy Australia Limited, 2014). This new system has not only created noticeable modifications and changes in the milking event itself but also in terms of the conventional farm system (Lyons & Kerrisk, 2017). This includes changes to farm layout, the pastoral-based grazing system, and the traffic system, all of which result in changes to the dairy farmers' management practices (Dairy Australia Limited, 2014). A Swedish study indicates that the success of the AMS relies on the voluntary and individual movements of the dairy cow entering and exiting the milking stall without intervention or assistance from farm staff and/or its herd. As a consequence, understanding the interactions between the dairy cows and the surrounding environment's impact on a cow's movement through the AMS as well as changes in the farm layout are of substantial importance to the AMS' success. For this reason, a large waiting area in front of the milking stalls should be provided to decrease competition amongst the cows so that they can access the milking stalls (Hermans, Melin, Petterson, & Wiktorsson, 2004). In America, most farms which use AMS include both entrance and exit lanes and gates to encourage an efficient queue for pre and post milking events, and to decrease negative social interactions which may affect the frequency of a cow's AMS visits (Jacobs, Ananyeva, & Siegford, 2012).

In the pastoral-based farming system, cows freely graze in the pasture; therefore, they are further away from milking robots. Consequently, as indicated in a study looking across a number of countries, it is more difficult to obtain regularly distributed milking events when using a pastoral-based system compared to a barn faming system (Rodenburg, 2017). In Australia, AMS requires the pasture to be divided into three sections by the dairy farmers every day (Kerrisk & Ravenhill, 2010). This results in increased cow traffic, greater milking frequency, and milk production during early lactation and late lactation when it is more difficult to motivate the cows (Lyons, Kerrisk, & Garcia, 2013). In countries which favour a pastoral-based system with AMS such as Australia, New Zealand, and Ireland, farmers must choose the right pasture to ensure they make a profit (Kerrisk, 2008d). An Australian study finds that poor pasture allocation affects the milking frequency, the movement of cows, the utilisation of the pasture, and ultimately the milk yield (Kerrisk, 2008c). Previous studies have shown that dairy farmers who have good pasture management skills when using conventional milking systems are often just as capable when using AMS. As noted above, compared to conventional milking systems, AMS requires more precise pasture allocation. If the dairy cows have excessive daily access to the pasture, they will not leave the pasture to be milked. In the AMS, when there is restricted access to the pasture, during and after milking, the AMS box and feed pad provide cows with a balanced portion of feed. Feed is the primary incentive to the dairy cows. Cows will leave the paddocks and go to the milking shed where they will be rewarded with supplementary feed or a fresh break of pasture. In both cases, dairy cows go through auto-drafting gates, which are set to move the dairy cows to pasture, or milking stalls based on specific circumstances, including when they were last milked. This set up effectively means that the dairy cows run out of pasture two times a day. Similar to the conventional milking systems, if the dairy cows graze the pasture insufficiently, they will be returned to the break or pasture to maintain the pasture's quality (Kerrisk, 2008d).

The AMS milking stall includes different entry and exit gates to guide the dairy cows to the AMS and back to the barn or pasture (Jago & Kerrisk, 2011). Rodenburg (2017) indicates that there are four types of traffic systems which are practiced in pastoral-based and barn systems to guide the movement of dairy cows. The traffic system can have an impact on labour productivity, feeding approaches, and a cow's comfort. Therefore, dairy farmers must select the most suitable traffic system for their farm. The four different types of traffic systems are outlined below:

- Free cow traffic system

In this system, cows can freely access the AMS, and resting or feeding areas of the barn (Rodenburg, 2017; Tremblay et al., 2016).

- Guided cow traffic system

In different forced traffic systems, the level of directing dairy cows (in terms of movement) differs. These traffic systems guide the movements from the resting zone to the AMS milking stalls before providing access to the feed lanes. In firmly forced traffic systems, dairy cows must be milked before they can access the feed zone (Melin, Hermans, Pettersson, & Wiktorsson, 2006). In this system, one-way gates block the resting zone and the feeding zone. Therefore, dairy cows departing the resting zone must go through the AMS milking stalls to be milked (if they have permission). After going through the AMS milking stalls, the cows are sent to the feeding zone and can return to the resting zone through a one-way gate (Halachmi, Shoshani, Solomon, Maltz, & Miron, 2009; Rodenburg, 2017). Some European studies have claimed that this traffic system encourages more dairy cows to visit the AMS milking stalls (Bach, Devant, Igleasias, & Ferrer, 2009; Ketelaar-de Lauwere et al., 2000). On average, the milking frequency is almost the same for both free and guided traffic systems (Hermans, Ipema, Stefanowska, & Metz, 2003; Munksgaard, Rushen, De Passillé, & Krohn, 2011). This system is not only used in the barn system, but also in pastoral-based systems where dairy cows go through pre-milking drafting gates, meaning there is limited access to the AMS milking stalls (Kerrisk & Ravenhill, 2010).

- Guided cow traffic system with pre-selection

This system provides an extra entry lane. Here a gate guides cows with milking permission to the AMS milking stalls and returns cows without milking permission to the feeding zone. Dairy cows with milking permission go through the milking stalls. This system decreases the wait time for both the milking event and feed (Rodenburg, 2017).

- First feed guided cow traffic system

This system is opposite to the guided cow traffic system as it uses pre-selection. In this system, after feeding, the cows are selected on their way to the stalls. Dairy cows with milking permission are guided to a waiting area to be milked on their way to the stalls. Dairy cows who do not have permission to be milked are guided to the resting zone (Rodenburg, 2017).

There are two types of AMS: the single box and the multi box. In a single box AMS, a cow's milk is taken at one time in a milking stall using a robotic arm. Each single box AMS is capable of performing 150 milking events per day; in other words, it can milk 60 to 70 dairy cows per day. A substitute for a single box AMS is the multi box AMS with a robot arm performing across more than a milking stall. The multi box AMS has the capability to milk more dairy cows per robotic arm, but with a smaller number of dairy cows per milking stall. This type of AMS is considered less time-consuming because when the milking cups are attached to one dairy cow in a milking stall, it can milk another dairy cow in another milking stall (Kerrisk, 2008a).

As shown in Figure 2.3, the AMS consists of several components: the identification of each cow, supplementary feed, the milking stall, the teat detection system, the robotic arm which attaches the cups to the cows' teats and removes them, the teat cleaning system, the automated monitoring and recording system, and the milking machine (DairyNZ, n.d.; Jago & Kerrisk, 2011; Kerrisk, 2008a). The dairy cows are required to wear a unique electronic identification collar which enables them to be recognised at the gates in the pastoral-based and barn-based farming systems and milking stalls (Kerrisk, 2008a). When a dairy cow goes through the entrance gate, the identification tag is scanned, and they are then able to enter the milking stall. As a result of the cow's tag number, the AMS knows the shape of a cow's physical body and the position of its udder, its last milking event, and how much milk it produced. It also records the milk production for each teat. In the next step, the robot's arm with cleaning brush or cups, sanitises the teats. The teats are detected by laser and the milking cups are attached. Unlike the milking event in the conventional milking system which milk the whole udder, in AMS, each quarter of the cow is milked separately. Consequently, dairy farmers have access to production data at an individual quarter of the cows. AMS also measures and records milk quality parameters, including the milk colour and conductivity (Dairy Australia Limited, 2014). In the last step, the milking cups sucks the milk out (Varinsky, 2017). The milk is taken from each quarter of the cow separately and is based on the milk flow of each of the cow's teats that the cups are attached to. Consequently, overmilking of each quarter is avoided (Kerrisk, 2008a). AMS and its software identify the cows by using sensors. This system can also detect abnormalities in the harvested milk (Driessen & Heutinck, 2015). The AMS software stores data, including operation details, milking quality and quantity (such as the milking intervals), and an individual cow's total and average milk yield (De Koning & Rodenburg, 2004). The AMS settings can be controlled by the AMS management programme;

therefore, a dairy farmer is able to identify and put the dairy cows which did not visit AMS for more than one set of periods on the attention list. These dairy cows can be checked by the dairy farmer and kept in the pre-milking area meaning that they will only be able to leave the area after visiting the AMS (De Koning & Rodenburg, 2004).

While there are a number of AMS manufacturers, with various designs for each of the AMS components, the different designs function in a similar way. The key features are robotic, with the robotic arm performing the primary functions of the system, such as cup attachment. These systems are voluntary meaning that the cow is able to choose when they want to be milked (DairyNZ, n.d.).

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Figure 2.3: Components of AMS
Source: (DairyNZ, n.d.b)

The AMS has an impact on social, economic factors, and animal health and welfare. The AMS impacts the character of the dairy cows and the farmer’s relationship with his/her herd. After the implementation of AMS, the dairy farmers must change as a part of the new system. American farmers often experience stress as a result of the time it takes to switch between a conventional milking system to the AMS (Crowell, 2012). It takes time for dairy farmers to understand and learn the new systems and roles (Driessen & Heutinck, 2015). AMS requires a new view of dairy cows and herd behaviour in order for the new system to work (Heutinck, Van Dooren, & Biewenga, 2004). Dairy farmers experience a new lifestyle: they supervise the dairy cows rather than fetch them. Normally, dairy farmers are known as the hardworking ones, spending long hours at work, with limited hours during weekends. Dairy cows need to be fetched and milked seven days a week early in the morning and late in the afternoon (Driessen & Heutinck, 2015). AMS is a type of automation, a continuous process which raises the production scale and diminishes the role of individuals in dairy farming. Consequently, this helps alleviate the dairy farmer’s need for a large labour force and improves their lifestyle (Driessen & Heutinck, 2015). In Ireland, for example, finding and maintaining both skilled and unskilled labour is a significant challenge for dairy farmers (Shortall, Shalloo, Foley, Sleator, & O’Brien, 2016). In the agriculture sector, dairy farming is known as a labour-intensive sector due to the long hours of work; approximately 48 hours per week (Morrison, 2016). The process of milking is also time-consuming and has a high physical workload. In New Zealand, there is also a high demand for skilled labour (Morrison, 2016). In the AMS, the milking event is carried out without human assistance; as a consequence, the demand for labour decreases (Jacobs et al., 2012; King & DeVries, 2018; Pirlo et al., 2005; Shortall et al., 2016). AMS lessens the physical tasks and workload related to milking, including the attachment and detachment of milking cups, and also eliminates tasks, including the harvesting of milk at specific times (Hogeveen et al., 2004). In AMS, labour involves visually monitoring the milking events and generated data, cleaning, and checking the attention list and the responding to any AMS alarms (Steeneveld, Tauer, Hogeveen, & Lansink, 2012). A Dutch study finds that investment in, and the adoption of, an AMS can improve a dairy farmer's and their staff's physical and mental health (Mathijs, 2004). In addition, farm staff are able to spend fewer and more flexible hours on the tasks associated with milk harvesting. The AMS may help transform the negative image dairy farming (the long work hours, and other labour issues), whilst boosting the occupational health and safety (Kerrisk, 2008b).

Based on the global studies, one of the reasons why AMS was developed was to save time and improve dairy farmers' social lives: it achieves this by freeing the farmers from attending the early morning milking shift and by allowing them to perform other tasks while the cows are being milked (Driessen & Heutinck, 2015; Shortall et al., 2016; Woodford, Brakenrig, & Pangborn, 2015). The reduction in labour units (Hansen, 2015; Tse et al., 2018) and increased time flexibility (Wagner-Storch & Palmer, 2003) mean that the AMS improves dairy farmers' social lives (Bijl, Kooistra, & Hogeveen, 2007; Jacobs et al., 2012; King & DeVries, 2018).

AMS is the result of development in innovation and technology. Converting from a conventional parlour milking system to an AMS leads to significant changes in the way that a farmer manages his/her cows. In AMS, there are modifications to both the farm labour and the dairy cows' behaviour. Some of conventional tasks are replaced with new activities (Calcante et al., 2016). Farmers who use the AMS no longer need to fetch and milk the cows. Those tasks are replaced with new tasks such as training the cows, the management of traffic systems and farm layout, and responding to any AMS alarms (Jago & Kerrisk, 2011; Kerrisk, 2008d).

Previous studies from the Netherlands and America show that AMS is a system which costs two to three times more than conventional milking systems (Driessen & Heutinck, 2015; Rotz, Coiner, & Soder, 2003). The AMS equipment may need replacing (Rotz, Soder, & Riley, 2004). The high capital cost of AMS means that dairy farmers are hesitant to adopt this technology (Common, 2014; Geleynse, 2003). When an AMS is adopted, dairy cows are no longer the only expensive capital on a farm (Driessen & Heutinck, 2015). Dairy farmers are also concerned about profitability and cash flow when switching from conventional milking systems to AMS (Moyes, Ma, McCoy, & Peters, 2014). This is because of the greater capital costs associated with AMS. There are also maintenance and running costs (Jago, 2006; Rotz et al., 2003; Shortall et al., 2016). To evaluate the investment in AMS, one must take into account the impact of investment on long-run profitability and the business' cash availability. Farmers must also consider the return made for the extra investment (Shortall et al., 2016).

In order to calculate the AMS return on investment, one needs to have a particular perspective on dairy farming. The capital and costs of investment, maintenance, and depreciation can be offset with increased milk production and reductions in labour units resulting from greater milking frequency (Van Vugt, 2005). Consequently, it is of importance to make the most of the AMS' capacity by using it for 22 – 24 hour per day. For this reason, dairy farmers are on a time budget (Driessen & Heutinck, 2015). Studies from the Netherlands and Sweden indicate that the AMS provides dairy farmers with the ability to control the frequency of milking events for each individual dairy cow, to alter the milk yield level or certain periods of lactation without incurring additional labour costs (Hogeveen, Ouweltjes, De Koning, & Stelwagen, 2001; Svennersten-Sjaunja & Pettersson, 2008). For instance, a Swedish study shows that dairy cows can be milked more frequently during lactation when producing more milk; therefore, milk production increases (Svennersten-Sjaunja & Pettersson, 2008). In addition, dairy cows are milked based on the milk yield, so cows with higher levels of milk production can be milked more than twice a day. As a result, the average milk production can be increased (Tse et al., 2018). Studies from the Netherlands have found that the adoption of AMS helped dairy farmers to increase milk production from 2% to 20% (Bijl et al., 2007; Wade, Van Asseldonk, Berentsen, Ouweltjes, & Hogeveen, 2004). Previous studies have shown that the adoption of AMS results in reduced labour requirements by between 19% to 30% (Bijl et al., 2007; Mathijs, 2004; Sonck, 1995). The reduction in labour varies from one country to another one (Mathijs, 2004). For instance, Belgian dairy farmers managed to reduce their labour requirements by 28% and Danish ones by 11%. Other studies found that AMS reduced the need for a full-time equivalent labour unit when compared to conventional milking systems (Bijl et al., 2007). One study found that in conventional milking systems, milking accounted for approximately 32% of the total dairy farming tasks. In contrast, using AMS it accounted for approximately 13% of the total labour input (K. O'Donovan et al., 2008). It is important to note that reductions and cost savings in labour units are dependent on the dairy farmer's management capacity (Land et al., 2000).

In the AMS, each individual milking event generates a wide range of information, more than 100 pieces on a daily basis. The generated information consists of milk quality, temperature, body weight, an individual cow's health, and the speed of milking. Dairy farmers can also access information about milk quantity and yield, the level of protein and fat for individual cow's milk. Any health issues can also be detected. The use of colour check and conductivity ease the diagnosis of mastitis. The colour check can be used for other purposes, including to detect blood and colostrum in the milk (Cummins, 2018; Jacobs & Siegford, 2012). The AMS is individually tailored to the cows; in other words, dairy cows are milked based on their production levels. In other words, cows that produce less milk are not overmilked and those which produce more are not undermilked. As the AMS increases the frequency of the milking event, it reduces the stress on the cow's udder. As cows can be milked more frequently, the milk production increases (Halachmi et al., 2003). In the case of a continuous health issue, this system enables dairy farmers to dry off a specific udder (Cummins, 2018). AMS and its health monitoring technology generates daily data and reports for each individual cow. It includes information about the cow's health, behaviour, and production level which assist the dairy farmers in preparing a better health management strategy. It also enables them to detect any illnesses earlier than in the conventional system (Jacobs & Siegford, 2012; Tse et al., 2017). Each dairy cow wears a collar to monitor and detect when it is in heat. This helps to optimise the mating period. The collar works by making comparison between the date of calving and previous heat (Cummins, 2018).

Inflammation of a dairy cow's udder or mammary gland, which is mainly caused by bacteria from Streptococcaceae, Staphlococcaceae, or the Enterobacteriaceae group, is called evolving bovine mastitis (Bradley, 2002). It is usually classified into clinical, sub-clinical, and chronic disease and raises concerns around animal welfare. Studies from the Netherlands find that the economic burden of clinical mastitis, which includes less milk production, treatment, and culling, vary from one dairy farm to another, but typically costs between $36 to $470 per cow annually (Halasa, Huijps, Østerås, & Hogeveen, 2007; Huijps, Lam, & Hogeveen, 2008; Lam et al., 2013). There is demand for trusted automatic mastitis detection because of the time needed to detect cows with mastitis requiring veterinary involvement (Mollenhorst, Rijkaart, & Hogeveen, 2012). AMS includes various milk monitoring and detecting gears such as milk production, rate of milk flow, incomplete milking event, a cow's movements, and electrical conductivity to identify the precise mastitis vigilant guideline (Hogeveen, Kamphuis, Steeneveld, & Mollenhorst, 2010; Hovinen & Pyörälä, 2011; Rutten et al., 2013).

Worldwide, lameness is a costly problem in dairying and occurs frequently in dairy cows. This causes cows pain. It also results in economic loss due to less milk production, the cow's weakened physical condition (Vermunt, 2004). Studies from Australia and the United Kingdom find more economic loss as a result of treatment, the compromised reproductive performance, mortality (Ranjbar, Rabiee, Gunn, & House, 2016), and a greater culling rate (Huxley, 2013). A reduction in milk production due to lameness starts four months prior to the diagnosis of clinical lameness and lasts up to five months after its diagnosis. Lame dairy cows produced less milk; over a 305-day lactation period, the average milk loss is approximately 360kg (Green, Hedges, Schukken, Blowey, & Packington, 2002). The loss of milk yield and impact of lameness on a cow's welfare can be reduced by identifying lameness at an early stage and beginning treatment in a timely manner (Guard, 2004). In AMS, the substantial risk factors for lameness are mainly related to the dairy cow's comfort level due to insufficient stall design, bedding management, overstocking of cows at the AMS, a narrow feet lane, and cow traffic management.

Dairy cows which are experienced in AMS do not have bad tempers and react well to the behaviour of the other cows (Crowell, 2012). The dairy cows are calmer and more relaxed compared to those who are milked using conventional systems (Hopster et al., 2002). As a result, they show much less step and kicking movements during the milking event (Driessen & Heutinck, 2015). Greater kicking frequency may be caused by the discomfort or pain that the cow suffers (Rousing, Bonde, Badsberg, & Sørensen, 2004).

Using AMS, dairy farmers are able to spend more time on farm operations and business management. The AMS herd management programme stores information which is collected automatically by the AMS or manually entered by the dairy farmers. This information can be used to generate reports and charts which in turn enable a farmer to make better management decisions, control and monitor an individual cow's performance and the system itself. The reports and figures help the dairy farmers to manage the farm by excluding sick cows, detecting disease at an early stage, and making practical decisions to increase the productivity of the entire farm (Kerrisk, 2008a).

2.3.1 Requirements of AMS

There are a number of requirements to make AMS work, and some potential issues which are associated with the dairy farmers' expectations: these include changes in the tasks, the flexibility of the dairy farmer, technical support, understanding and dealing with the computer, and the training of the dairy cows (Dairy Australia Limited, 2014; Kerrisk, 2008a & 2008c). It is important for farmers to have realistic expectations about what they wish to achieve by installing milking robots. The benefits of milking robots vary from one farmer to the other. There is also likely to be changes in the process and timing of the farm's tasks and the daily tasks that need to be performed (Dairy Australia Limited, 2014). There is a transition in the traditional focus of dairy farming from manual farm labour to a windowed office overlooking the dairy cows and the use of computers (Driessen & Heutinck, 2015). As compared to conventional systems, voluntary milking systems offer better flexibility in terms of scheduling milking events, the time, and the frequency. This leads to a shift in a dairy farmer's concentration towards other farm tasks, namely feeding the herd, health treatments, breeding, and raising calves (Dairy Australia Limited, 2014). Even though dairy farmers benefit from flexible working hours and days, they are required to be available 24/7 in order to benefit from the milking robots (Crowell, 2012). Dairy farmers need to be flexible. Milking robots work 24 hours a day, seven days a week. Alarms can go off at any time of the day or night. In the case of an alarm, depending on the severity of issue, it may be possible for the dairy farmer or their staff to solve the issue remotely. However, in severe cases, it is necessary to seek help from a properly trained technician via telephone or in person. Operating the milking robots also requires a specific level of computer literacy (Huhtala et al., 2007). It is essential for the dairy farmers to monitor the reports from the milking robot software and manage the cows appropriately (Huhtala et al., 2007). The AMS is significantly dependent on the voluntary and unassisted movement of the dairy cows to the milking stalls; in short, it is necessary to train the cows (Dairy Australia Limited, 2014; Jago & Kerrisk, 2011; Kerrisk, 2008a, 2008c). A farmer must train inexperienced cattle. It takes time for the cows to become familiar with the system. The dairy farm staff play a significant role in training and encouraging the cows to move towards the milking shed (Donohue, Kerrisk, Garcia, Dickeson, & Thomson, 2010). The training process includes exposing the dairy cows to the process and sound of the AMS before attending the first milking event (Jago & Kerrisk, 2011). Making heifers familiar with the AMS before calving has positive impacts on the milking intervals, milk yield, and feed frequency (Kashiwamura et al., 2001; Widegren, 2014). There is no specific procedure for training the dairy cows during the transition to the AMS. Farmers commonly use a supply of grain-based concentrates to motivate the cows to move to the milking stalls (Calcante et al., 2016). The training process not only varies in terms of approaches used but also the duration. During the training process, dairy farmers might experience changes in cow health management (Tse et al., 2017). Efficient training of the dairy cows to voluntarily use the AMS plays an important role in labour unit reductions and diminishing the effects of milk yield during the transition to the AMS. In the training process dairy cows have to learn to walk to the AMS milking stalls, either from the pasture or barn area, get into the milking stalls, wait for the milk harvesting to be completed, and, at the conclusion of the milking event, to leave the stall. Training young cows is difficult because they are hesitant to move into the AMS milking stalls because they are unfamiliar to them. Regardless of herd size, the walking distance and difficulty of the walking path to the AMS milking stalls mean that training is essential in all the AMS processes (Jago & Kerrisk, 2011).

2.3.2 Adoption of AMS

The automation of the milking process has resulted in a revolution in the dairy industry and from there more AMS installation continued happening (De Koning & Rodenburg, 2004). Countries which have adopted and implemented AMS are located mainly in north-western Europe: the Netherlands, Germany, France, Scandinavia, the UK, and Ireland. AMS adoption has also expanded to include North America, Australia, and New Zealand (Driessen & Heutinck, 2015).

In the 1990s, the first AMS was installed in a commercial farm in the Netherlands (De Koning & Rodenburg, 2004). As shown in Figure 2.4, in the 1990s, more manufactures and companies participated in the development of milking robots (Kuipers & Rossing, 1995). By 2003, there were approximately 2,200 dairy farmers across the world using AMS (De Koning & Rodenburg, 2004). By 2008, more than 6,000 dairy farms had adopted AMS. As Figure 3 shows, by 2010, the adoption of milking robots stood at 10,000 dairy farms globally (De Koning, 2011). More than 80% of these were located in north-western Europe where most of the dairy farms are family businesses with small herds. These cows are kept inside during lactation and fed a mixed ration feed. In this case, the cost of labour is high (De Koning & Rodenburg, 2004; Rodenburg, 2008). Of the early adopters, the Netherlands, and Scandinavian countries were ranked at the top (Barkema et al., 2015).

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Figure 2.4: Timeline of AMS innovation in Europe
Source: (Eastwood, Klerkx, & Nettle, 2017)

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Figure 2.5: Worldwide adoption of robotic milking systems over time
Source: (De Koning, 2011)

In Canada, the first AMS was introduced at the University of Guelph. Since then, AMS has been adopted in other regions like Ontario, Quebec, and Nova Scotia. In Quebec and Ontario, there was a similar rate of AMS adoption; there were approximately 50 AMS operating in 30 dairy farms (Geleynse, 2003). By the end of 2012, the adoption rate of AMS had grown to 273 dairy farms which, at that time, represented 3% of the dairy farms across all regions. Amongst the regions, Manitoba had a greatest rate of AMS adoption, approximately 12.1%. This was followed by British Colombia at 6% and Alberta at 5.2% (The Bullvine, 2013).

There are many reasons why farmers in the Netherlands and Canada have adopted AMS in their barn-based systems. The reasons include reducing labour units, upgrading their milking sheds, increasing the milking frequency, and to have a better lifestyle and flexibility.

In America, in a conventional milking parlour, the milking task requires two staff to work 12 hour per day, including the weekends. Dairy farmers cannot afford to have more staff working on their farms and depend on non-family staff (Griekspoor, 2018). AMS adoption reduces the cost and units of labour (Griekspoor, 2018; Rodenburg & House, 2007; Rushen, 2017). Replacing and upgrading old holding tanks and milking parlours have also contributed to AMS adoption (Griekspoor, 2018). The AMS presents dairy farmers with an alternative to potentially increase the milking frequency, resulting in an increase in milk production (Rushen, 2017). This means that farmers can offset the cost of the AMS with increased milk production and reduced labour units and costs (Griekspoor, 2018). At the same time, dairy farmers are able to have more leisure time (Griekspoor, 2018; Pengelly, 2017). The AMS thus represents a good solution for dairy farmers seeking to have more flexibility at work, for those wanting to complete other farm tasks or those who want to spend more time with family members (Milkproduction, 2014; Rodenburg & House, 2007), and also for dairy farmers who are tied to the daily routine of milking three times a day (Common, 2014). The other reasons that dairy farmers adopt AMS in barn systems include improving work quality and conditions, improving animal health and welfare, ensuring sustainable dairy farming, coping with labour shortages (The Bullvine, 2013, July), reducing costs related to buildings, a willingness to be innovative, reducing their physical workload, wanting to expand their business without having to employ non-family staff, and farmers' concerns about their health (Rodenburg & House, 2007). In addition to the reasons outlined above for AMS adoption in barn-based system, dairy farmers achieve better feed management, improved animal health, welfare, and freedom, and herd size expansion.

Based on collected and generated data from individual cows, AMS helps dairy farmers to have better feed management in the milking stalls based on cows' body condition, amount of milk yield, and place of gestational cycle of the dairy cows. Consequently, the dairy cows receive an appropriate portion of concentrated feed in the milking stalls (Griekspoor, 2018).

Most Canadian dairy farmers who adopted AMS were satisfied with their decision and felt that their expectations had been met, especially after making more profit, seeing increased conception rates, and enjoying a better quality of life (Rushen, 2017; Tse et al., 2017; Tse et al., 2018). However, dairy farmers face challenges during the transition period, including learning how to use the technology and interpreting the generated data, changes in health management, and cow training (Tse et al., 2018).

The collected data and generated reports of individual cows and their production levels are promptly available in the AMS software which helps dairy farmers to manage their dairy cow's health and welfare (Common, 2014; Rushen, 2017; Tse et al., 2017; Tse et al., 2018), identify problems and sicknesses related to their dairy cows, and take timely actions (Griekspoor, 2018, May; Pengelly, 2017). For instance, in some cases, before a dairy farmer was able to spot changes in a cow's behaviour, using AMS, they are able to identify and isolate dairy cows suffering from a health issue at an early stage, separate the affected milk from the milk tank, and use the milk for the heifers (Griekspoor, 2018). In the AMS process, the cows have the freedom to follow their natural routine in terms of feed, movement, and milking events. In other words, dairy cows are not forced to follow the dairy farmer's schedule. Subsequently, dairy cows are more relaxed and comfortable (Common, 2014; Geleynse, 2003; Pengelly, 2017).

One of the pre-requirements of AMS installation is to make changes in the layout and infrastructure of the dairy farm. The dairy farmers who adopted an AMS found it easy to install more AMS since they had the required infrastructure and thus were able to expand their herd size (Griekspoor, 2018; Rodenburg, 2008; Tse et al., 2017).

Despite the noticeable adoption of AMS in barn-based systems, there is there been considerable adoption of AMS in pastoral-based dairy farming systems (John et al., 2016). In countries like Australia (Greenall et al., 2004), New Zealand (Woolford et al., 2004), and Ireland (O'Brien, 2012), AMS is mostly installed in complete pastoral-based farming systems. In these countries, grazing is of significant importance, as it allows farmers to produce low-cost milk (De Koning, 2011), and adoption of AMS is under different circumstances when compared to Europe (Woolford et al., 2004).

The first AMS installed in New Zealand was in 2001. The Greenfield Project in Hamilton wanted to examine the viability of the technology in a pastoral-based dairy farming system. It took until 2008 for two commercial farms to adopt the technology. Figure 2.6 shows that between 2001 and 2013 there was gradual growth in the adoption rate of AMS in New Zealand, with most of the growth occurring in the latter four years of that period, culminating in 15 dairy farms milking their cows using AMS. From 2013 to 2018, more dairy farmers introduced AMS on their farms. There are currently approximately 27 dairy farms in New Zealand operating AMS. Adopters are a combination of pastoral-based, barn-based, and hybrid dairy farming systems (DairyNZ, n.d.a). Most of the famers who have adopted AMS have smaller herds (Hardie, 2015), and are not intending to pass their farms onto their children or expand their herd size (Harrigan, 2016).

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Figure 2.6: AMS adoption in New Zealand
Source: (DairyNZ, n.d.a)

In Australia, AMS operation began in 2001 (Greenall et al., 2004). As with New Zealand, there were no new commercial installations until 2008 (Molfino, Kerrisk, & García, 2014a). Today, there are 43 dairy farms operating AMS, most with just under 300 dairy cows. These AMS milk 10,500 dairy cows, which accounts for approximately 60 million litres of milk every year. AMS have been installed in various farming systems, including barn-based systems (10% of the farms), corral systems (6% of the farms), and grazing with variable levels of supplementation (Lyons & Kerrisk, 2017).

In Ireland, there are 18,000 dairy farmers who milk approximately 1.4 million of the total dairy cows grazing in the farms (Teagasc, 2017). There are less than 20 dairy farms with AMS in the north and south of Ireland (Teagasc, 2013) which means less than 1% of the dairy farmers use AMS (Tuohy, Upton, O'Brien, & Quigley, 2019). The demand for AMS has grown noticeably in the Irish dairy sector. It is expected that in the next few years, almost half of the milking equipment will be automated, and farmers will use smart gear (Healy, 2015).

In European countries, the AMS adoption rate has been rapidly expanding (De Koning, 2010). However, the adoption and use of AMS has been slow in Australia and New Zealand (Eastwood, Kenny, & Nettle, 2011). The main reasons for the slow rate of AMS adoption include financial restrictions due to low milk prices and drought, bigger than average herd sizes, differences in dairy farming systems, including barn-based system and pastoral-based systems in New Zealand, technology acceptance and dairy farmers' attitude, the cost of AMS, and the lack of AMS knowledge and support (Eastwood et al., 2011). Irish studies have also identified the challenges associated with getting dairy cows to voluntarily move from the pasture to the AMS and have argued that this is a major barrier to AMS adoption (Donnelly, 2015). However, in these three countries some dairy farmers have adopted AMS. The reasons for adopting AMS vary in accordance with each dairy farmer's needs and expectations. The most important factors include the desire for a better lifestyle (in terms of planning for semi-retirement), better managing the physical nature of dairying, reducing health worries, reducing labour and hours worked, the potential for improved profitability through reduced labour costs, perceived animal health benefits, and experiencing new technology.

A better or more balanced lifestyle is one of the major or contributing factors in AMS adoption. Many young dairy farmers have reported wanting to spend more quality time with their partners and children (Molfino et al., 2014e). Moreover, dairy farmers also want to have an improved lifestyle in their old age; most rely on family labour (Molfino, Kerrisk, & Monks, 2014f). These farmers saw AMS as one way to improve their work/life balance. Some also talked about considering their medium to long-term goals and desire to transition to semi-retirement (Kerrisk, 2014). The dairy farmers believed that AMS would provide an opportunity to remain in the dairy industry without the hassle of milking the cows twice a day (Molfino, Kerrisk, & Monks, 2014d).

In addition, many farmers were concerned with better managing the physical nature of dairy tasks. Milking dairy cows requires intensive physical ability and it is considered time-consuming (Hardie, 2015). The vast majority of elderly dairy farmers have worked on their dairy farms for many years. However, as they age, this task becomes increasingly hard as a result of physical difficulties (Hardie, 2015). Many also reported losing the incentive to milk the cows (Haldane, 2018). This issue arises when the dairy farmer has temporary physical disabilities, namely injuries (Hardie, 2015). In other cases, dairy farmers considered AMS when they were faced with serious or ongoing health issues. Other factors include ameliorating health conditions and reduce the reliance on employed labour (Molfino, Kerrisk, & Monks, 2014b).

Some small dairy farms have limited capacity, resources, and space and also suffer from lower levels of income. For these reasons, it may be hard to hire employees, a farm manager, or sharemilker to complete the farm jobs. Two of the contributing factors for considering technology and AMS are the long intensive work hours associated with dairying and challenges in recruiting workers (Allen, 2017). Running a dairy farm requires long hours of work in order to get the jobs done. Dairy farmers have revealed that they regularly spend up to 60 hours a week carrying out the tasks. The AMS appeals to farmers because of its ability to potentially reduce their work hours (Kerrisk, 2014). Some dairy farmers have reported challenges associated with keeping a reliable workforce which would enable them to reduce their work hours. This might be due to factors such as the location of the farm (many are located in remote regions), the long distance between the farm and the nearest town, and employees' reluctance to work long hours on a dairy farm (Kerrisk, 2014; Molfino et al., 2014f). In these instances, AMS was found to be a viable alternative, because it offers the chance to decrease the labour unit (even with more cows) and to save on labour costs (Molfino et al., 2014b & 2014e), as well as increasing the herd size.

One study found that AMS adoption was related to farmers' desire to boost milk production per cow and maintain profitability, whilst decreasing the herd size, related workload, and labour unit. Prior studies have found that AMS not only reduces the cost of labour, but also the cost of animal health. These costs offset the high investment capital needed to install and run AMS (Deavoll, 2015).

An interest in technology and automation systems is one of the reasons that farmers adopt AMS. The other reason for AMS adoption is experiencing a new and different system resulting in self-satisfaction without being imposed to much tax. One farmer noted that finances are not the only consideration, but that sometimes you do something simply because you want to (Brown, 2014).

In addition to the reasons for AMS adoption, the dairy farmers need an improved set of skills including computer and management skills in terms of farm management, health management of the dairy cows, and milk production and quality.

AMS relies on technology and systems. In order to deal with AMS, dairy farmers need to learn about the technology and gain particular computer skills (Kerrisk, 2014). Developments in technology can assist dairy farmers in running their farms remotely (to a certain extent), such as changing the gates (Molfino, Kerrisk, & Monks, 2014c). It is also possible that a high level of technology in a dairy farm appeals to the younger generation and encourages them to work in the dairy industry (Molfino et al., 2014e). Although AMS requires computer skills, it is user-friendly and easy to use. It provides a useful back-up service and comprehensive information about individual cows which results in well-organised management and farm operation. For instance, before installing AMS, one farmer was concerned about separating the dry cow from the milking cows. The farmer had to use paint or tape around the cow's tail to distinguish between the cows. The AMS has facilitated useful and more likely to be actioned data (Pickett, 2017). Farmers can use this detailed and comprehensive information about each of their cows to make informed business decisions (Brown, 2014; Pickett, 2017). The voluntary milking system records details about each cow and provides dairy farmers with in-depth analysis. This makes it possible for the farmers to make better decisions at an earlier stage (Kerrisk, 2014; Molfino et al., 2014f). The AMS' wide range of information is an important management tool as it contributes to better milk quality and quantity (Molfino et al., 2014b). In the AMS database system there is no room for human mistake or error. The database includes information about every milking event, each cow's weight, level of activity, feed intake, and milk yield and composition. If there are any changes in the cow's condition, the AMS is able to inform the farmer immediately (Brown, 2014; Pickett, 2017). For example, if a cow has a health issue, the AMS will alert the farmer via his/her smartphone. In addition, robot sensors provide a detailed information of individual cow to be given to AMS technicians in case of issues occurs (Hardie, 2015). The AMS cameras and alarms around the farm enable technicians to fix the problem even before the farmer is alerted (Hardie, 2015). Moreover, having access to information via a smartphone has made it possible for farmers to monitor the farm's operation from any place (Hardie, 2015). The alert system and the timeliness of the milking robot systems means that there less lame and sick cows (Haldane, 2018). Information produced via AMS software enables dairy farmers to analyse and monitor the performance of their farms at an advanced level (Agriland Team, 2017 & 2018; Molfino et al., 2014c).

AMS provides a voluntary milking system for the cows. In other words, the cows have unlimited and unrestricted access to the milking shed resulting in less pressure on their udders which has positive effect on a cow's health (Agriland Team, 2017; Brown, 2014). Some farmers have also found that their cows are heavier, healthier, and visibly more content after AMS installation (Haldane, 2018). The AMS has also made it possible to increase production (Deavoll, 2015). One farmer increased their milk production from 450 kg milk solids (MS) to 505 kg MS per cow in the initial year of operating AMS (Brown, 2014). Another noticeable example is a 20% increase in production despite having 40 fewer cows (Haldane, 2018). Using AMS enabled a dairy farmer to hit the milking production target with a smaller herd size (Kerrisk, 2014) and boost production levels without the need for extra staff (Agriland Team, 2018; Molfino et al., 2014c & 2014e; Ryan, 2017). Noticeably, after introducing AMS one dairy farmer experienced less clinical cases of mastitis (Pickett, 2017), and another, less lameness (Deavoll, 2015) due to the conductivity sensors. AMS enables dairy cows voluntarily to move on their own freely from the pasture to the milking robots (Deavoll, 2015; Haldane, 2018). After installing AMS, one dairy farmer noted that the cows were calmer, there were less cases of mastitis case and lame cows, and the cows lived longer (Molfino et al., 2014b, 2014c, & 2014e). AMS is capable of detecting whether there is blood or colostrum in the milk. Therefore, the farm staff are able to make sure that the milk does not reach the main vat (Pickett, 2017).

2.4 Conclusion

The reasons for adopting AMS and the farmers' achievements in both pastoral-based and barn-based systems are similar to each other. AMS offers dairy farmers a wide range of benefits. Some dairy farmers are interested in experiencing automatic systems and thus install them on their farms; however, this means that farmers must learn computer skills and need to interpret a wide range of detailed information and reports. Any failure in generating and interpreting the reports means that the farmer may not be able to make a right decision at an early stage. For many farmers, a better lifestyle is one of the primary considerations in the adoption of AMS. It allows the farmers to reduce the amount of physical work, and to have more flexible working days and hours. In other words, the farmer and their staff no longer need to wake up early in the morning to milk the cows, nor do they need to spend hours milking them. However, as the AMS operates 24/7, farmers must be prepared to deal with any issues. Despite reducing a farmer's need for labour, the nature of AMS means that is essential to have at least one person who is computer literate and able to monitor the milking software. While there are reduced labour costs, there are still costs associated with AMS, including high capital costs, maintenance costs and the cost of implementing the system.

While studies have reported that AMS can increase milk production, this relies on correctly training the cows to eliminate intervals between milking events. In short, it is crucial that farmers consider their expectations and needs before installing an AMS. Lastly, the data and reports about individual cows generated by AMS can help a dairy farmer to identify issues related to the health of that cow at an early stage and to act in a timely matter.

The aim of this research was to identify the critical factors influencing successful adoption of AMS in New Zealand pastoral-based dairy farms. There is a limited literature about the characteristics of New Zealand dairy farmers who have adopted or have not adopted AMS in pastoral-based dairy farming systems, their perceptions of AMS, the benefits and challenges associated with AMS adoption, reasons (or barriers) which contribute to its adoption.

Chapter 3

Methodology

This chapter provides an overview of the research design and approach, the theoretical framework, the data collection methods, and analysis of the data.

3.1 Research design and approach

Research design can be defined as the overall strategy which governs the research. A research design acts as a blueprint or plan which enables the researchers to answer a precise research question. A research design includes three primary components: the plan, the structure, and the strategy (Burns, Grove, & Gray, 2015). Taking elements of the research design into consideration helps a researcher to determine a hypothesis, conduct the research, and analyse and interpret the collected data (Bloomfield & Fisher, 2019).

There are two main approaches used: inductive and deductive (Adams, Khan, & Raeside, 2014). The inductive approach is associated with Mill (1869). Poincaré (1905) formulated the deductive approach in the beginning of the twentieth century, which was later developed by Popper (2005).

The inductive approach depends on the empirical confirmation of a general conclusion obtained from a limited number of observations. If an event reoccurs several times, then it can be concluded that the event will keep happening. This approach works from the particular to the general (Adams et al., 2014). This approach, which relies on qualitative data, believes that observations reveal patterns of a particular variable of interest. These patterns are used to generate a general theory about the nature and behaviour of that particular variable (Adams et al., 2014; Johnsen, 2011). The inductive approach is a flexible approach capable of accommodating unexpected issues which occur during the research (Johnsen, 2011). When there is limited or no existing literature and empirical data for a specific topic, researchers tend to use this approach (Creswell & Creswell, 2017). They collect data via observations in the hope that they will find a pattern which in turn while enable them to formulate a theory (Burney, 2008). This research approach is dependent on words and their analysis, and an individual's perceptions (Bhattacherjee, 2012).

The deductive approach, associated with the positivist paradigm, is used to test an existing theory. If there is no theory, the deductive approach cannot be used (Johnsen, 2011). The deductive approach is mainly applied in natural science. The deductive approach is comprised of a number of steps: it begins with initiating a theory, formulating a hypothesis based on that theory, collecting quantitative data from large samples, analysing data, and deciding whether to accept or reject the hypothesis (Bhattacherjee, 2012). Unlike the inductive approach, this approach works from the general to the particular (Adams et al., 2014).

Both qualitative and quantitative methods are used to conduct research studies. Qualitative research is concerned with definitions, perceptions, metaphors, signs, characteristics, and descriptions of things, whereas quantitative research calculates and measures things (Lune & Berg, 2016). It is important to select the most appropriate approach based on the nature of the research (Frankfort-Nachimas & Nachimas, 2008; Lee, 1991; Mingers, 2001; Wildemuth, 2016).

Qualitative research is an approach where a researcher tries to understand the behaviour of the individual/s under consideration and their values, symbols, belief, sentiments, and rituals (Frankfort-Nachimas & Nachimas, 2008). It is also about understanding an individual's social and cultural background (Goodman, 2011). The primary aim of qualitative research is to recognise and present the experience and actions of an individual and the circumstances they live in (Elliott, Fischer, & Rennie, 1999) and to interpret these events from the participant's perspective (Corbin & Strauss, 2014).

There are different qualitative research approaches: narrative, phenomenology, ethnography, grounded theory, and case studies. Narrative and phenomenological approaches are related to the study of people. The ethnographic approach focuses on the broad cultural belief of individuals. Both grounded theory and case studies approaches are applied when exploring events, actions, and procedures in detail (Creswell & Creswell, 2017).

Data collection is a significant part of research design. It is essential to properly consider and plan for data collection. In qualitative research, there are different approaches a researcher can use to collect data including through observation, interviews, diary methods, open-ended surveys, and focus groups (Adams et al., 2014).

Quantitative research refers to a formal and systematic process which is applied to define the research variables, test the relationship between variables, and examine the relationship between the variables (Burns et al., 2015) by applying mathematical, statistical, and computational approaches (Ahmad et al., 2019). This type of research is recognised as empirical research because it can be measured precisely (Ahmad et al., 2019), and is impartial (Davies & Fisher, 2018). In the process of quantitative research, a null hypothesis assumes that there is no relationship between the variables. Assumptions related to the relationship between the dependent and independent variables are tested. This is achieved by selecting a relevant sample of participants from an identified population and applying statistical analyses. In accordance with statistical analysis, the null hypothesis is either accepted or rejected (Bloomfield & Fisher, 2019).

There are four main quantitative research approaches: descriptive, correlational, experimental, and quasi-experimental (Borbasi & Jackson, 2015; Burns et al., 2015). Whilst quantitative research deals with numeric data, qualitative research deals with non-numeric data, namely the narrative text (Lune & Berg, 2016).

The differences between qualitative and quantitative research are presented in Table 3.1.

Table 3.1: Differences between qualitative and quantitative research
Source: (Ahmad et al., 2019)

Factors for comparison	Qualitative research	Quantitative research
Meaning	An approach which attempts to explore or understand an individual or society's ideas, perceptions, and emotions of to generate a hypothesis or theory	An approach which tests a hypothesis or theory to produce numerical data and facts by applying statistical, logical, and mathematical practices
Nature	Holistic	Particularistic
Approach	Subjective	Objective
Type of research	Exploratory	Conclusive
Reasoning Approach	Inductive	Deductive
Sampling	Small samples	Large samples
Data	Verbal	Calculable
Inquiry	Process-oriented	Result-oriented
Hypothesis	Produced	Analysed
Analysis	Texts, objects, and images	Figures and numbers
Objective	Explore and discover ideas utilised in continuous procedures	Examine cause and effect relationship between both dependent and independent variables
Data collection	Non-structured methods, including case studies, interviews, observations, ethnography, and focus groups with open-ended questions	Structured methods including observation, surveys, and questionnaires, experiments, content analysis, with close-ended questions
Results	Generate initial understanding presented in words	Accept or reject hypothesis. Data presented in figures, tables, and graphs

The most suitable and appropriate type of research approach for this study was an inductive and qualitative approach. The inductive research approach helped to explore and understand the characteristics of both the dairy farmers who had adopted and those who had not adopted AMS in terms of various demographic factors. Using an inductive approach, which moves from the specific to the general, the researcher was able to identify patterns from the qualitative data relating to the adoption/non-adoption of AMS. In addition, this approach assisted the researcher in understanding dairy farmers' post adoption experiences, and the implications that AMS adoption had on their farm business, personal lives, animal health and welfare. The qualitative approach enabled the researcher to identify the economic, social, and animal health and welfare benefits that the dairy farmers gained as a result of installing an AMS installation. This research required an approach to facilitate the understanding of the behaviour and perceptions of dairy farmers towards automation in the dairy farm and AMS adoption. The qualitative approach helped the researcher to explore and understand the dairy farmers' backgrounds, behaviour, and perceptions, both those who had adopted the technology and those who had not. It was also useful for identifying barriers relating to AMS adoption, and the benefits and challenges associated with AMS adoption.

3.2 Theoretical framework

There are various models and theories related to the adoption of technology which focus on understanding users' behaviour and intention towards new technologies and systems. The most popular and common technology acceptance models and theories are, to a certain extent, similar to each other. The Theory of Reasoned Action (TRA) is the original technology acceptance theory which has since been developed and extended in new models and theories: The Theory of Planned Behaviour (TPB) and different versions of the Technology Acceptance Model (TAM). The following section reviews these models and theories.

- Diffusion of Innovations Theory (DIT) (Rogers, 1995)
- Technology Readiness (TR) (Parasuraman & Colby, 2001)
- Theory of Task-Technology Fit (TTF) (Goodhue & Thompson, 1995)
- Theory of Reasonable Action (TRA) (Fishbein & Ajzen, 1975)
- Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989)
- Technology Acceptance Model 2 (TAM 2) (Venkatesh, 2000)
- Technology Acceptance Model 3 (TAM 3) (Venkatesh & Bala, 2008)
- Technology Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003)
- Theory of Planned Behavior (TPB) (Ajzen, 1987)

3.2.1 Diffusion of Innovation Theory (DIT)

Rogers' (1995) theory of Diffusion of Innovation (DIT) established the basis for conducting research studies on innovation acceptance and individual and organisational adoption (Rogers, 1995). This theory explains how an idea, behaviour, or product can gain momentum and diffuses through a particular social system over time. The users represent the final output, and they are part of the social system and adopt a new idea, behaviour, or product. Adoption refers to an individual who conducts a task or job in a different way compared to before. The main contributing factor in adoption is that an individual must believe that an idea, behaviour, or product is new or innovative. Previous studies have shown that individuals who adopt new technology early on have different characteristics compared to the people who adopt innovations at a later stage. Understanding the characteristics of the targeted individuals is important for innovation adoption. In accordance with this theory, innovation and adoption take place after passing through several stages: understanding, persuasion, decision, implementation, and confirmation. The innovation adopters can be divided into five categories: innovators, early adopters, the early majority, late majority, and laggards. Innovators include individuals who want to be the first ones to experience the innovation. They are often risk takers and favour new ideas and innovation. Early adopters are individuals who represent opinion leaders. They are interested in leadership roles and embrace opportunities to change. They are well aware of the need for change; therefore, these individuals are open to new ideas. While early majority are not leaders, they adopt new ideas before most individuals. For this group, innovation adoption occurs when there is sufficient evidence to prove that the innovation works well. Late majority are the individuals who are resistant to change. These individuals only adopt technology after it has been adopted by most users. Laggards are conservative individuals who are resistant to change; it is difficult to influence them to adopt technology. They only adopt technology after being pressured by others or as a result of fear.

Credibility gap is a gap between every innovation adopter. This gap becomes bigger from the seeking to use innovation adopter group on the left side as a reference base for the innovation adopter group on the right side. The reason for having this gap is that members of an innovation adopter group consider recommendations from their own group members. Consequently, this gap is indicated as a chasm (See Figure 3.1).

The focus of this theory is mainly on five categories of technology adopters which are innovators, early adopters, the early majority, late majority, and laggards. This theory has relevance to AMS adopters potentially being innovators, or at least early adopters, but fails to examine the famers' perception and identify the barriers towards AMS adoption.

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Figure 3.1: DIT
Source: (Lai, 2017)

3.2.2 Technology Readiness (TR)

This method was developed to understand individuals’ inclination to embrace new technologies to achieve personal and career goals (Blut & Wang, 2020; Parasuraman & Colby, 2001). It considers four dimensions; innovativeness, optimism, insecurity, and discomfort collectively to explain technology usage (Blut & Wang, 2020). Innovativeness and optimism are characteristics associated with technology readiness, whilst insecurity and discomfort are inhibitors which reduce an individual’s technology readiness (Parasuraman, 2000).

This theory is limited to individual’s technology adoption to achieve personal and career goals based on four dimensions; innovativeness, optimism, insecurity, and discomfort collectively to explain technology usage. It provides some insight into the factors that may influence AMS adopters but fails to provide insight into the barriers towards AMS adoption.

3.2.3 Task Technology Fit (TTF)

This theoretical framework investigates the fit between the technology, the task and the resultant performance. TTF’s primary focus is on the individual to evaluate and explain the success of the Information System (IS) and its impact on an individual’s performance (Goodhue & Thompson, 1995). In this framework, characteristics associated with Information Technology (IT), the user, and specific tasks explain IS usage and a user’s performance. Experimental studies show that TTF and usage explain the impact of IT on user task performance better than usage itself. TTF measures the IT value and forecasts user performance (Goodhue, Klein, & March, 2000; Goodhue & Thompson, 1995). TTF reveals the relationship between tasks and technology use from several perspectives, including better performance (Carswell, Thomas, Petre, Price, & Richards, 2000), improved user usage (Kim & Malhotra, 2005; Ngai, Poon, & Chan, 2007; Venkatesh et al., 2003), and different user perceptions (Wenger & Carlson, 1995).

This theory is relevant to the characteristics of AMS and milking task, use of AMS and its impact on the nature of milking task and performance, and how well AMS fits within the milking task. This theory fails to examine the characteristics of technology adopters (farmers who have adopted and have not AMS) and their perceptions towards technology (AMS) adoption.

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Figure 3.2: TTF
Source: (Rondan-Cataluña, Arenas-Gaitán, & Ramírez-Correa, 2015)

3.2.4 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) is one of the most common and popular theories used to determine an individual's behavioural intention towards a specific behaviour (Fishbein & Ajzen, 1977). TRA examines determinants of a user's conscious behaviour. In accordance with this theory, an individual's behaviour is determined by his or her intention to perform the behaviour. This idea is known as Behavioural Intention (BI). Behavioural intention is determined by an individual's Attitude (A) and Subjective Norms (SN). Attitude is based on a range of beliefs about the behaviour and the individual's evaluation of those beliefs. An individual's subjective norms are his or her perception of the wider community's attitude towards a certain behaviour, and the value that the individual places on their perceptions (Fishbein & Ajzen, 1977).

This theory could potentially be used for this study, however, there are other models explained in the next sections and developed from this which also have relevance.

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Figure 3.3: TRA
Source: (Fishbein & Ajzen, 1977)

3.2.5 Technology Acceptance Model (TAM)

This model is a modified version of TRA which is used primarily to model an individual's acceptance of technology which in turn explains their acceptance and usage of technology acceptance (Davis, 1989). This model was developed to identify important factors proposed in previous studies related to cognitive and effective determinants of technology acceptance. TAM applies TRA as the theoretical background to model the relationship between the factors. The basic version of TAM examines two beliefs: perceived usefulness (PU) and perceived ease of use (PEU). PU is the level to which a user believes that using a specific system will improve their job performance. PEU is the level at which the potential user expects the system to require less effort. A user's belief about a system can be impacted by other external variables embedded in TAM (Davis, 1989). The main difference between TRA and TAM is the concept of SN which is not included in TAM due to its uncertain psychometric and theoretical status.

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Figure 3.4: TAM
Source: (Davis, 1989)

It was later found that PU and PEU have a strong and direct effect on BI, and that the effect of attitude can be reduced over the time; consequently, (Venkatesh & Davis, 2000) removed attitude from their model.

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Figure 3.5: Extended model of TAM
Source: (Venkatesh & Davis, 2000)

The TAM model was later extended to TAM2. The researchers added social influence and cognitive instruments to the TAM2 model to further explain the reasons that a user finds a system useful. The social influence process variables include subjective norms, images, and voluntariness which are related to social forms, whilst cognitive instrumental process variables include job relevance, output quality, result demonstrability, and perceived ease of use. The social influence process assists a researcher in determining whether an individual is likely to accept or reject a new technology. A subjective norm is an individual’s perception that important people to him/her think that s/he should/should not behave in a particular way. Voluntariness is the degree to which potential technology adopters perceive that it is not necessary to adopt a particular technology. Image is the extent to which the use of technology is perceived to improve an individual’s social status. Experience is the direct outcome of subjective norms on intentions which might decrease over time as the individual’s experience with technology improves. Job relevance refers to an individual’s perception about whether a targeted technology is relevant to his/her job. In perceptions of outcome quality, an individual who uses the technology considers how well the technology performs the tasks which are relevant for his/her job. Result demonstrability refers to the tangibility of the outcomes of using the technology. This directly affects PU. (Venkatesh & Davis, 2000).

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Figure 3.6: TAM 2
Source: (Venkatesh & Davis, 2000)

TAM2 was combined with PEU model determinants (Venkatesh & Bala, 2008) to develop an integrated technology acceptance model called TAM3 (Venkatesh, 2000). This model mainly consists of PEU determinants. The model’s components are shown in Figure 3.8. Computer efficiency refers to the level to which an individual thinks that s/he is able to conduct a task using a computer. Perception of external control is the level to which an individual thinks that both organisational and technical supports are available. Computer anxiety is an individual’s level of fear when using a computer to perform a task. Computer playfulness is the level of cognitive spontaneity a user experiences when interacting with computers. Perceived enjoyment refers to an individual’s enjoyment of using a computer (apart from performance outcomes which are the result of using a computer). Objective usability refers to the differences between computer programmes/technologies based on the level of effort needed to carry out a specific job (Venkatesh & Bala, 2008).

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Figure 3.7: TAM3
Source: (Venkatesh & Bala, 2008)

Different versions of TAM theory including perceived usefulness and ease of use could potentially be used for this study to investigate the perception of farmers towards AMS social, economic, and animal health and welfare benefits.

3.2.6 Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) was formed based on previous models and technology acceptance theories (Venkatesh et al., 2003). This model tries to determine a user’s level of technology acceptance. The UTAUT model assesses whether users accept new technologies and whether they are able to deal with them or not. The four main constructs impacting BI and which play a critical role in user acceptance and usage behaviour are performance expectancy, effort expectancy, social influence, and facilitating conditions. In addition, there are four moderators which are used to predict BI to utilise a particular technology: age, gender, experience, and voluntariness. Similar to TRA and TAM, BI has a direct impact on the use of technology. In contrast to

TRA and TAM, in the UTAUT model, BI is not the only factor which affects the use of technology: Facilitating conditions also directly determine the use of technology (Venkatesh et al., 2003).

Performance expectancy is the level to which an individual believes that using the system improves their job performance. It is hypothesised to moderate the effect on behavioural intention by factors including age and gender. Effort expectancy is associated with the perception of ease of use. It is hypothesised to moderate the effect on behavioural intention by age, gender, and experience. Social influence refers to the impact of others' perceptions of a new technology. It is hypothesised to moderate the effect on behavioural intention by age, gender, experience, and volunteers of use. Facilitating conditions refer to the level to which the users believe that there is adequate organisational and technical infrastructure to support the use of new technology. It is hypothesised to moderate the effects on behavioural intention by age and experience (Venkatesh et al., 2003).

This theory is partly relevant to this study. The focus of this study is not only on if there are adequate organisational and technical infrastructures to support AMS adoption, but also if AMS fits within the farm operation and farmers personal and social life, and also how it was/would be easy/difficult for them to adopt AMS.

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Figure 3.8: UTAUT
Source: (Venkatesh et al., 2003)

3.2.7 Theory of Planned Behaviour (TPB)

This theory was derived from TRA, consisting of two primary components: attitudes and subjective norms. In addition to these primary components, the main contribution of TPB is the addition of perceived behavioural control. Perceived behavioural control is an individual's perception of how easy or difficult it is to perform a particular behaviour (Ajzen, 1987). TRA explains the behaviour through behavioural intent which is based on attitudes and subjective norms. In contrast, TPB states the issue of incomplete volitional control over a behaviour in the form of question (Fishbein & Ajzen, 1980). For this reason, perceived behavioural control is included. In accordance with this theory, behaviour is the result of attitudes and social norms (perceived as social pressure) (Wauters, Bielders, Poesen, Govers, & Mathijs, 2010). Attitude shows a brief assessment of a psychological object which is taken in attribute dimensions such as good or bad, harmful or beneficial, satisfying or unsatisfying, and likable or dislikeable (Ajzen & Fishbein, 2000). The primary focus of this social psychological and conceptual framework is to predict and explain particular human behaviour (Wauters et al., 2010). Users' attitudes and motivations play an important role in terms of performance parameters (Jansen, Van Schaik, Renes, & Lam, 2010; Leach et al., 2010). There are two influential factors that influence whether an individual performs a particular behaviour or not: how strong an attempt the individual makes to perform the behaviour and how much control they have over that behaviour. Behavioural intention is developed by attitudes towards a behaviour, subjective norms, and perceived behavioural control (Ajzen, 2002).

TPB suggests that people with highly positive attitudes towards a task are more likely to practice it (Múnera-Bedoya, Cassoli, Machado, & Cerón-Muñoz, 2017). This theory has been applied by various scholars with the purpose of identifying situational, personal, and cognitive reasons why an individual carries out a task in different fields. For instance, Jansen et al. (2009) applied this theory to determine the degree to which farmers' attitudes, over and above farmers' behaviour, determine the rates of mastitis. Using this same theory, Lind et al. (2012) investigated dairy farmers' behavioural intentions to call a veterinarian in the case of a mastitis diagnosis or start treatment. Múnera-Bedoya et al. (2017) used TPB to establish the effects of dairy farmers' attitudes, behaviour, and knowledge around performing milking task using hygienic parameters associated with bulk-tank milk quality. While Hardeman et al. (2002) applied TPB to investigate behavioural change interventions, Beedell and Rehman (2000) investigated farmers' conservation-related behaviour. (Burton, 2004) examined reconceptualising the 'behavioural approach' in agricultural studies, and Ellis-Iversen et al. (2010) studied perceptions, circumstances, and motivators that influence the implementation of zoonotic control programmes on cattle farms.

TPB consists of three conceptually independent components of intention. Attitude toward a behaviour refers to an individual's positive or negative assessment of performing a specific task. Subjective norms reveal perceptions of social pressure or the effect of others' beliefs on an individual's decision to perform a specific behaviour. The last component of the theory, perceived behavioural control, focuses on the factors which facilitate or impede behavioural performance (Ajzen, 2005). The following figure depicts the theory of planned behaviour.

This is the most relevant theory to this study. It helps to understand the farmers perception towards AMS adoption and farmers ability and perception on AMS adoption in terms of how easy/difficult the requirements and required changes of AMS were/would be to them to adopt AMS.

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Figure 3.9: TPB
Source: (Leviston, Porter, Jorgensen, Nancarrow, & Bates, 2005)

3.2.8 Selected theoretical framework

All of the above-mentioned technology acceptance models and theories have been used to explain the reasons behind users’ acceptance of particular technologies. Of these, TAM, TRA, TPB are the most popular. They share many similarities. The aim of this research was to understand the characteristics of New Zealand dairy farmers who have adopted or have not adopted AMS in pastoral-based dairy farming systems, their perceptions of AMS, the benefits and challenges associated with AMS adoption, reasons (or barriers) which contribute to its adoption. For this reason, the Theory of Planned Behaviour covering attitudes, subjective norm, and perceived behavioural control were seen as the most appropriate theoretical framework to achieve the aim of the study, taking account of insights from the TAM and UTAUT models.

TPB claims that human and social factors have the potential to contribute to technology acceptance (Mathieson, 1991; Mun, Jackson, Park, & Probst, 2006). Consequently, TAM can be extended with social factors stated in the previous parts to explain technology adoption. While TAM is easier to apply, it only provides general information about a user’s opinion about a particular technology. TPB provides more specific information that can be used in the development of new technology. As TAM provides general determinants for an individual’s acceptance of technology, this model can be used to predict an individual’s behaviour over a wide range of computing technologies (Davis et al., 1989). In order to solve TAM’s limitations (and in particular, its explanatory power), scholars developed TAM2. TAM2 maintains the main determinants of TAM, including perceived usefulness and intention of use, to understand how the impact of these determinants varies with a user’s increasing experience (over the time) with a specific technology (Venkatesh & Davis, 2000). In the TAM3 model, the TAM determinants (for example, PEU and intention of use), are included to ensure robustness (Venkatesh & Bala, 2008). Consequently, TAM3 consists of a complete nomological network of determinants of user technology acceptance (Venkatesh & Bala, 2008).

UTAUT is an extended version of the TAM2 and TAM3 models. It includes social influence. This model is also similar to TAM and TRA. However, in this model, both BI and facilitating conditions are considered contributing factors for technology adoption (Samaradiwakara & Gunawardena, 2014). UTAUT has better explanatory power. However, this model fails to examine the direct effect between the factors which might reveal significant factors and new relationships. This is the same for TAM2 and

TAM3. These three technology acceptance models, TAM2, TAM3, and UTAUT, fail to consider direct relationship between the factors. Regardless, these models have been widely applied by various scholars (Samaradiwakara & Gunawardena, 2014).

TRA has been used for a number of years in both academia and business. It has been widely used in the IS literature. However, this model has its own limitations, including the risk of confusion between attitudes and norms. TRA's other limitation relates to a key model assumption: the model assumes that once an individual has decided to act, they are free to take action without limitations. Practically, freedom to act can be affected by factors such as time, environmental limits, unconscious habits, and limited ability. Additional explanatory variables need to be added to TRA to overcome these limitations (Thompson, Higgins, & Howell, 1991; Webster & Martocchio, 1992). TPB was developed to resolve TRA's limitations and to provide a comprehensive understanding of the use of technology (Taylor & Todd, 1995). Compared to TPB, TAM is an inexpensive and easy model if a researcher wants to collect information about an individual's perception of a particular technology. However, different studies have extended TAM by adding extra variables which has resulted in confusion (Samaradiwakara & Gunawardena, 2014). Despite TPB's advantages, this theory does not consider economic, environmental, and emotional factors which influence an individual's intention to perform a specific behaviour. TPB also believes that behaviour is the result of a linear decision-making process which can vary over time (Wayne & LaMorte, 2019).

Having considered each of the models and theories, the researcher decided the most suitable theory for this study was TPB. The main reason for applying this theory was because it has subjective norms which is not included in TAM and perceived behavioural control which is not included in TRA, TAM, TAM2, TAM3, and UTAUT models. In TPB, attitude helps understand dairy farmers' positive or negatives attitude towards AMS, subjective norms can be used to assess the perceptions of social pressure or influence from individuals dealing (directly or indirectly) with the farmers, and perceived behavioural control helps to understand the farmer's ability to adopt AMS in a pastoral-based farming system; how easy or difficult it is for them to follow AMS requirements and make changes in their farms and operation system. These three predictors will help to explain dairy farmers' behaviour towards AMS adoption. Lastly, TPB has proved it is reliable in explaining different kinds of information systems relevant to an individual's behaviour.

3.3 Data collection

In qualitative research, the thoughts, ideas, and perception of the participating individuals provide the primary data. There are different approaches to data collection for qualitative research, including the observation of participants, a review of texts and documents, interviews, and diaries (Seidman, 2006).

In qualitative research, interviews are the most common method of data collection (Jamshed, 2014). Interviews provide a way to obtain an in-depth understanding of a participant's story (Seidman, 2006). A participant's story provides insight into their attitudes, experiences, perceptions, and emotions (Fontana & Frey, 2005). Interviews enable a researcher to gather a pool of detailed information and data. Interviews can be conducted using a face-to-face approach or via phone calls (Adams et al., 2014). Interviews can be structured, semi-structured, and unstructured (Fontana & Frey, 2005).

In this study which initiated in 2017, the researcher conducted a series of interviews and collected data from farmers who had adopted AMS and those who had not. In the first stage of this process which took place from 2017 to 2018, the researcher used semi-structured interviews with three of the farmers who participated in DairyNZ conference calls and had adopted AMS in a pastoral-based dairy farming system. The first set of interviews helped facilitate the design of the second stage of interviews which took place from 2018 to 2020. As a result of the first stage of interviews and with the findings from the literature in mind, in the second stage, the researcher developed a structured interview survey based on TPB to interview both groups of farmers: those who had adopted and those who had not adopted AMS. The farmers who were interviewed in the first stage of interviews and four other farmers who had adopted AMS in pastoral-based dairy farming system participated in the second stage of interviews. In addition, 13 farmers who had not adopted AMS in pastoral-based dairy farming system participated in the second stage of interviews. Table 3.2 presents the timeline of this study.

Table 3.2: Timeline of the study

Year	Purpose	Description
2017	Project initiation	• This study initiated with the purpose of interviewing farmers who had adopted and had not adopted AMS
2017 - 2018	Identifying farmers who had adopted AMS	• Attended DairyNZ conference call with farmers who had adopted AMS • Visited dairy farms with AMS
2018	Conducting semi-structured interviews with AMS farmers attended DairyNZ conference call	• Used the results to develop the second stage of interview's questions
2018	Developing the interview's questions of the second stage of interviews	• Developed the interview's questions based on the results from the first stage of interviews with AMS farmers, available literature, and Theory of Planned Behaviour (TPB)
2018 - 2020	Conducting interviews with farmers	• Interviewed farmers who adopted AMS and who had not adopted AMS in both North and South Island of New Zealand

A structured interview uses a pre-defined set of questions which the interviewer asks every interviewee in the same order (Zhang & Wildemuth, 2009). This approach requires an extensive amount of pre-planning (Trueman, 2015). Unlike surveys, which subjects complete by filling in a form, structured interviews are performed orally (Zhang & Wildemuth, 2009). This type of interview is used to ensure that the interviewer asks subjects the same questions in the same order. In short, the researcher is not allowed to make changes to the questions during the interview. However, this ensures consistency and reliability in the collected data. This means that a researcher can make comparisons between different samples or various survey periods and have a high level of confidence in the results. The consistency and reliability mean it is easy to repeat the interviews. The quality of the collected data and information relies heavily on the quality of the questions. Structured interviews enable a researcher to determine a participant's feelings about a particular subject (Trueman, 2015).

Semi-structured interviews are recognised as a more flexible method because they contain a mixture of open-and close-ended questions. There is no pre-defined sequence for the questions. In this method, the interviewer has the opportunity to add more relevant questions based on a participant's answers (Zhang & Wildemuth, 2009). Semi-structured interviews can be more in-depth (Corbin & Strauss, 2008) and last anywhere from half an hour to more than an hour (DiCicco-Bloom & Crabtree, 2006).

Unstructured interviews collect in-depth information. However, these interviews tend to be more informal, and the questions are not prepared in advance (Jamshed, 2014; Zhang & Wildemuth, 2009). This type of interview depends on the flow of conversation between the researcher and the participant. It requires an interviewer to form questions spontaneously during the course of the interview (Zhang & Wildemuth, 2009). There are three types of unstructured interviews: these are non-directive, focused, and conversational interviews. In non-directive interviews, the researcher does not plan the questions before the interview. The focus of these interviews is to collect information about the topic in detail. In focused interviews, the interviewer is aware of the participant's beliefs and leads the conversation towards the topic. In conversational interviews, another informal method, the questions are not planned in advance, but rather, are generated during the interview (Gray, 2009).

Normally, there are two stages in the data collection process: pre-testing of the survey and then the main research study. In the pre-testing stage, a small sample is used to confirm the feasibility of the data collection method for the main research. Pre-testing is also used to reduce errors related to design and sequence of the questions (Adams et al., 2014). The researcher interviewed a dairy farmer to determine the length, sequence, design and clarity of the interview and the appropriateness of the questions.

3.3.1 Selected sampling methods

Sampling is a method which is applied to select an appropriate sample with the purpose of drawing conclusions about a specific population. In order to determine the sample size and method, it is important to take the required time, costs, and size of the survey into account. A representative sample is used to draw conclusions about a specific population (Adams et al., 2014). The sampling method includes various phases. The initial stage of sampling involves defining the target population. A population can refer to an individual, a group/s, or units that have particular characteristics that a researcher plans to study. The next phase of sampling is to select a sampling frame or a list from which the sample can be drawn. The last phase of sampling is to select the sample from the sampling frame by applying sampling methods (Bhattacherjee, 2012). There are two main types of sampling methods: probability and non-probability sampling. In the probability sampling method, each unit of the population has the same chance of being selected as any other unit. The opposite is true for the non-probability sampling method which means that some units of the population have no chance of being selected. In other words, the selected sample is chosen based on specific non-random criteria (Adams et al., 2014). In qualitative research, the probability sampling methods include simple random sampling, systematic sampling, stratified sampling, and cluster sampling. Non-probability sampling methods include convenience, voluntary, purposive, and snowball sampling. Convenient sampling comprises of individuals who are readily available to participate in the study. Voluntary response sampling comprises of individuals who voluntarily choose to participate in the research study. In purposive sampling, the researcher selects a sample which is most appropriate and relevant to the research based on his/her judgment. If it is difficult to access the population, then a researcher can use snowball sampling to find participants; this involves asking participants for the names of other potential participants (Bhattacherjee, 2012).

The target population for this study is New Zealand pastoral-based dairy farmers who have either adopted or not adopted AMS. The sampling frame included a contact list of dairy farmers who had adopted and not adopted AMS in their pastoral-based dairy farming system. For this study, the researcher used two types of non-probability sampling methods (convenience and snowball sampling) to choose a suitable sample. Using the convenience sampling method, the researcher was able to contact dairy farmers who participate in a regular DairyNZ conference call for AMS adopters. Using the snowball method, more dairy farmers who had adopted and not adopted AMS in a pastoral-based dairy farming system were introduced to the study through the recommendations of other dairy farmers, DairyNZ scientists, and AMS suppliers.

In 2017, the number of dairy farmers who had adopted AMS in their pastoral-based dairy farming system was 19. They were located in both the North and South Islands of New Zealand. However, only a small number of them participate in the regular DairyNZ conference call. Therefore, the sample size of the first stage of interview was limited to three dairy farmers; two from the South Island located close to Canterbury and Southland and one from the North Island, close to the Hamilton region. In the second stage of interviews, the number of AMS adopters grew to seven dairy farmers. Five of the dairy farms were located in the North Island, close to Auckland, Waikato, and Palmerston North. The remaining two were located in Canterbury and Southland. The study included 13 pastoral-based dairy farmers who had not adopted AMS. While this is a small sample, it is comparable to the adopters' sample. These dairy farmers were located in both the North and South Islands, including Waikato and Canterbury.

3.3.2 Design of interview survey

This study included two stages of interviews. In the first stage, the researcher interviewed dairy farmers who had adopted AMS in a pastoral-based dairy farming system. In the second stage, the researcher interviewed both dairy farmers who had adopted AMS and those who had not. The purpose of the first stage of interviews was to identify the number of dairy farmers who had adopted AMS in a pastoral-based system and their distribution (in both the North and South Islands of New Zealand), identify the benefits and challenges associated with AMS adoption, the general reasons for AMS adoption, and assess the farmers' willingness to participate in the research. In the first stage, the researcher used both DairyNZ conference calls and telephone calls.

A regular DairyNZ conference call was a useful platform for being introduced to the dairy farmers who had adopted AMS in both North and South Island of New Zealand and to find out about their experience of adopting AMS and in particular, the benefits and challenges.

The semi-structured interview was comprised of two main sections. While the first section was designed to obtain general information about each of the dairy farmers, the aim of the second section was to collection data about AMS adoption; specifically, the advantages and disadvantages associated with AMS. The first section of the interview survey included close-ended questions to obtain the dairy farmers' contact details, with the purpose of making interactions more convenient. The second section included open-ended questions to determine the factors which resulted in the successful adoption of AMS. A copy of the interview survey is provided in Appendix A.

The primary objectives of the second stage of the interview process were to critically explore and gather in-depth information about dairy farmers who had adopted AMS in a pastoral-based farming system and those who had not. The researcher was particularly interested in obtaining their perceptions of AMS and the benefits and challenges associated with it, and the reasons and barriers that had contributing towards AMS adoption.

In this stage, interviews were conducted face-to-face, with both dairy farmers who had adopted AMS and those who had not. The interview surveys were reviewed by professional consultants from the

New Zealand dairy farming sector, New Zealand and Australian dairy farming scientists in the field of dairy farming in both New Zealand and Australia, and academic members from Lincoln University to ensure its feasibility, to determine the time needed to complete the interview, and any potential adverse events prior to being sent to Lincoln University ethics committee and conducting the full-scale interviews. The information sheet was improved and, as a result of feedback from the experts and the ethics committee, more details were added to ensure that the dairy farmers' anonymity was preserved. Participants were advised that they could withdraw from the project at any time. In addition, a consent form was added to protect the researcher's and the dairy farmers' rights in terms of interview audio recordings, any publications resulting from the study, and other details stated in the information sheet. In the second stage of interviews, the researcher used a structured questionnaire comprised of seven sections: Section 1: General information, Section: 2: Details of farm business, Section 3: Details of AMS, Section 4: Attitude towards AMS, Section 5: Operation and labour before and after AMS adoption, Section 6: Changes as a result of AMS, and Section 7: Personal information. The interview structure was developed as a result of the first stage of interviews and with the existing literature in mind. Dairy farmers who had not adopted AMS answered the first, second, fourth, and the last section of the interview survey, whilst dairy farmers who had adopted AMS answered all of the sections of the interview survey. A copy of the interview questions used for both dairy farmers who had adopted AMS and those who had not are provided in Appendices B and C.

Sections 1, 2, 3 and 7 were designed to gather background information and participants' personal information. The first three sections and the last section of the interview survey were designed to gain a better understanding of the demographics of both sets of dairy farmers. These sections used a mix of close-ended and multiple-choice question.

Existing literature suggests that there are a range of demographic factors which affect farmers' adoption of technology. The main factors are: the farmer's age (Boz, Akbay, Bas, & Budak, 2011; Connolly & Woods, 2010; Edwards-Jones, 2006; El-Osta & Morehart, 1999; Gloy & LaDue, 2002; Howley, Donoghue, & Heanue, 2012; Shahin, 2004; Solano, León, Pérez, & Herrero, 2003), their years of experience (Paudel, Gauthier, Westra, & Hall, 2008; Rezaei & Bagheri, 2011; Shahin, 2004), their level of education (Edwards-Jones, 2006; El-Osta & Morehart, 1999; Mishra, Wilson, & Williams, 2009; Paudel et al., 2008; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008; Shahin, 2004), their gender (Edwards-Jones, 2006), the existence of a successor (Howley et al., 2012; Paudel et al., 2008), the family lifecycle, the structure of the farm business, the social milieu and capital, and trust (Edwards-Jones, 2006) , the farm's financial position (Boz et al., 2011; El-Osta & Morehart, 1999; Mishra, El-Osta, & Steele, 1999; Paudel et al., 2008; Prokopy et al., 2008; Shahin, 2004), the farmer's involvement in an advisory programme/s (Howley et al., 2012), the farmers' exposure to mass media (Shahin, 2004), the farmer's level of contact with third parties, including veterinarians (Shahin, 2004), the farmer's access to different sources of information (Prokopy et al., 2008), his/her use of social networks (Prokopy et al., 2008), the level of complication (how easy/difficult it is it to use the technology) (Douthwaite, Keatinge, & Park, 2001), and the farmer's environmental awareness (Prokopy et al., 2008).

Demographic information helps to understand the background and characteristics associated with AMS adoption. In these sections of the interview survey the demographic factors and also other relevant factors were included. Section 1 included open-ended and multiple-choice questions designed to elicit information about the dairy farmer and asked for specific information (the farmer's name, contact details, farm address, job role, years in dairy farming and at the current farm, the total number of dairy farms that the farmer had worked on, and whether the farm had a successor. Section 2 included open-ended and multiple-choice questions designed to collect information about each farm, including its size (effective hectares), milk production, the milk processor, the production system, the number of full-time equivalent (FTE) staff, details of the herd (size, breed, age, and calving system). Section three focused on AMS adoption: AMS supplier, years of AMS adoption, number of years that the farmer had considered adopting AMS, and the number of milking robots. This section contained a mixture of open-ended and multiple-choice questions. The last section asked farmers to provide personal information, including information about their age, their level of education, and gender. Section 7 featured multi-choice questions.

The primary objective of section 4 of the survey for dairy farmers who had adopted AMS was to identify the factors that influence the use of AMS in pastoral-based systems, to understand the perceived impact of AMS on farmer lifestyle, farm operation management, animal health and welfare, milk production, milk quality, investment and operating costs of AMS for the dairy farmers. The other objective was to understand barriers to adoption, identified in the interviews with farmers who had not adopted this system. The study also sought to identify the individuals that influence farmers to adopt AMS and also the factors which facilitate or hinder AMS adoption and implementation. In this section of the survey, the researcher interviewed both sets of dairy farmers (those who had adopted AMS and those who had not).

This section included open-ended and Likert scale questions and applied TPB. As discussed in the literature review, these technologies help to save on labour costs, increase the efficiency of the farm labour, and improve milking effectiveness. They also provide flexibility, effective animal monitoring, decrease stress levels, and support decision making, all factors which farmers have identified as important (Edwards, Rue, & Jago, 2015). AMS is a voluntarily system which enables dairy cows to freely, and without assistance from farm staff, move from the pasture to the milking stalls for the purpose of harvesting milk. Therefore, the milking events are not limited to twice a day. AMS reduces the need for staff to perform milk harvesting. As a consequence, milk production and effectiveness, and labour efficiency can be improved because farm staff have more time to focus on other tasks. The AMS system also provides detailed data. However, farmers must have the necessary computer skills to interpret the generated data. In AMS, the milking task is carried out by robots. Consequently, dairy farmers have more flexibility in terms of when they work and the hours they work. This system frees up more time and decreases dairy farmers' stress levels. AMS generates detailed information about each individual dairy cow which enable dairy farmers to monitor them and detect any health issues at an early stage. This information and data support enables dairy farmers to make accurate decisions in timely manner. It is evident that AMS provides benefits to the dairy farmers, but, in New Zealand, there has been a slow adoption rate in. Therefore, it is important to understand New Zealand dairy farmers' perceptions of AMS, the benefits and challenges associated with such a system and the barriers to adoption in pastoral-based dairy farming systems. This section of the interview sought to determine the relevant factors. Along with the literature, findings from the first stage of the interview, in particular the reasons for AMS adoption, and the advantages and disadvantages of AMS adoption were added to this section. The first stage of interviews revealed that the advantages and disadvantages associated with AMS adoption can be divided into three main categories: social, economic, and animal health and welfare.

These factors were included under attitude in section four. The questions assisted in the identification of the factors contributing to AMS adoption, the importance of each factor to the dairy farmers, and how much AMS impacts on these factors. The reasons for adoption included experiencing new technology, better animal health and welfare, help with future planning and succession, and the dairy farmers' personal values. The main advantages and disadvantages of AMS adoption identified included changes in cow behaviour, flexibility, labour savings, increased milk production, having access to detailed data about each individual cow, the high capital cost, the difficulty of locating staff members who have the appropriate computer skills, and the need to monitor the system 24/7.

Individual attitudes focus on beliefs about the consequences of certain behaviours. In this research the emphasis is on the advantages and disadvantages of operating milking robots in a pastoral-based farming system. In other words, this study is concerned about what a dairy farmer thinks the outcomes of adopting certain behaviours will be (in this case, adopting AMS) and also how favourable these outcomes are to the dairy farmer. For instance, how does AMS influence the milking process, and does it represent a good or bad outcome? Questions from this section include:

- What do you see as the advantages of running AMS in a pastoral-based dairy farming system?
- What do you see as disadvantages of running AMS in a pastoral-based dairy farming system?

- What do you see as the perceived impact of AMS in a pastoral-based dairy farming system?

- What else comes to your mind when you think about running AMS in a pastoral-based dairy farming system?

The social factors included in this section were flexibility in terms of working hours and days, a better and more relaxed working environment and the operating system, shifts in the tasks to be performed and a reduced workload, changes to the requirement for labour unit, succession planning, making dairy farming attractive to future generations, automation in the dairy farm, the usefulness of AMS, and experiencing new challenges and technology in pastoral-based dairy farming system. The economic factors investigated were milk quality and production, profits and financial return, costs of labour, the operation and maintenance of the milking shed, and the resale value of the farm. The animal health and welfare factors considered were cow welfare, mastitis and lameness, observing cows, detailed information and records of cow's feed intakes, health, and milk quality.

Subjective norms focus on what others may think, and how motivated the individual is to comply with what other people think. It refers to the extent to which significant others think a particular behaviour should be accepted. It is measured by motivation to obey and normative beliefs. Motivation to obey refers to how influential others are in the decision-making process about the adoption of milking robot behaviour. Normative beliefs refer to the dairy farmer's perception of whether others think the behaviour should be adopted. In other words, this study was interested in how significant others feel or think about AMS and whether the farmer took those opinions into consideration. This section included the following comments or questions:

- When it comes to running AMS in a pastoral-based dairy farm, there might be individuals or groups who have an impact on your decision as to whether you should or should not adopt AMS in a pastoral-based dairy farming system. Were there individuals or groups who had an impact on your decision to adopt or not adopt AMS.

- Please list the individuals or groups who would agree or think that you should run AMS in a pastoral-based dairy farming system.

- Please list the individuals or groups who would disagree or think that you should not run AMS in a pastoral-based dairy farming system.

- When we are not certain what to do, we look to find out what others are doing. Please list the individuals or groups who most likely run AMS in a pastoral-based dairy farming system.

- Please list the individuals or groups who are least likely to run AMS in a pastoral-based dairy farming system.

Subjective norms help us to better understand the individuals or groups who influence both dairy farmers who adopt AMS and those who do not. As discussed in the literature review, there is a large group of individuals who interact (both directly and indirectly) with dairy farmers (Eastwood, Chapman, & Paine, 2012; Klerkx & Jansen, 2010; Murphy, Nettle, & Paine, 2013). They include service providers from both the public and private sectors like consultants, scholars, farm equipment technicians, veterinarians, agronomists, and nutritionists. These individuals may influence dairy farmers in the technology adoption decision-making process. Other individuals who interact and deal with dairy farmers include the dairy farmers' spouses, children, and family members, farm staff members, other farmers (both those who have adopted AMS and those who have not), milk processors, industry good bodies and their resources including DairyNZ and Dairy Australia, private consultants. Farmers may also be influenced by printed and online media articles, and resources/publicity materials provided by AMS suppliers.

Perceived behavioural control focuses on the perceived ease or effort associated with performing a particular action. It refers to the perception of how easy or difficult it is for the dairy farmer to adopt the behaviour. It is measured by control beliefs and personal power. Control beliefs is the perceived control over the decision to adopt the behaviour. Personal power refers to an individual's perceived control to overcome factors that may delay the adoption of a specific behaviour. For instance, what does the individual think about the cost, and do they think that this cost is affordable to them? The example questions of this section include:

- Please list any circumstance or factor that would make it simple or enable you to run AMS in a pastoral-based dairy farming system.
- Please list any circumstance or factor that would make it hard or stop you from running AMS in a pastoral-based dairy farming system.

The factors included in perceived behaviour are the complexity of AMS installation, the high capital cost of AMS, the requirement for changes in farm layout and infrastructure, the grazing system, seasonal calving, the need for skilled labour, the need for staff to be available 24/7 to deal with any concerns, and ongoing support from AMS suppliers. These factors had a significant role in identifying the barriers towards AMS adoption and the impact of AMS on the dairy farm from different perspectives.

Section 5 of the survey examined farm operation and labour before and after AMS adoption. Only those who had adopted AMS in pastoral-based dairy farming system completed this section. This section focused on understanding the impact of AMS on dairy farmers' lifestyles and operations management in terms of changes in the farm before and after AMS adoption and how it had changed the dairy cows' behaviour. This section used open-ended questions to investigate the factors below:

Issues before and after AMS installation were:

- Training of cows
- Voluntary milking
- Number of labour units
- Working schedules, including hours and days, workload, and shift in tasks
- Grazing system
- Traffic system
- Gate time changes
- Design of milking shed
- Animal health and welfare

Section 6 of the survey aimed to identify the implication found within AMS in terms of features and functions. AMS suppliers can use results from this section to understand dairy farmers' needs, expectations, and to improve the features and functions of existing AMS. The Likert scale questions were designed to investigate whether the factors listed below expected, needed, got, not get, liked, disliked, and or indifferent by dairy farmers adopted AMS or not.

Current AMS features and functions covered were:

- Milk production, quality, and the process
- Animal health and welfare, including mastitis and lameness
- The cost of investment required
- Reduced operational, labour, and maintenance costs

- Reduced work hours, workload, and changes in tasks of labour
- Adopted software and mobile applications
- Changes in farm layout
- Adapted milking shed infrastructure, grazing system, and traffic system

The following part of the interview survey was designed to determine the dairy farmers' future plans and also whether they had achieved their original goals or not. The results from the open-ended questions will be helpful for AMS suppliers to understand whether this system fulfils dairy farmers' expectations or not. This section's findings also provide useful information for AMS suppliers about how they can enhance and develop the robotic system based on dairy farmers' future plans.

- What did you hope to achieve when you adopted AMS?
- Did you achieve your goals?
- Is there anything you would like to see in future versions of AMS which is not currently available in terms of technology, farm system adoption, or support?
- What are your future plans/goals?

3.3.3 Research reliability and validity

Unlike quantitative research, qualitative research is a naturalistic inquiry in which planning and execution take place simultaneously. Research design may also change during the course of the study. The initial steps must be carried out prior to the design, from establishing early contacts to having access to the field, discussing consent, establishing trust, and selecting the participants. These steps can be replicated over the research process. As a consequence, appropriate practices must be applied to ensure the research process' rigour (Morse, Barrett, Mayan, Olson, & Spiers, 2002).

Reliability and validity are crucial to any research (Lincoln & Guba, 1999). In qualitative research, rigour refers to reliability and validity (Brink, 1993; Tappen, 2016). Rigour involves being precise, vigilant, and ensuring accuracy. Consequently, in qualitative research, rigor involves the process of discovery (Thomas & Magilvy, 2011) and an explanation of the research attribute without strict limitations (Davies & Dodd, 2002; Sandelowski & Barroso, 2002). According to Lincoln and Guba (1999) in qualitative research, rigor is the same as trustworthiness which refers to authenticity, truthfulness, and the quality of the research results. In order to establish the trustworthiness of qualitative research, there are four criteria which must be met. These criteria relate to the credibility, transferability, dependability, and confirmability of the instrument and the research results (Lincoln & Guba, 2000). The researcher considered each of these four criteria before selecting the relevant research design. The following table presents the four criteria in the context of this study.

Table 3.3: Trustworthiness of the research study
Source: Lincoln and Guba (1986)

Criteria	Purpose	Strategy	Application of the strategy
Credibility	To ensure that results from the participants' perspectives are credible, true, and believable to ensure confidence in the research output	Prolonged engagement	➢ Dairy farmers were introduced to the research study prior to interviews to establish trust. ➢ The study's aim and objectives were discussed with them in advance. ➢ The interviewer undertook farm visits prior to the interviews to gain an understanding of the farmers' experiences and perceptions.
	To achieve a more comprehensive understanding of the studied phenomenon by applying various methods, sources of data, and theories	Triangulation	➢ In terms of methods triangulation, the study had two different interview stages. It also used both face-to-face and phone interviews to ensure the consistency of the research results. ➢ In terms of sources triangulation, the study used different data sources within the same method. The researcher interviewed two different populations – two sets of dairy farmers (those who had adopted AMS and those who had not) so as to compare their perceptions of AMS benefits and beliefs about adopting such technology. ➢ In terms of analyst triangulation, peers and scientists reviewed the analysis and study's findings to check for blind spots in the data analysis and to ensure that the findings were robust and correct.
	To ensure that the collected data is reliable, it was verified by the participants	Member checking	➢ The collected data, its interpretation, and conclusions were shared with all of the interviewed dairy farmers and AMS suppliers. They were given the opportunity to verify their answers, correct mistakes, and provide further information if required. ➢ In the interview survey, the researcher asked the participants whether they would like to receive a copy of the study at its completion. ➢ In the information sheet and consent form of interview survey, participants were advised that they were able to withdraw from the project at any time. The information sheet also provided the

			researcher's and the supervisory team's contact details in case participants had any questions about the project.
	To verify the data collection and sampling methods, and design of the interview survey	Peer debriefing	➢ Peer debriefing was conducted via Skype meetings and discussion with experts (data scientists) and other researchers working in the same field (AMS adoption). A similar project, AMS KPI in pastoral-based dairy farming system of Australia was considered to ensure the consistency and accuracy of the interview survey, process, methods, and results. In addition, scientists and dairy farming consultants were involved in the verification process.
Dependability	To ensure that the research study results are replicable over the time	In-depth description of the research approach and methods	➢ Interview protocols were developed to guide the collection of data. The protocol includes information about the objectives, a research description, the complete interview survey, and the sampling methods to be used. This means that other researchers can apply the same processes and methods to obtain similar results in the future. The data collection process and methods are described in detail.
Transferability	To extend to which the findings of the study can be transferred to other studies	Thick description	➢ In-depth description of each stage of the interviews. The applied methods and techniques, data collection and findings are provided in the methodology and results chapters of the research study to enable other researchers to apply the results of this study to the same or similar situations.
	To obtain data saturation and complete replication	Combination of sampling methods	➢ Two types of non-probability sampling methods (convenience and snowball sampling) were applied to choose a suitable sample size. These methods were used to recruit participants and collect enough data to obtain saturation and ensure replication.
Confirmability	To confirm the validity of the results via expert input	Verification of results	➢ The design of the interview survey, applied methods, and results from the data analysis were reviewed by senior lecturers at Lincoln University with a dairy farming background, dairy farming consultants and scientists from DairyNZ, researchers working on similar projects (focusing on AMS KPI) in pastoral-based dairy farming systems in Australia, and professionals from across the dairy farming sector to ensure that the results are reliable.

3.4 Data analysis

Qualitative analysis strongly relies on a researcher's analytical and integrative skills. It also depends on their own knowledge of the social context where the data is gathered. Qualitative analysis focuses more on sense making or understanding a phenomenon than providing an explanation or forecasting (Bhattacherjee, 2012).

There are different methods a researcher can use to analyse qualitative data. One method of analysis that can be used in both qualitative and quantitative research is content analysis. A basic type of content analysis is sentiment analysis which explores an individual's opinions or attitudes towards an object, individual, or phenomenon. Using this method, messages can be categorised into positive, negative, and neutral categories; every message is a singular unit of analysis. As a consequence, analysis enables a researcher to determine whether the sample is positively, negatively, or neutrally disposed towards a technology or behaviour. This type of data analysis method has five stages. In the first stage, the collected data is converted into raw text with the purpose of analysing the content. Raw text is then converted into shortened protocols. Subsequently, the protocols are converted into preliminary categories. The categories are used to make coded protocols. In the last stage, the coded protocols are analysed with the purpose of interpreting the phenomenon (Bhattacherjee, 2012).

The main focus of this study was to understand dairy farmers' attitudes, behaviour, and perceptions of AMS adoption in a pastoral-based dairy farming system. It was essential to determine whether dairy farmers' perceptions of AMS adoption were positive, negative, or neutral. The study hoped to understand the reasons for AMS adoption, the perceived benefits and challenges associated with AMS adoption, and the factors preventing dairy farmers from adopting AMS. Sentiment content analysis was chosen as the most suitable method for this study.

As mentioned in the sampling method section, at the start of this study, there were only 19 dairy farmers using AMS in a pastoral-based system. Three of them participated in the first stage of interviews. Four new dairy farmers took part in the second stage interviews. The study also had a small sample of dairy farmers who had not adopted AMS; only 13 agreed to participate. As the research had a small sample size, the researcher decided to use Microsoft Excel to analyse the collected data.

This study followed similar stages of sentiment content analysis. After conducting the interviews, the researcher entered the data into Microsoft excel sheets. For the open-ended questions, the text was converted into shortened protocols to identify the repeated answers and conduct calculations to interpret the data. Due to the small sample size, it was possible to apply the same method for close-ended questions, multiple-choice questions, and the Likert scale questions from section 4 (attitudes towards AMS). Likert questions were coded in the following manner: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

3.5 Conclusion

This chapter has explained the study's research methods and the choice of an inductive, qualitative approach. The data collection method was compromised of two stages of structured and semi-structured interviews. In terms of the theoretical basis for the interview survey, TPB was applied to understand dairy farmers' behaviour and perceptions of AMS adoption in a pastoral-based dairy farming system, the benefits and challenges associated with AMS, and the barriers relating to adoption. In order to select the right participants, this study used two sampling methods: convenience and snowball sampling. The chapter has outlined the different strategies used to ensure research reliability and validity.

Chapter 4
Results from interviews with AMS adopters

This chapter presents the results from the two stages of interviews with the dairy farmers who had adopted AMS in their pastoral-based farming systems. Three farmers who had adopted AMS participated in the first stage of interviews. Results from this first stage, which facilitated the design of the second stage, revealed many of the main reasons for AMS adoption in pastoral-based dairy farm systems, and the main advantages and disadvantages associated with AMS adoption.

Seven farmers participated in the second stage of interviews. This was a more structured interview survey than the first. Its design was informed by the literature review and results from the first stage of interviews. It included questions about the dairy farmers' backgrounds and demographic information, the factors that influenced farmers' decision to install AMS, and the challenges associated with AMS adoption.

4.1 Results from the first stage of interviews with AMS adopters

The purpose of the first stage of interviews was to identify the general reasons for AMS adoption, and the benefits and challenges that arose as a result of this decision.

Based on the discussions during the DairyNZ AMS conference calls, there were a total of 25 farmers in New Zealand who had adopted AMS in both pastoral-based and barn-based dairy farming systems. Six of the dairy farmers installed AMS in a barn-based system. The remainder installed it in a pastoral-based system. Most of the farmers who had installed AMS lived in the Waikato region, located in the North Island of New Zealand.

The first stage of interviews, which were semi-structured interviews, were conducted over the phone. The three participants were farmers who participated in the DairyNZ conference calls. The interview survey had two sections. While the first section asked the farmer to provide general information about the farm and themselves (age, gender, years on current farm), the second section asked farmers to provide information about why they chose to install AMS, and the advantages and disadvantages associated with AMS. The results of the analysis from these three interviews, alongside the literature review, led to a more structured interview survey in the second stage. As the number of participants in this stage was small, it was not necessary to use a specific data analysis tool.

The farmers provided several reasons for installing AMS on their farm: having witnessed AMS in operation overseas or in Hamilton (New Zealand), AMS features, including the voluntary movement and milking of the cows, changes in cow behaviour, and being able to treat them individually, an interest in experiencing new technologies, and challenges associated with the pastoral-based dairy farming system, to help with future succession planning, and farmers' personal values. These reasons are outlined in Table 4.1.

Table 4.1: Main reasons for AMS adoption in New Zealand pastoral-based dairy farm systems

Factors	Reasons for AMS adoption
Watching AMS overseas	➢ Led to thinking how to adopt AMS in a pastoral grazing system ➢ To experience a new challenge
Visiting the Greenfield Project in Hamilton	➢ Interested in installing AMS in a grazing system
AMS Features	➢ Interest in voluntary movement of the cows
	➢ Interested in history of voluntary milking systems
	➢ Interesting to watch cows changing
	➢ Interest in treating cows individually rather than as a herd
Interest in new technologies	➢ Interested in research, automation, and computers in dairy farming
Future planning	➢ Future succession planning and farmer's personal values

For the interviewed farmers, one of the primary advantages of AMS were the positive changes in cow behaviour, the milking process, the increased flexibility with working days and hours, the reduced work hours, shift in tasks, the decrease in physical work, savings associated with hiring labour, increased milk production, and having access to detailed data and information about each individual cow for cow management. These advantages are outlined in Table 4.2.

Table 4.2: Advantages associated with AMS installation in a pastoral-based dairy farming system

Factors	Description
Cow's behaviour	➢ Changes to cows' behaviour ➢ More relaxed ➢ More individual behaviours ➢ One of the farmers stated that: "*it is more difficult to change a farmer rather than a cow*".
Milking process	➢ Not spending a lot of time on milking task
Flexibility	Flexible working hours and lifestyle ➢ Relaxed operating system (can get up later) ➢ Reduced work hours ➢ Flexible working days ➢ Shift in tasks ➢ Less physical work
Labour	➢ Saving on labour
Production	➢ Increased production
Data	➢ Detailed data and information generated by AMS which enables better management of cows

The farmers reported several disadvantages associated with AMS installation: finding staff with computer and technology skills, the need to observe cows to spot any problems in a timely manner, the cost of AMS (the capital, maintenance and operation costs), earning sufficient financial return on the investment, and being available 24/7 so that they could respond to any alarms. These disadvantages are listed in Table 4.3.

Table 4.3: Disadvantages associated with AMS installation identified by pastoral-based dairy farmers

Factors	**Description**
Observation of cows	Frequency of individual cow observations reduced: ➢ Timeliness in spotting problems ➢ E.g., Observing lameness
24/7 job	➢ Issues with system (very rare call outs) ➢ Most common during early phases of installation
Labour	➢ Finding the right staff with computer and technology skills
Financial cost	➢ Huge capital, maintenance, servicing, and running costs ➢ Challenge to be profitable, gain sufficient financial return on investment

The findings from this stage suggest that an interest in experiencing technology and new challenges in a pastoral-based dairy farming system was one of the primary factors that encouraged the farmers to adopt AMS.

The main advantages and disadvantages associated with AMS adoption identified by pastoral-based dairy farmers can be divided into three categories: economic, social, and animal health and welfare. The economic factors relate to the investment and operating costs, financial returns, production levels, and the benefits associated with the data management system. The social factors relate to the farmers' lifestyles, reduction in physical workload, increased flexibility in working hours and days, and shift in tasks. The animal health and welfare category include the detailed data that AMS provides on each individual cow which enables farmers to detect issues related to the cow's health, the cow's freedom and comfort, and changes in the cow's behaviour. The findings from this stage of interviews helped the researcher to design the next stage of interviews.

4.2 Results from the second stage of interviews with AMS adopters

This stage of interviews was conducted with seven of the 19 (37%) New Zealand dairy farmers who had adopted AMS in their pastoral-based farming system.

4.2.1 Characteristics of the dairy farms and the farmers who adopted AMS

4.2.1.1 Results from section 1: General information

This section asked farmers to provide information about themselves, their role on the farm, their total number of years farming, and the farm operating AMS respectively.

Five of the farmers were from North Island; the remaining two were located in the South Island (Figure 4.1).

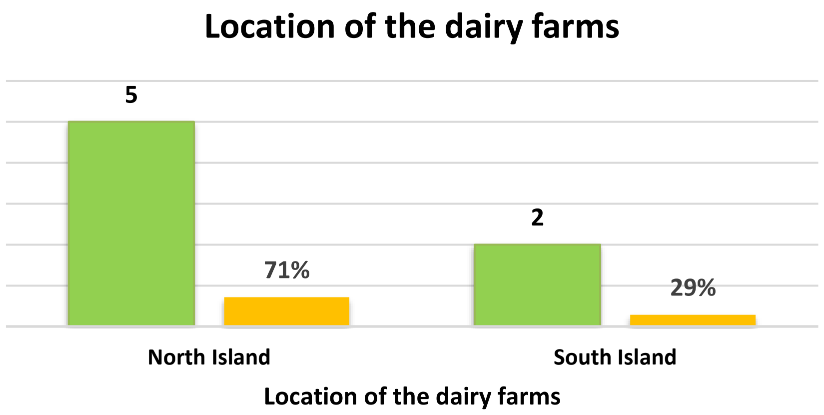

Figure 4.1: Location of the dairy farm

Four of the farmers were owners. The remaining three were sharemilkers (Figure 4.2).

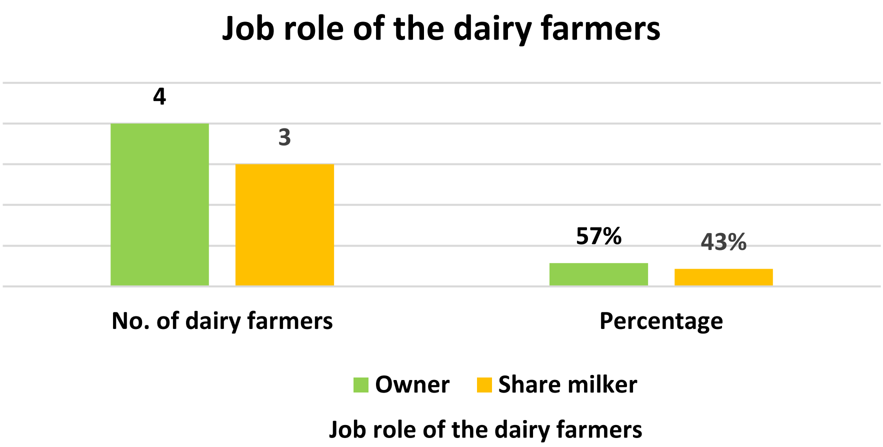

Figure 4.2: The dairy farmers' job role

The number of years of farming was divided into four categories with ten-year intervals. Six of the farmers had 20 to 40 years of experience in dairy farming (Figure 4.3).

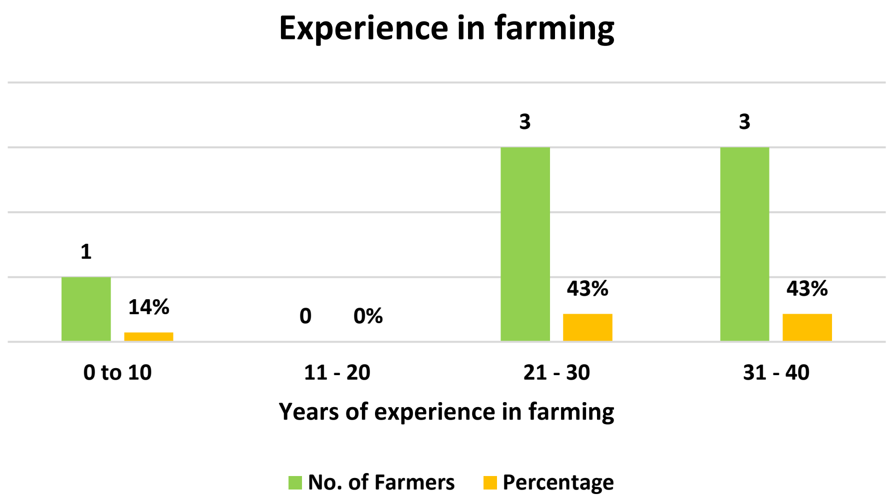

Figure 4.3: Experience in farming (years)

In terms of years of experience on the current farm, the responses were divided into four categories with ten-year intervals. Three of the farmers had worked on the current farm for less than 10 years, two between 11 and 30 years, and the remaining two had worked 31 to 40 years (Figure 4.4).

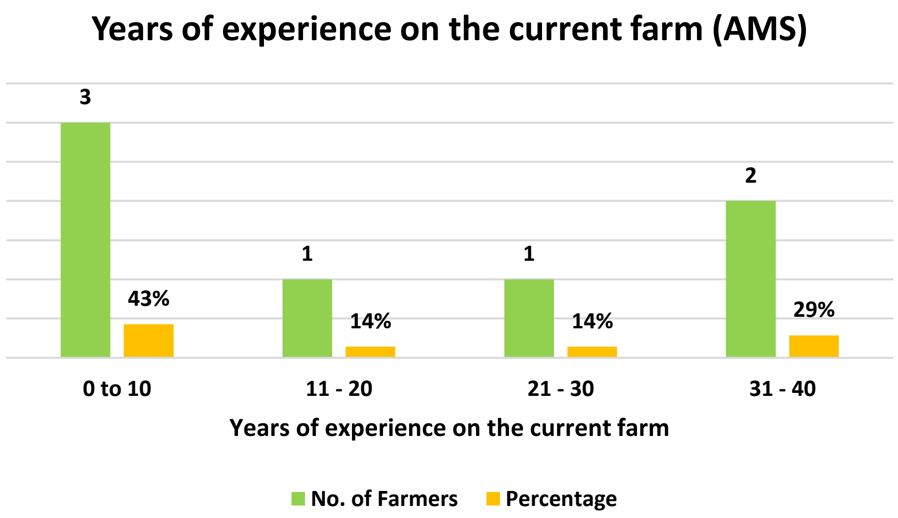

Figure 4.4: Years of experience on the current farm (AMS)

In terms of identifying a successor, four stated that this was not relevant or had not been undertaken. None of the farmers had identified a definitive successor (Figure 4.5).

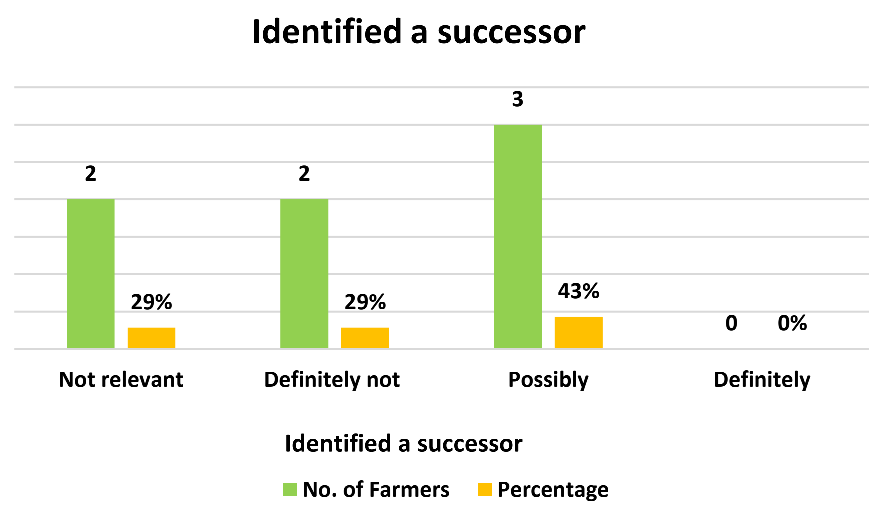

Figure 4.5: Definitive successor

Three of the farmers had worked on more than one dairy farm, the other four had not (Figure 4.6).

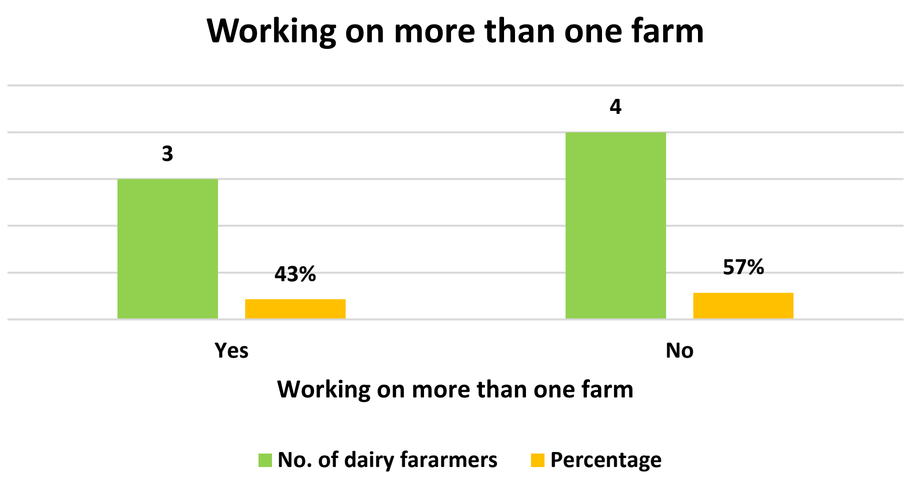

Figure 4.6: Working on more than one farm

4.2.1.2 Results from section 2: Details of farm business

This section asked the farmer questions about the dairy farm's location, the farm size, the number of effective hectares, milk production details, who purchases the milk, grazing support, the production system, the number of FTE, herd facts, and the calving system.

The farmers were spread around New Zealand, in both the North and the South Islands (Table 4.4).

Table 4.4: Location (region) of the dairy farms

Dairy farmers	**Farm location (region)**
Farmer 1	Auckland, North Island
Farmer 2	Hamilton, North Island
Farmer 3	Palmerston North, North Island
Farmer 4	Waikato, North Island
Farmer 5	Auckland, North Island
Farmer 6	Invercargill, South Island
Farmer 7	South Canterbury, South Island

The farm size ranged from 61 to 154 ha, with effective hectares from 55 to 125 ha. The herd sizes ranged from 160 to 500 cows. The number of young stock ranged from 20 to 120 for rising 1-year-olds (R1) and 22 to 120 for rising 2-year-olds (R2). The dairy cows' milk production ranged from 190 to 480KgMS/per cow/per year. One farmer chose not to respond to this question (Table 4.5). Six of the farmers sell their milk to Fonterra. The farmers all had a mix of Friesian, Holstein and Jersey crosses, breeds common in New Zealand (Figure 4.7).

Table 4.5: Farm details

Farmer	**Farm Size**	**Effective hectare**	**Herd size**	**Rising 1-year- olds (R1)**	**Rising 2-year-olds (R2)**	**Milk produced (KgMS/Cow/Yr)**
Farmer 1	135	120	165	50	50	400
Farmer 2	82	76	300	30	30	480
Farmer 3	100	95	295	80	72	426
Farmer 4	154	125	500	120	120	-
Farmer 5	136	82	230	37	63	280
Farmer 6	100	81	160	20	22	370
Farmer 7	61	55	160	35	40	190

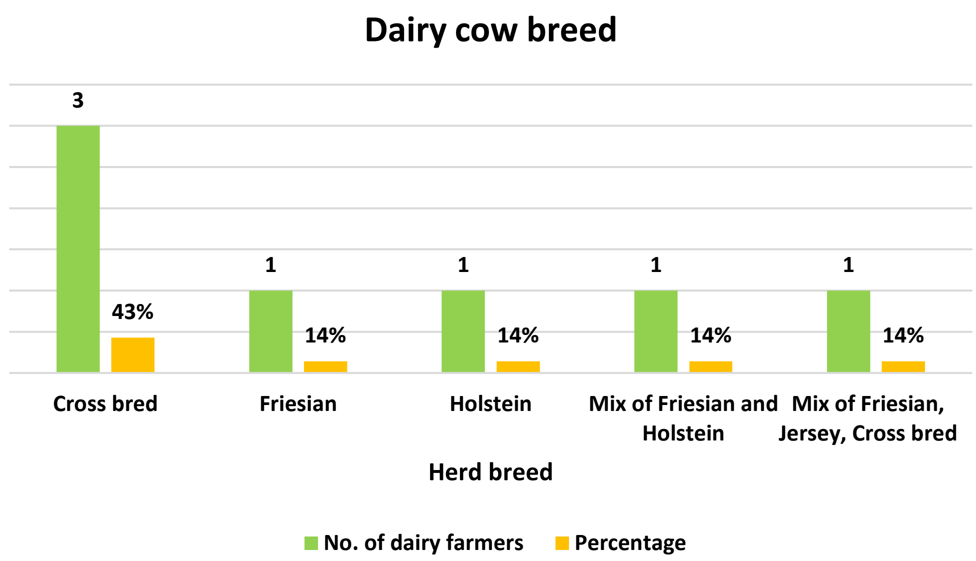

Figure 4.7: Dairy cow breed

In terms of grazing support, farmers provided five responses; three were self-sufficient, and two used maize silage, palm kernel, Nutri-Liq, and molasses. None of the farmers practised system 2 of dairy production, with one or more practising systems 1, 3, 4, and 5 (Figure, 4.8).

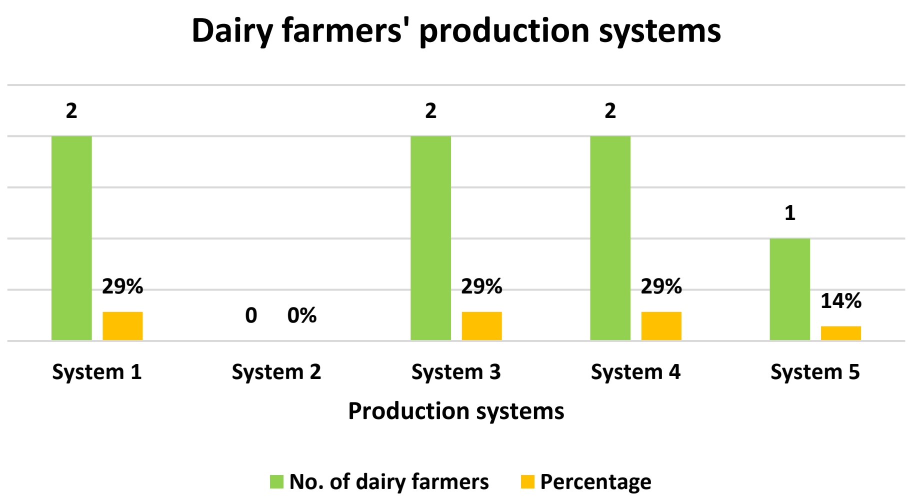

Figure 4.8: Production systems practised by the dairy farmers

The farmers employed between one to three FTE staff (including themselves) (see Figure 4.9).

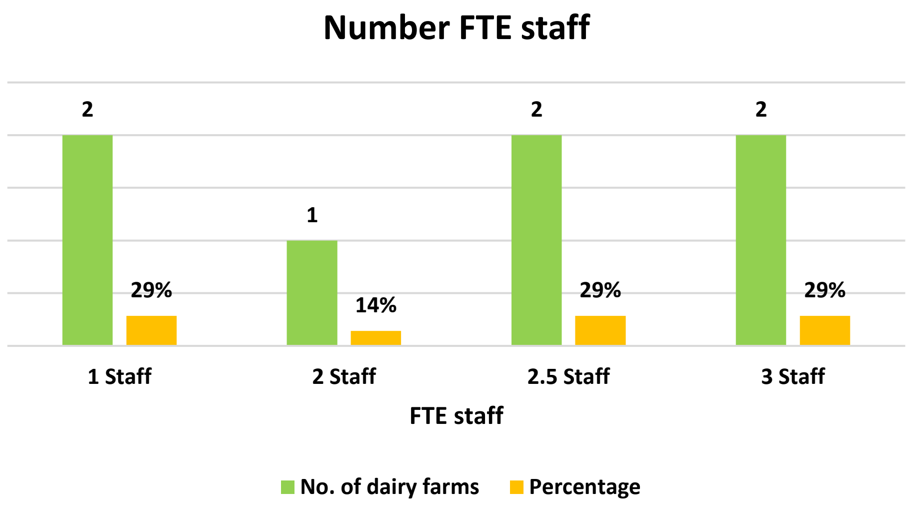

Figure 4.9: Number of FTE staff

Four of the farmers used a split calving system. Two were seasonal and one had a year-round calving system (Figure 4.10).

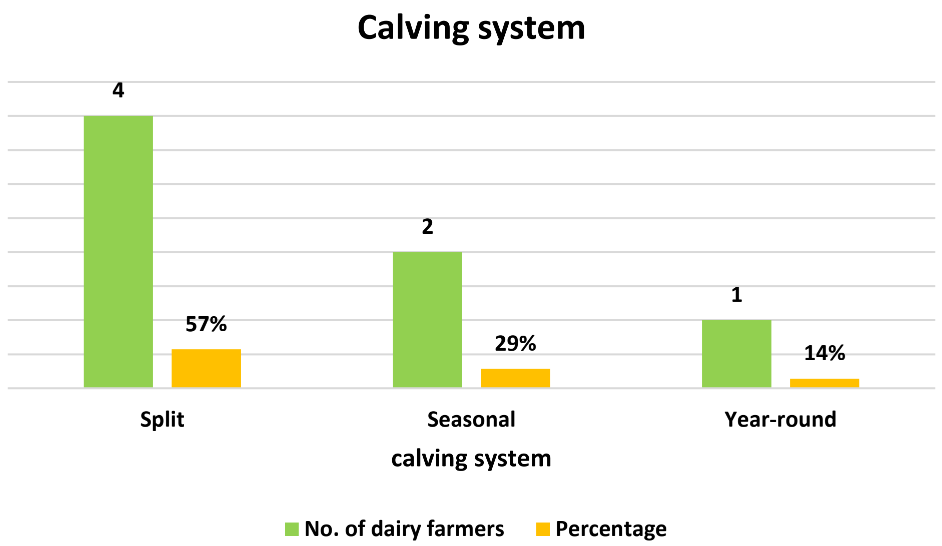

Figure 4.10: Dairy farmers' calving systems

4.2.1.3 Results from section 3: Details of AMS

This section included questions related to the AMS suppliers, the year AMS was installed, the period of time that the farmers considered installing AMS, and the number of AMS installed on each individual farm (Table 4.6).

It took four farmers more than two years to install AMS. One farmer considered AMS for one to two years, with the remaining two taking less than a year to consider and install AMS (Figure 4.11).

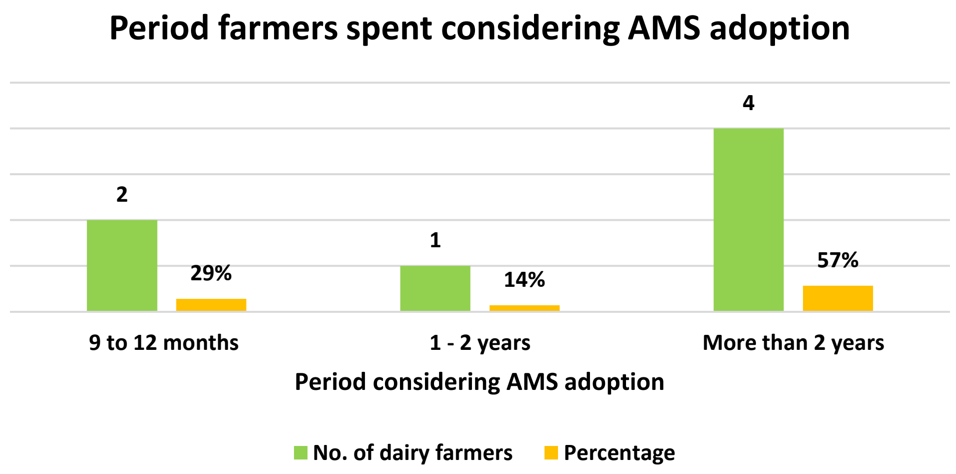

Figure 4.11: Period farmers spent considering AMS adoption

Table 4.6: Details of AMS

Farmer	Year AMS installed	No. of AMS	AMS supplier
Farmer 1	2010	2	DeLaval
Farmer 2	2011	4	DeLaval
Farmer 3	2014	4	Lely
Farmer 4	2013	6	DeLaval
Farmer 5	2016	3	Lely
Farmer 6	2013	2	Lely
Farmer 7	2015	3	Lely

4.2.1.4 Results from section 7: Personal information

This section asked farmers to provide personal information, including their age, gender and level of education. Five of the farmers had finished high school. Two of them had no formal education (Figure 4.12).

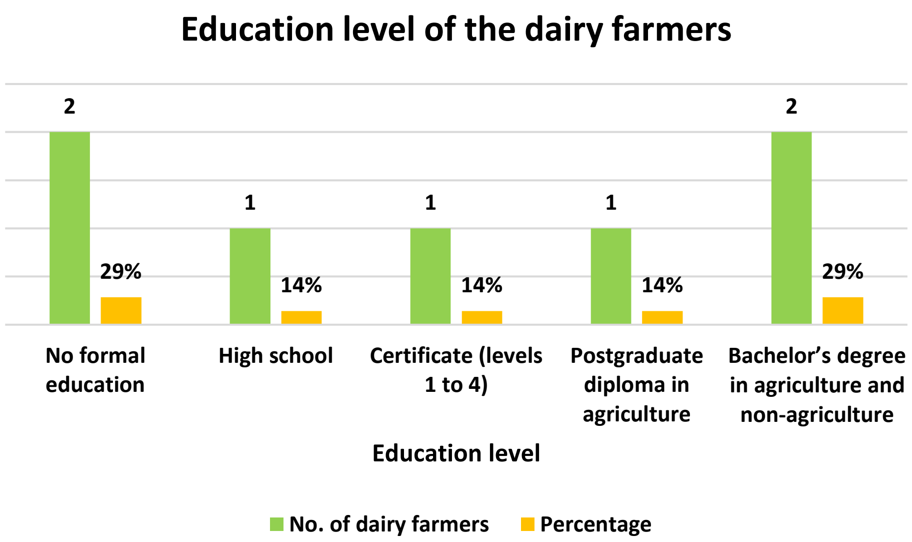

Figure 4.12: Dairy farmers' level of education

In terms of age, the farmers were equally split across the 35 to 64 years age group (Figure 4.13). All respondents were male.

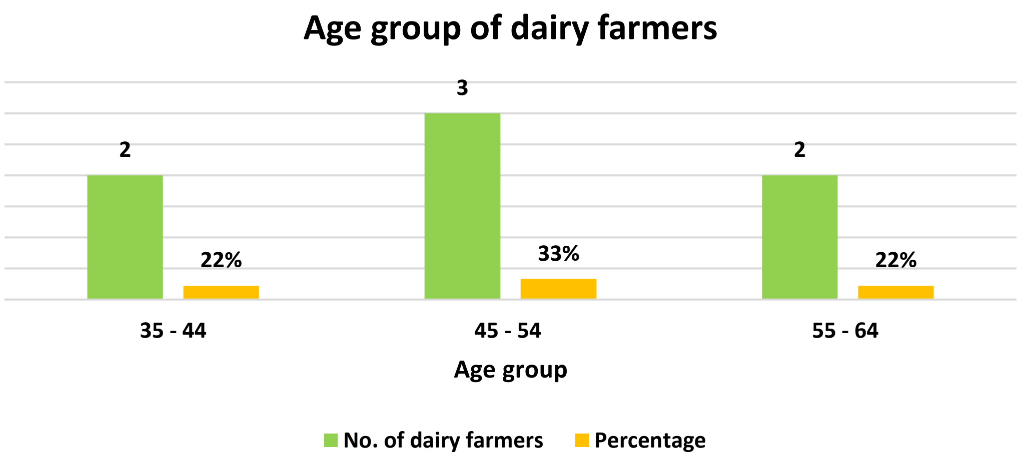

Figure 4.13: Age of the dairy farmers

4.2.1.5 Summary of dairy farm and farmer characteristics

Farmers who had adopted AMS were located in different regions across both the North and South Islands of New Zealand. Four of the interviewees were owners. The remaining farmers were sharemilkers. Six of the farmers had more than 20 years of experience in farming, although not necessarily on the current farm. None of the farmers had definitely identified a successor to overtake the farm.

Farm sizes ranged from 61 to 154 ha, with effective hectares ranging from 55 to 125 ha and herd size ranging from 160 to 500 cows. The dairy cows' milk production ranged from 190 to 480KgMS/per cow/per year. None of the farmers used the second production system; the rest adopted system 1, 3, 4, or 5. Most of the farmers had a single breed of dairy cows. Four of the farmers followed split or batch calving, where the dairy cows calve in two to three distinct groups.

It took four of the farmers more than two years to adopt and install either a Lely or DeLaval AMS.

Five of the farmers had obtained a high school level education. Two of them had no education. All of them were male and were older than 35 but less than 64 years old.

In conclusion, all of the farmers had long-term experience in the dairy industry. None had identified a definite successor. The other demographic factors, location, production level and system, and cow breed, suggested they had little influence on the farmers decision-making around adoption of AMS.

4.2.2 Results from section 4: Behaviour towards AMS adoption

This section of the interviews, which follows TPB, had three main sub-sections: attitude, subjective norms, and perceived behavioural control. The attitude sub-section was comprised of two sections: behavioural beliefs and evaluation of behavioural outcomes. The second sub-section consisted of normative beliefs and motivation to comply. The last sub-section included control beliefs and perceived power.

In TPB, behavioural belief is calculated by multiplying the strength of each belief concerning an outcome by the outcome evaluation of that factor. The subjective norm is calculated by multiplying the strengths of each normative belief for each referent by the motivation to comply with the referent. Perceived behavioural control is calculated by multiplying the strengths of each control belief by the perceived power of the control factor (Francis et al., 2004). These calculations were applied to analyse the results from section 4 of the interview survey with both dairy farmers who had adopted AMS and those who had not.

The aim was to identify the factors that influenced the use of AMS in pastoral based systems, to understand the perceived impact of AMS on milk production, animal health and welfare. An additional goal was to determine the perceived costs of AMS for New Zealand dairy farmers and the perceived added resale value to their dairy farm after AMS installation. The results that follow are presented first as raw data and then with the multiplication applied.

4.2.2.1 Attitude results

Both behavioural beliefs and the evaluation of behavioural outcomes focused on seven sections: farm working environment, labour management, milk production, cost of AMS, herd health and animal welfare, herd data management, and technology.

The farm working environment section included social factors such as the creation of a better lifestyle, freeing up time, less physical work, better working conditions, more up-to-date working conditions, and a more relaxed operating system.

Better lifestyle was important for six of the farmers and they agreed that AMS provides this (Figure 4.14).

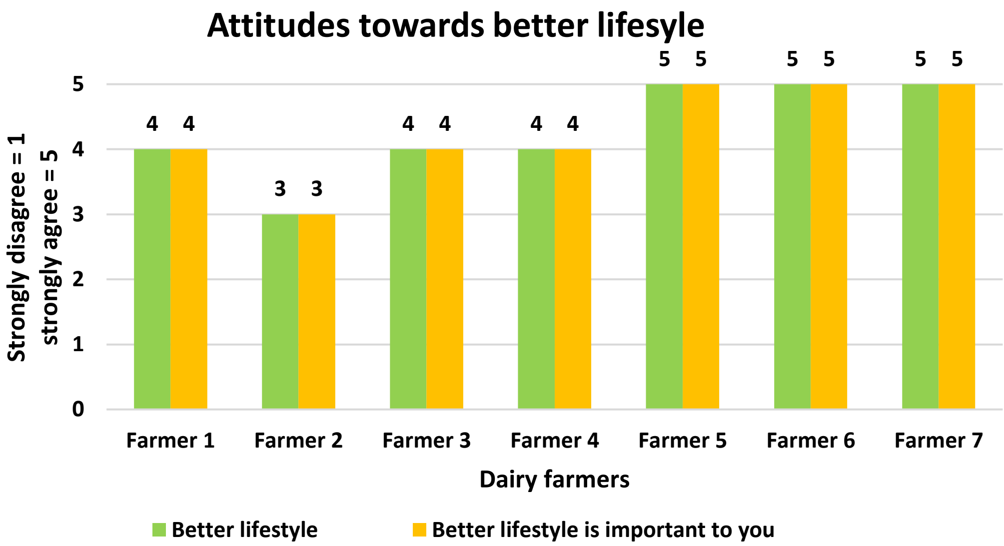

Figure 4.14: Attitudes towards a better lifestyle

Freeing up time was important for five of the farmers. Four of them agreed that AMS provides this (Figure 4.15).

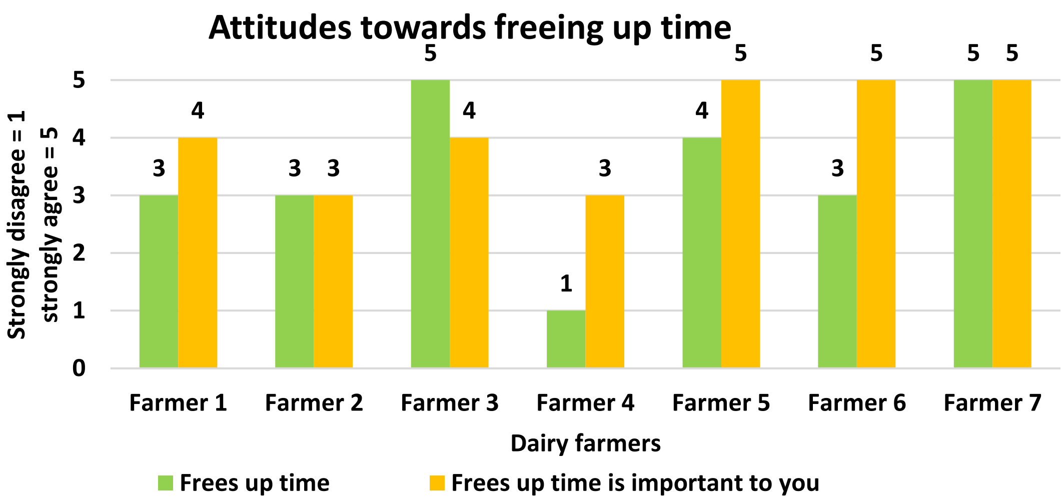

Figure 4.15: Attitudes toward freeing up time

Four of the farmers stated that less physical work was important for them. Six of them agreed that AMS provides this. This was not important for one farmer (Figure 4.16).

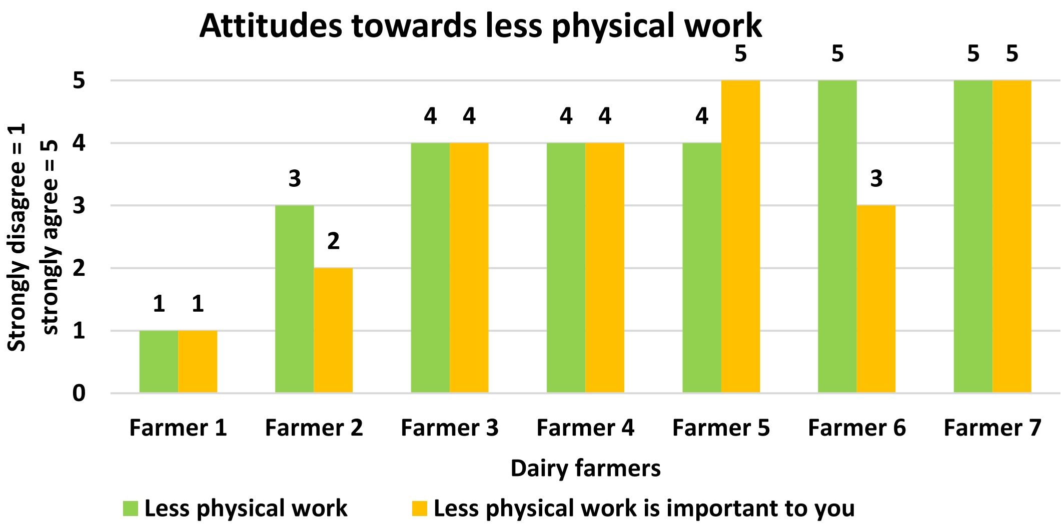

Figure 4.16: Attitudes towards less physical work

Better working conditions was important for five farmers. All seven agreed that AMS provides this (Figure 4.17).

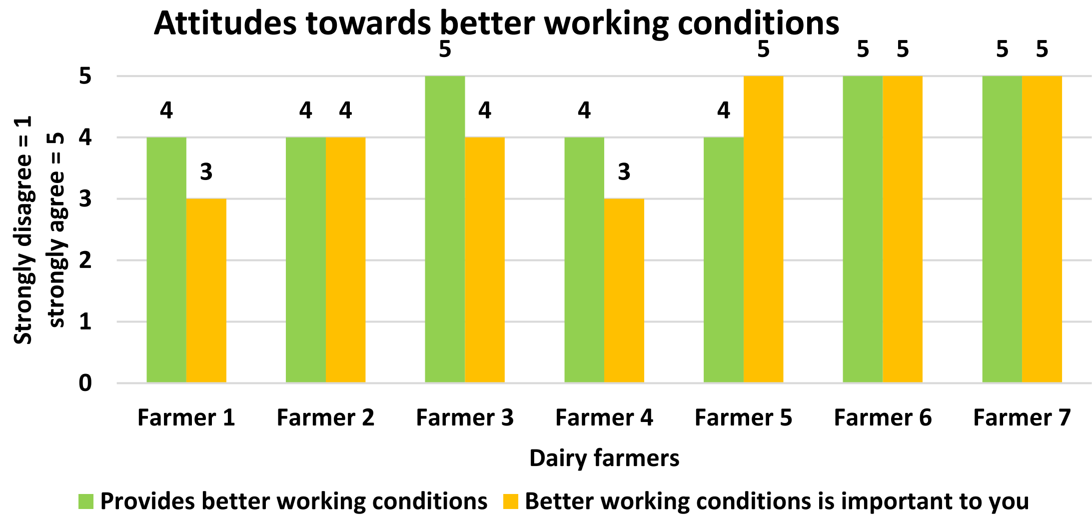

Figure 4.17: Attitudes towards better working conditions

More up-to-date working conditions was important for five farmers. Six farmers believed that AMS provides this (Figure 4.18).

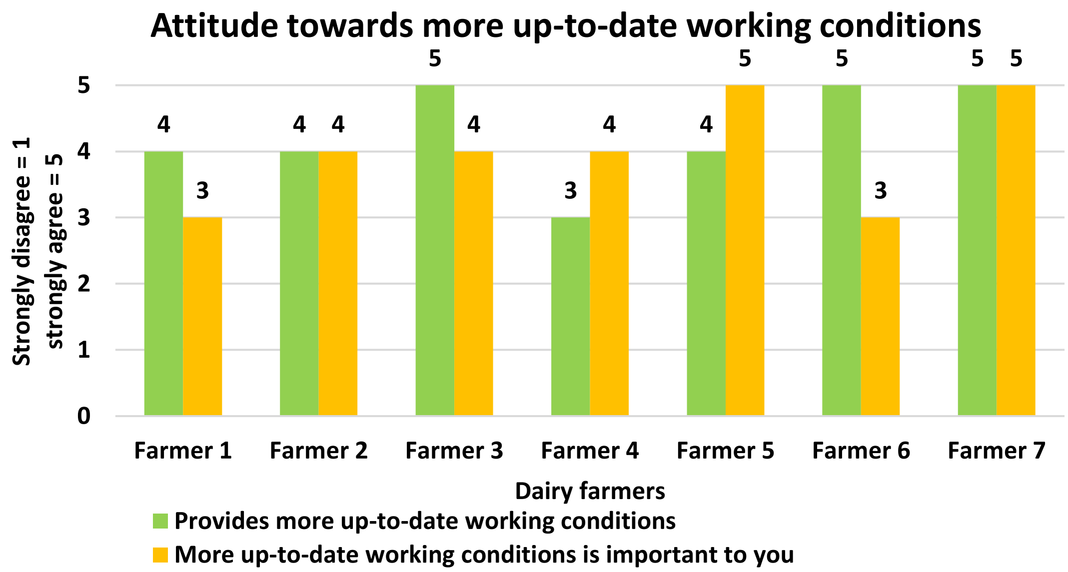

Figure 4.18: Attitude towards more up-to-date working conditions

The need for a relaxed operating system was important for six of the farmers. All of them agreed that AMS provides this (Figure 4.19).

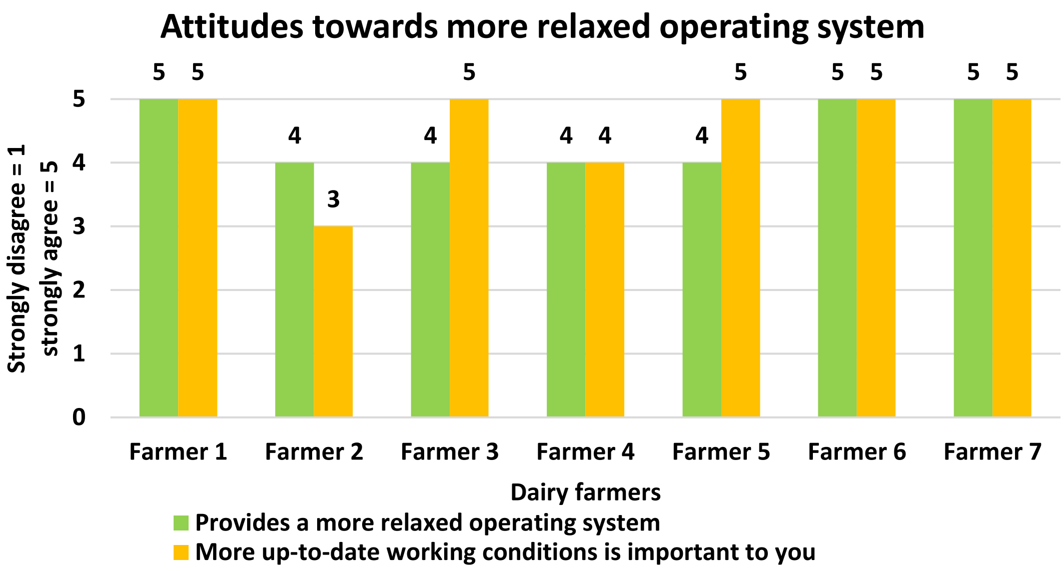

Figure 4.19: Attitudes towards a more relaxed operating system

In order to understand the attitudes towards AMS adoption, the behavioural belief strength of each factor was multiplied by the outcome evaluation of that factor. The scale range was 1 to 5, where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree, resulting in a minimum total of one (one multiplied by one) and a maximum total of 25 (five multiplied by five). For instance, if the farmer strongly agreed that AMS provides a better lifestyle and also strongly agreed that a better lifestyle was important to them, then the attitude measurement was five multiplied by five producing a total of 25. The attitude calculations and total value for a better lifestyle are presented in Table 4.7.

Table 4.7: Calculations of total value of farm working environment factors

Farmers	**AMS provides a better lifestyle**	**Better lifestyle is important to you**	**Attitude calculations**
Farmer 1	4	4	4 * 4 = 16
Farmer 2	3	3	3 * 3 = 9
Farmer 3	4	4	4 * 4 = 16
Farmer 4	4	4	4 * 4 = 16
Farmer 5	5	5	5 * 5 = 25
Farmer 6	5	5	5 * 5 = 25
Farmer 7	5	5	5 * 5 = 25
Total	16 + 9 + 16 + 16 + 25 + 25 + 25 = **132**		

The same calculations were applied to the rest of the factors included in farm working environment; therefore, each factor has been given a total number. The farm working environment was comprised of better lifestyle, freeing up time, less physical work, better working conditions, more up-to-date working conditions, and relaxed operating system factors. Using the total values of each factor, the average value was calculated so as to compare these categories. The calculations for the average of category are provided in Table 4.8.

In terms of social factors included in the farm working environment, a more relaxed operating system, a better lifestyle, and better working conditions had a higher total ranking. In other words, this finding suggests that farmers either felt these social factors were more important and/or they agreed that AMS provides these benefits. Other social factors, including more up-to-date working conditions, freeing up time, and less physical work, were either less important to the farmers and/or they did not agree that AMS provides these benefits (Table 4.8).

Table 4.8: Total value of farm working environment factors

Social factors	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**	**Farmer 6**	**Farmer 7**	**Total**
Better lifestyle	16	9	16	16	25	25	25	**132**
Frees up time	12	9		20	3	20	15	**104**
Less physical work	1	6	16	16	20	15	25	**99**
Better working conditions	12	16	20	12	20	25	25	**130**
More up-to-date working conditions	12	16	20	12	20	15	25	**120**
Relaxed operating system	25	12	20	16	20	25	25	**143**

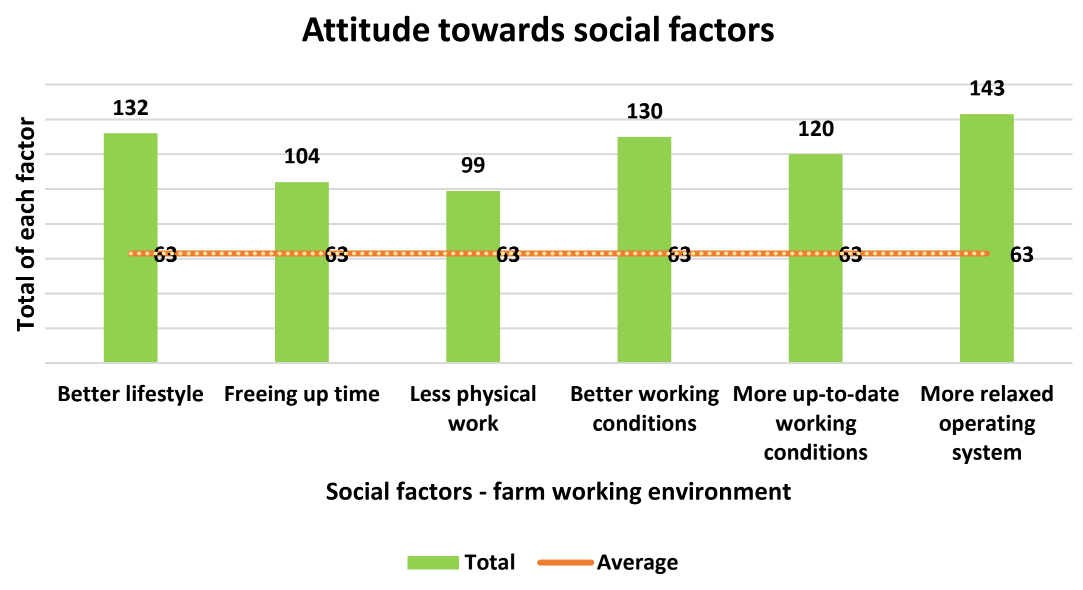

Figure 4.20: Total value of farm work environment factors

Figure 4.20 presents the total value of each farm working environment factor and the average line of 63. If farmers were neutral on both factors, then this figure would be three multiplied by three; with a total of seven farmers, this in total would be 63 (nine multiplied by seven). The average line is included in all of the total value figures to show all of the factors that are above that line which are then a positive influence. It also indicates the strength of that influence for all those that are below the average line. The same calculations were applied for those dairy farmers who had not adopted AMS.

The labour management section focused primarily on social factors, including less working days, flexible working days, less working hours, flexible working hours, a shift in the tasks, reduced labour requirements, attractiveness to future generations, help with succession planning, and help with labour recruitment.

Less working days was important for two farmers. One farmer agreed that AMS provides this. Three were neutral and the remainder disagreed (Figure 4.21).

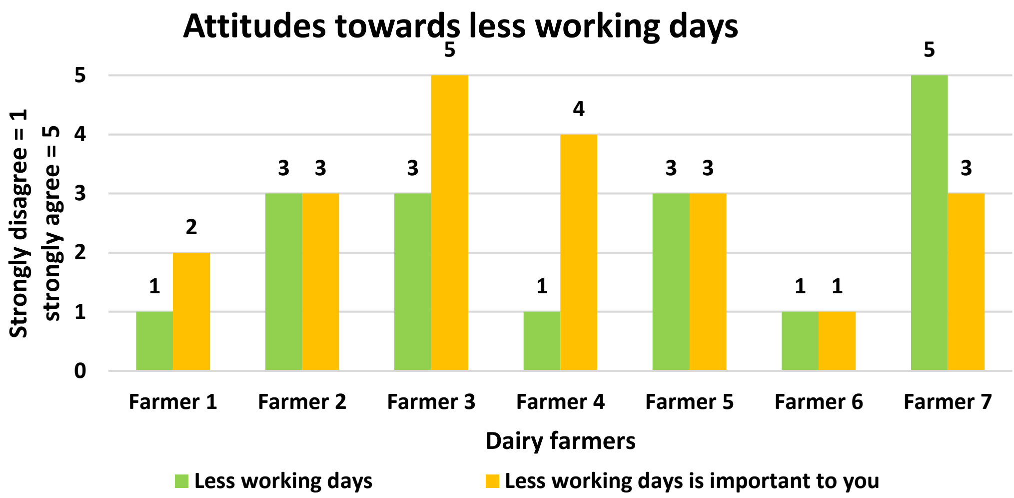

Figure 4.21: Attitudes towards less working days

While more flexible working days was important for six farmers, only three of them agreed that AMS provides this (Figure 4.22).

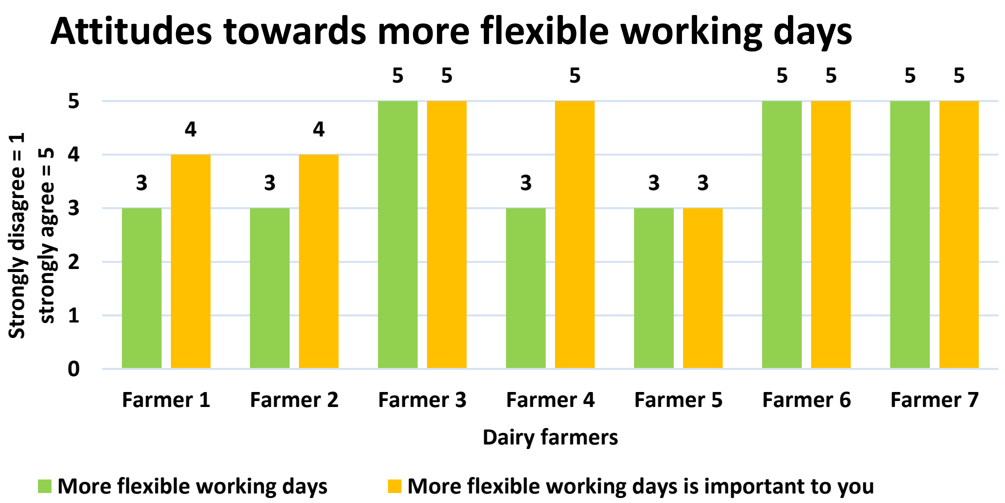

Figure 4.22: Attitudes towards more flexible working days

Less working hours was important for one farmer. Five were neutral. Two of them agreed that AMS provides this (Figure 4.23).

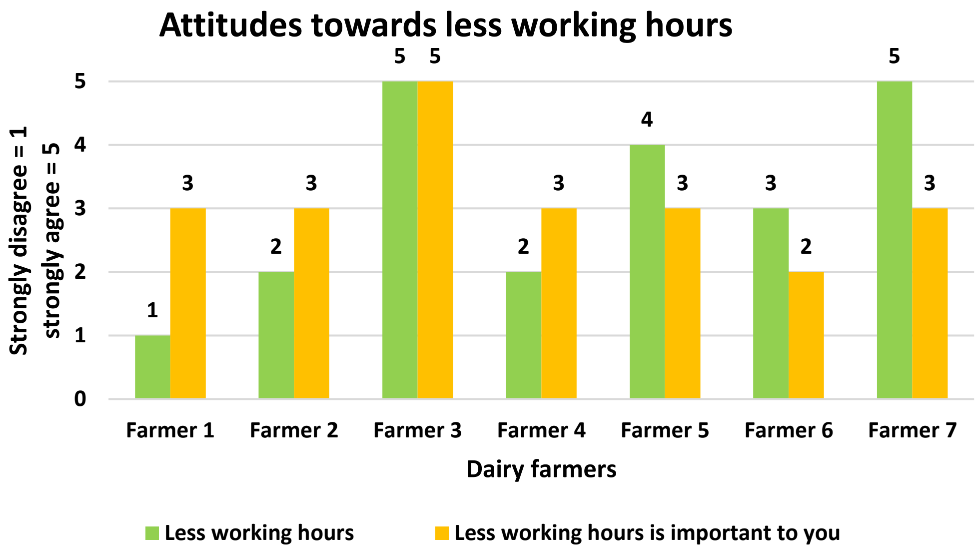

Figure 4.23: Attitudes towards less working hours

More flexible working hours was important for four farmers. Three were neutral. Six of them agreed that AMS provides this (Figure 4.24).

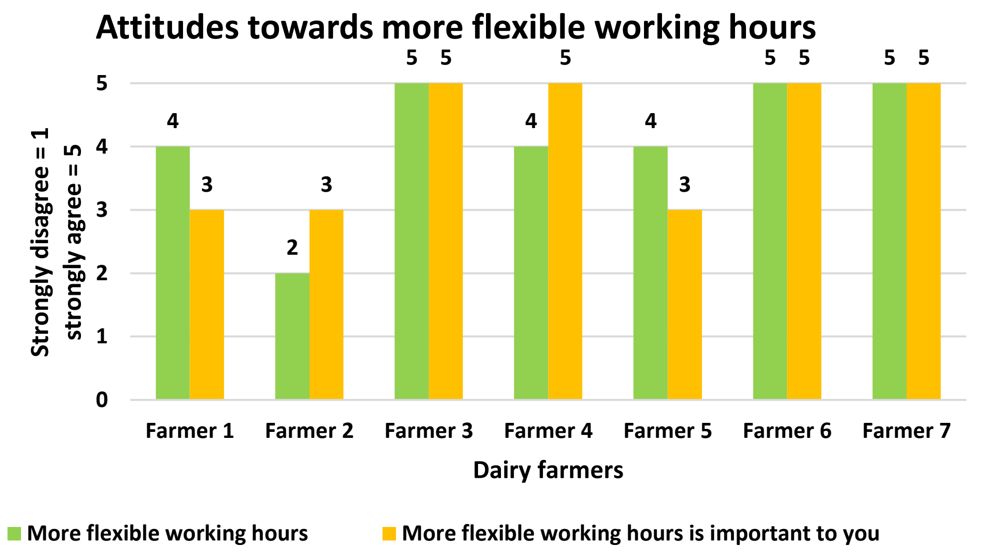

Figure 4.24: Attitudes toward more flexible working hours

A shift in tasks was important for five of the farmers. Six of them agreed that AMS provides this (Figure 4.25).

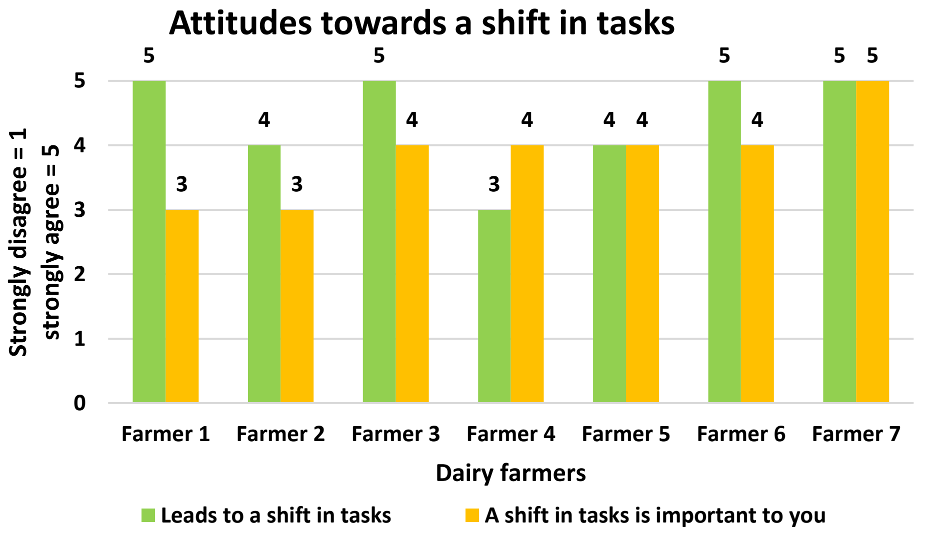

Figure 4.25: Attitudes towards a shift in tasks

Two farmers stated that reducing labour requirements was not important for them as they ran the farm themselves. This factor was important for four farmers. Four of them agreed that AMS provides this (Figure 4.26).

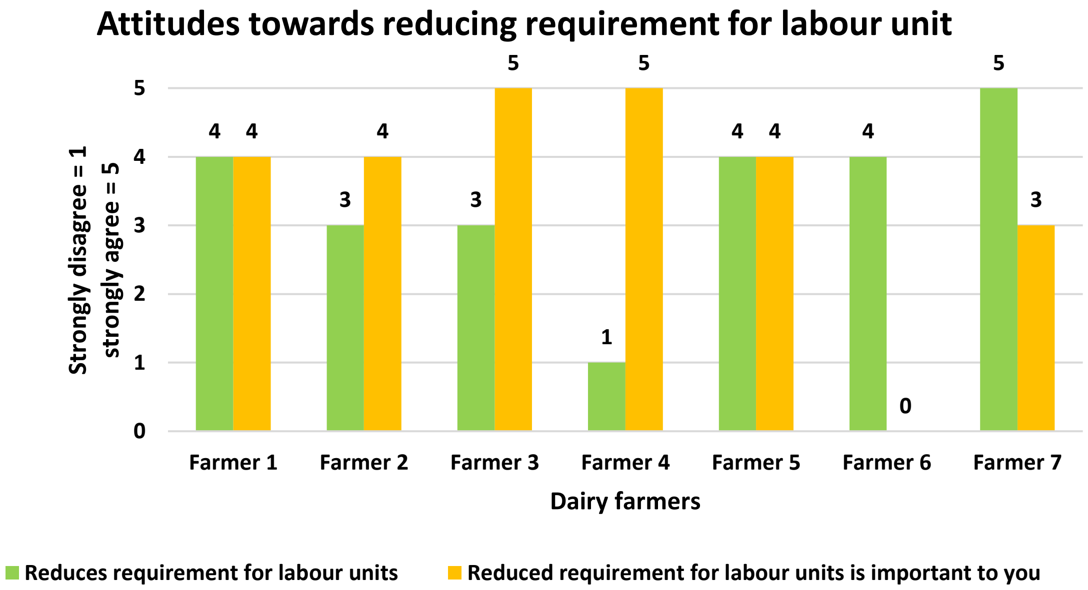

Figure 4.26: Attitudes towards reducing the requirement for labour unit

Being attractive to future generations was important for three farmers. Four of the farmers were neutral. While three of the farmers agreed that AMS provides this; the rest indicated that they were neutral (Figure 4.27).

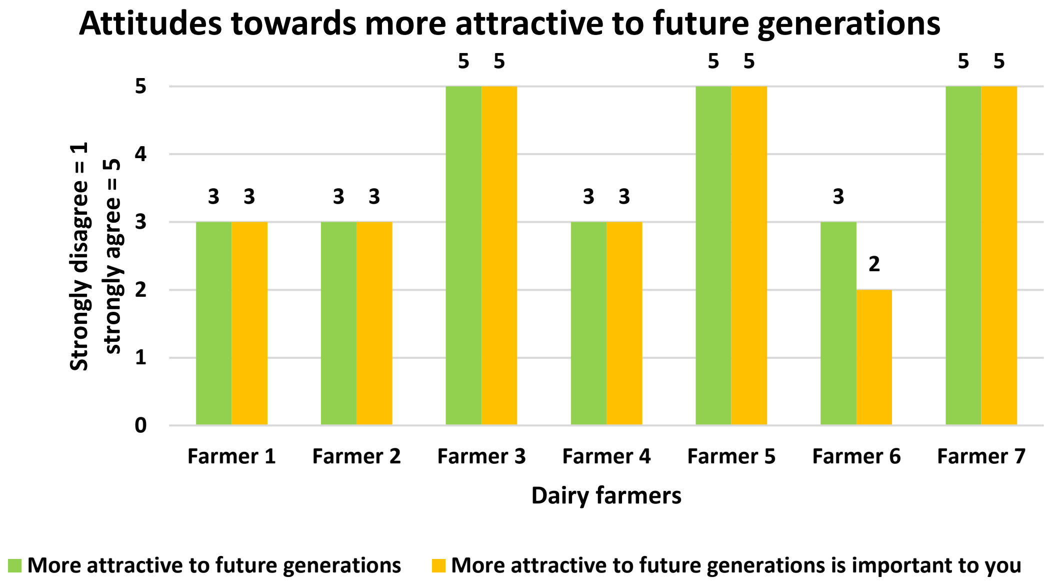

Figure 4.27: Attitudes toward more attractive to future generation

Succession planning was important for two of the farmers. Three of them agreed that AMS provides this (Figure 4.28).

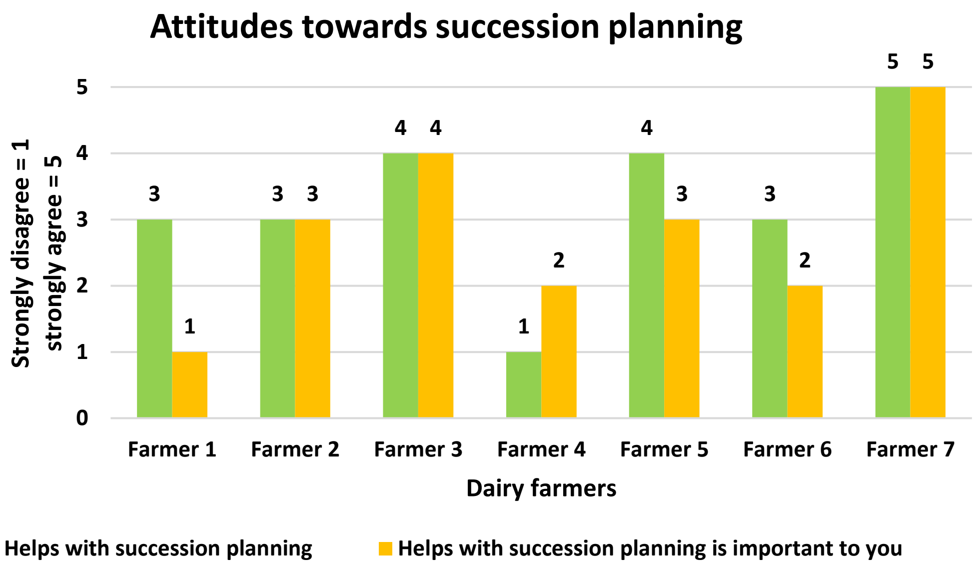

Figure 4.28: Attitudes toward succession planning

Help with labour recruitment was not applicable to one of the farmers since he was running the farm on his own. This factor was important for three of the farmers. Two of them agreed that AMS provides this (Figure 4.29).

Figure 4.29: Attitudes towards help with labour recruitment

Flexible working hours and days, shifts in tasks, and attractiveness to future generations had higher total rankings (Figure 4.30). These social factors were either more important to the farmers and/or they agreed that AMS provides them with these benefits. Other social factors, including less working days and hours, help with succession planning, and labour recruitment, were either less important to the farmers and/or they did not believe that AMS provides them with these benefits (Table 4.9).

Table 4.9: Total value of labour management factors

Social factors	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Total
Less working days	2	9	15	4	9	1	15	**55**
Flexible working days	12	12	25	15	9	25	25	**123**
Less working hours	3	6	25	6	12	6	15	**73**
Flexible working hours	12	6	25	20	12	25	25	**125**
A shift in tasks	15	12	20	12	16	20	25	**120**
Reduce in requirement for labour unit	16	12	15	5	16	0	15	**79**
Attractiveness to future generations	9	9	25	9	25	6	25	**108**
Help with succession planning	3	9	16	2	12	6	25	**73**
Help with labour recruitment	9	9	16	12	3	0	25	**74**

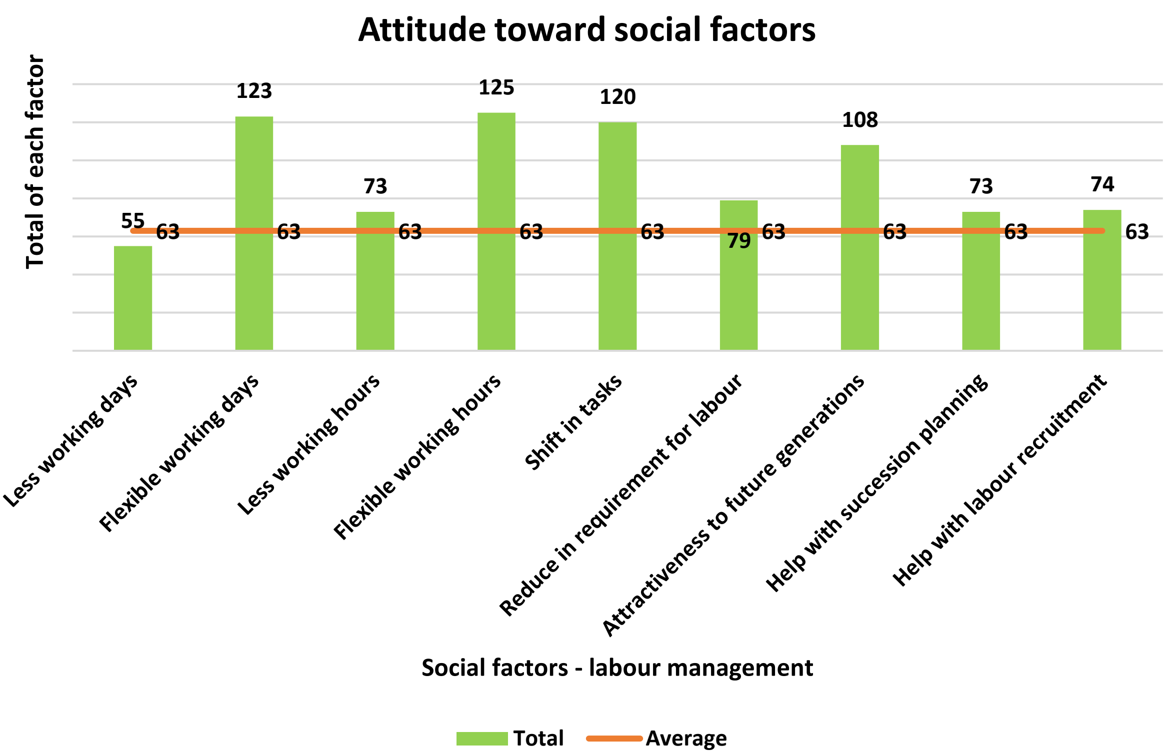

Figure 4.30: Total value of labour management factors

The milk production section focused on economic factors, including milk production and quality.

While six farmers reported that an increase in milk production was important for them, only four of them agreed that AMS provides this (Figure 4.31). Three were neutral.

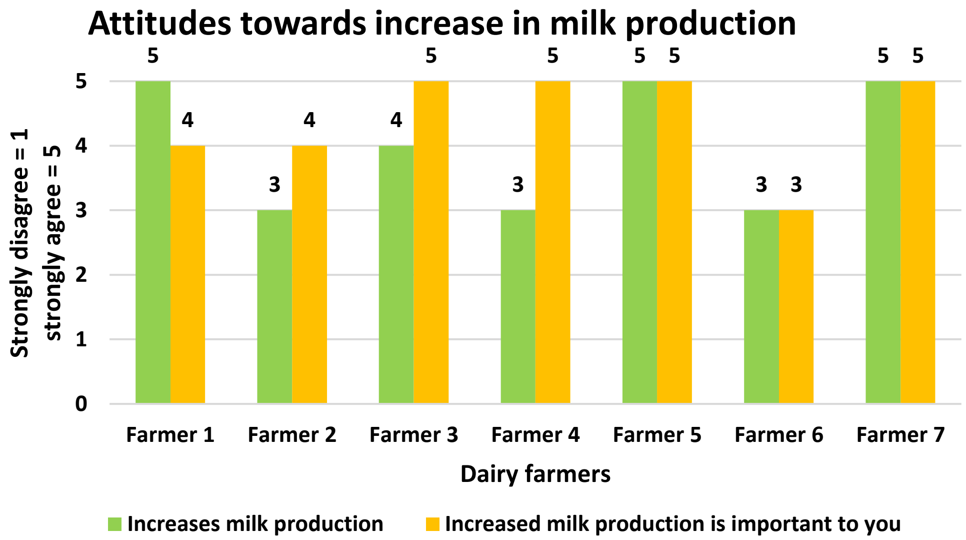

Figure 4.31: Attitudes towards increase in milk production

While improved milk quality was important for all of the farmers, only three of them agreed that AMS provides this (Figure 4.32). Four were neutral.

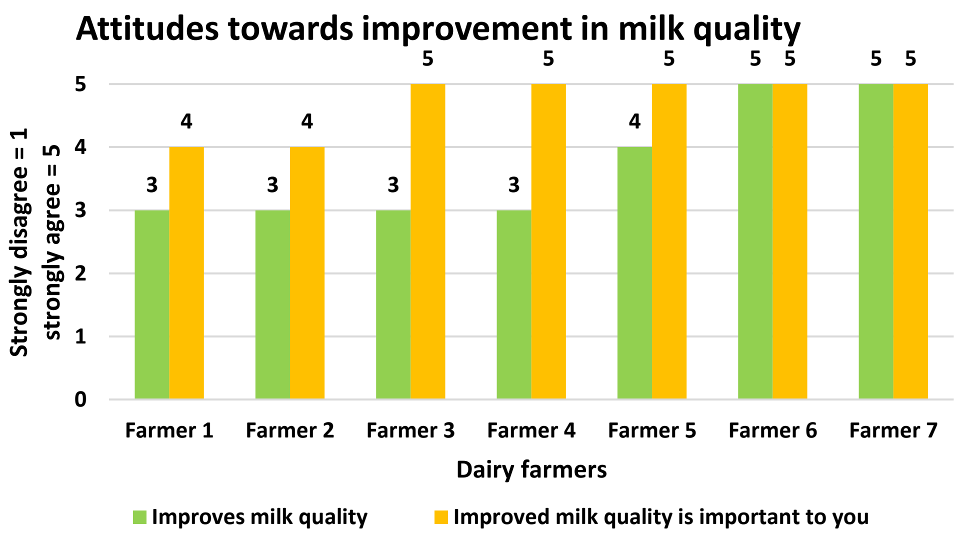

Figure 4.32: Attitudes towards improvement in milk quality

Based on the responses, it can be concluded that that increase in milk production was important to six of the farmers, whilst improvement in milk quality was important to all of them. While three of the farmers were neutral that AMS increases milk production, four of them were neutral that AMS improves the milk quality. None of them disagreed that AMS provides these benefits.

Table 4.10: Total value of milk production factors

Farmers	Increased milk production	Improved milk quality
Farmer 1	20	12
Farmer 2	12	12
Farmer 3	20	15
Farmer 4	15	15
Farmer 5	25	20
Farmer 6	9	25
Farmer 7	25	25
Total	**126**	**124**

The cost section focused on economic factors, including profits improvement, financial returns, reductions in operating and milking shed maintenance costs, reduced labour costs, and the farm's resale value.

Profit improvement was important for six of the farmers, but only three of them agreed AMS provides this. Two were neutral and one disagreed that AMS provides this (Figure 4.33).

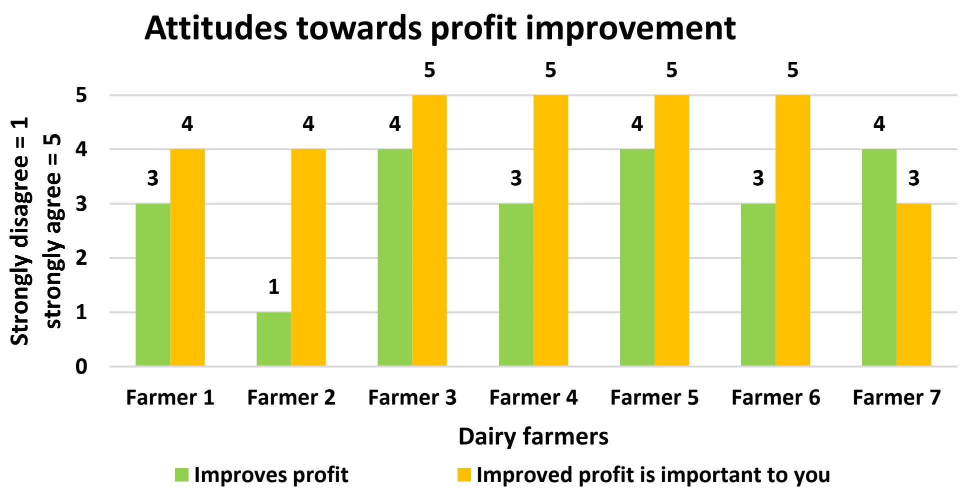

Figure 4.33: Attitudes towards profit improvement

While improved financial returns were important for six of the farmers, only two of them agreed that AMS provides this. Four of the farmers were neutral and one disagreed (Figure 4.34).

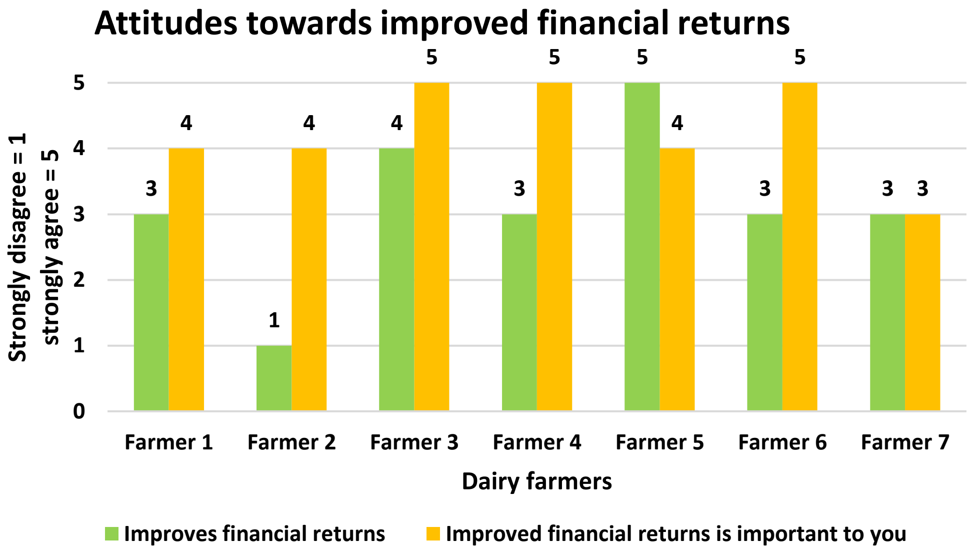

Figure 4.34: Attitudes towards financial returns

Reduced milking shed operation costs was important for six of the farmers. However, six of them disagreed that AMS provides this. One farmer was neutral (Figure 4.35).

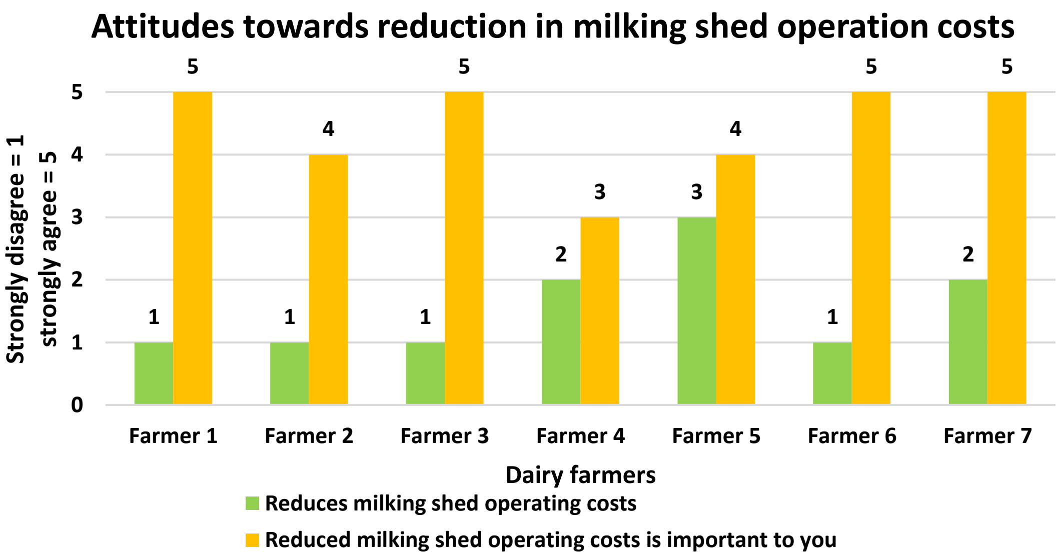

Figure 4.35: Attitudes towards reduced milking shed operation costs

Reductions in milking shed maintenance and servicing costs was important for six of the farmers. However, six of them disagreed that AMS provides this and one was neutral (Figure 4.36).

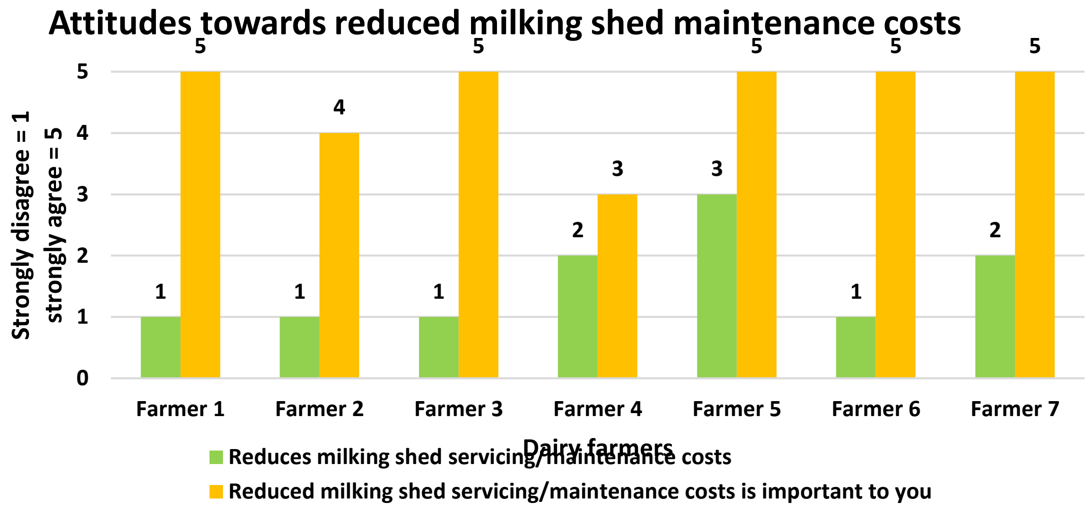

Figure 4.36: Attitudes towards reduced milking shed maintenance costs

One farmer stated that he was not concerned about reduced labour costs as he was running the farm on his own. This factor was important for five of the farmers. Four of them agreed, two were neutral and one disagreed that AMS provides this (Figure 4.37).

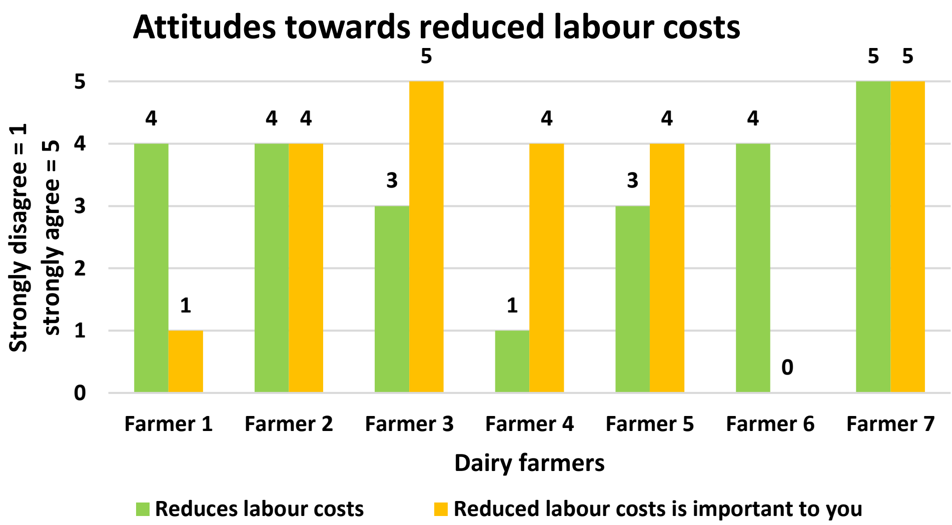

Figure 4.37: Attitudes toward reduced labour costs

While four of the farmers were concerned about an increase in the resale value of their dairy farm after AMS installation, four of them were neutral. Three disagreed that AMS provides this (Figure 4.38).

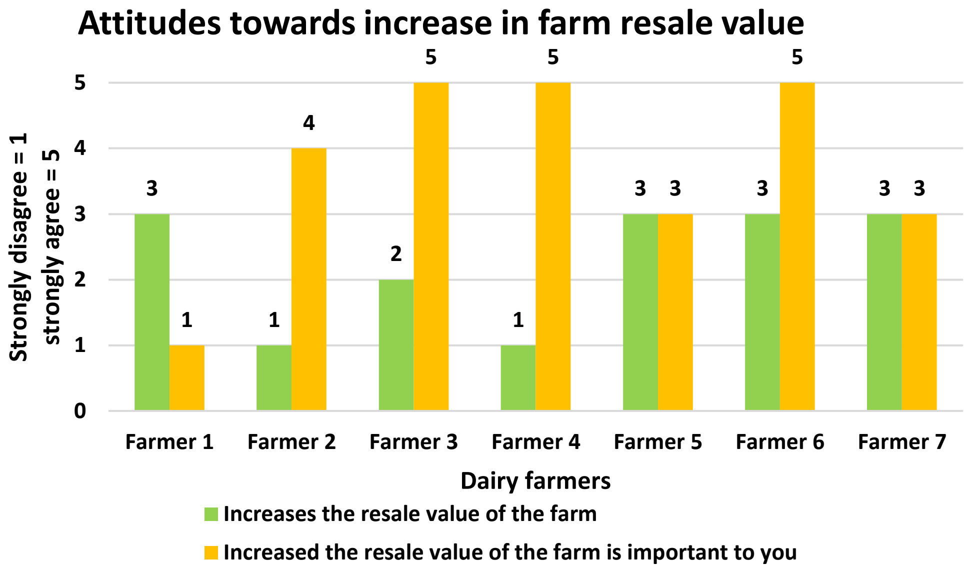

Figure 4.38: Attitudes towards increase in farm resale value

The results indicate that most farmers are concerned about different types of costs related to the operation and maintenance of the milking shed and labour, and also improvements in profits, financial returns, and the resale value of their dairy farms. However, the farmers stated that AMS had failed to improve their profits and reduce costs as desired by the farmers.

In terms of economic factors, improved profit and financial return, and reduced labour costs had higher total rankings (Figure 4.39). These economic factors were either more important to the farmers and/or they agreed that AMS provides them with these benefits. Other economic factors, including reduced milking shed operation and maintenance costs, and an increased resale value of the farm, were either less important to the farmers and/or they did not agree that AMS provides them with these benefits (Table 4.11).

Table 4.11: Total value of cost of AMS factors

Economic factors	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Total
Profit improvement	12	4	20	15	20	15	12	**98**
Financial returns improvement	12	4	20	15	20	15	9	**95**
Reduced milking shed operating costs	5	4	5	6	12	5	10	**47**
Reduced milking shed maintenance costs	5	4	5	6	15	5	10	**50**
Reduced labour costs	4	16	15	4	12	25	0	**76**
Increased resale value of the farm	3	4	10	5	9	15	9	**55**

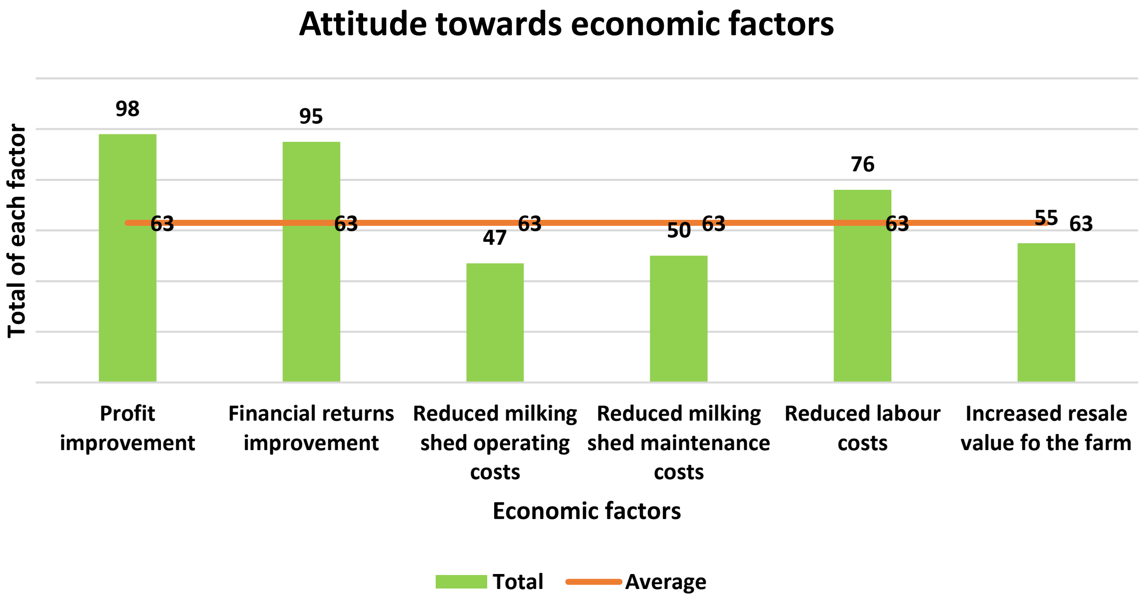

Figure 4.39: Total value of cost of AMS factors

The herd health and animal welfare section focused on animal health and welfare factors, including better animal welfare, more relaxed dairy cows, treating cows as individuals rather than herds, opportunities to observe the cows, opportunities to spot problems in cows, and reduced rates of mastitis and lameness.

Animal welfare was important for all the farmers, and all of them strongly agreed that AMS ensures greater animal welfare (Figure 4.40).

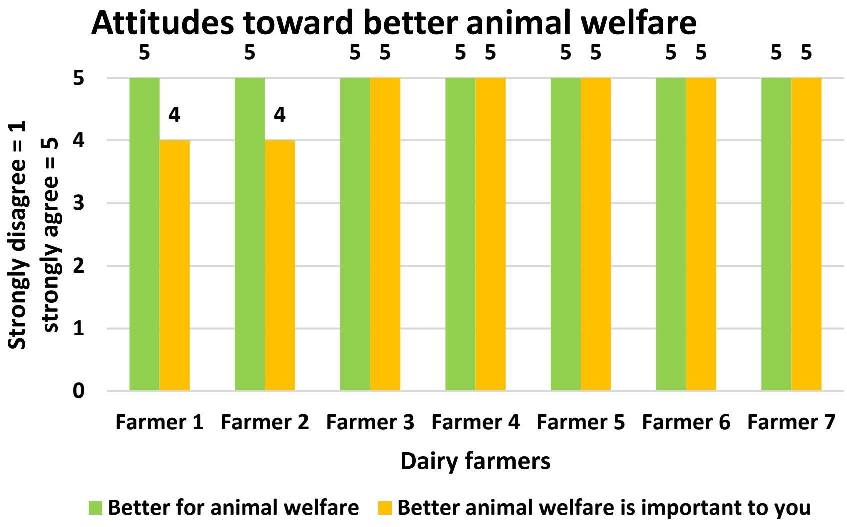

Figure 4.40: Attitudes towards animal welfare

Having relaxed and calm cows was important for all the farmers, and all of them strongly agreed that AMS provides this (Figure 4.41).

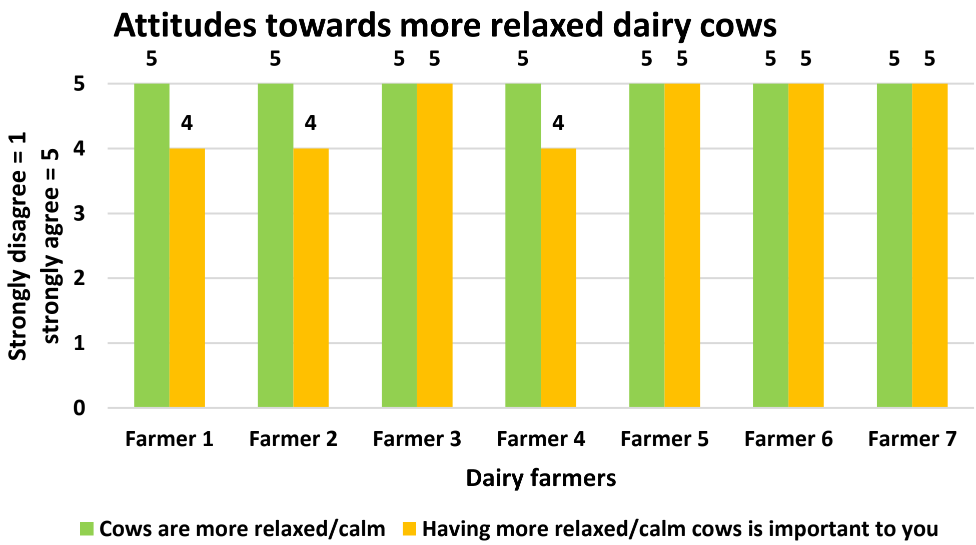

Figure 4.41: Attitudes towards more relaxed dairy cows

Treating the dairy cows as individuals rather than as a herd was important to six of the farmers. All of them agreed that AMS provides this (Figure 4.42).

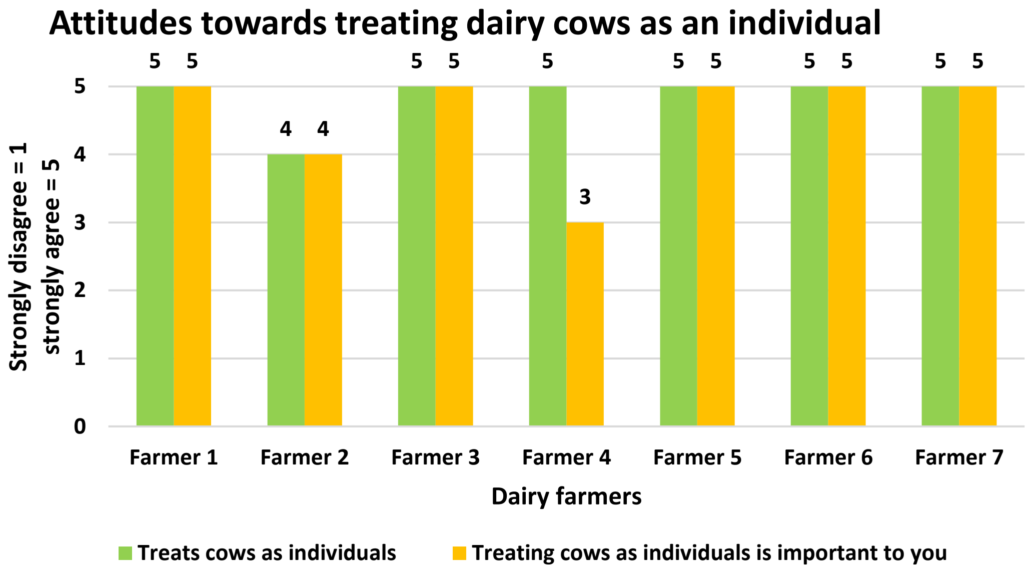

Figure 4.42: Attitudes towards treating dairy cows as individuals

Opportunities to observe the dairy cows was important for five of the farmers, but only two of them agreed that AMS provides this. Two even suggested that AMS reduces the opportunities to observe the dairy cows (Figure 4.43).

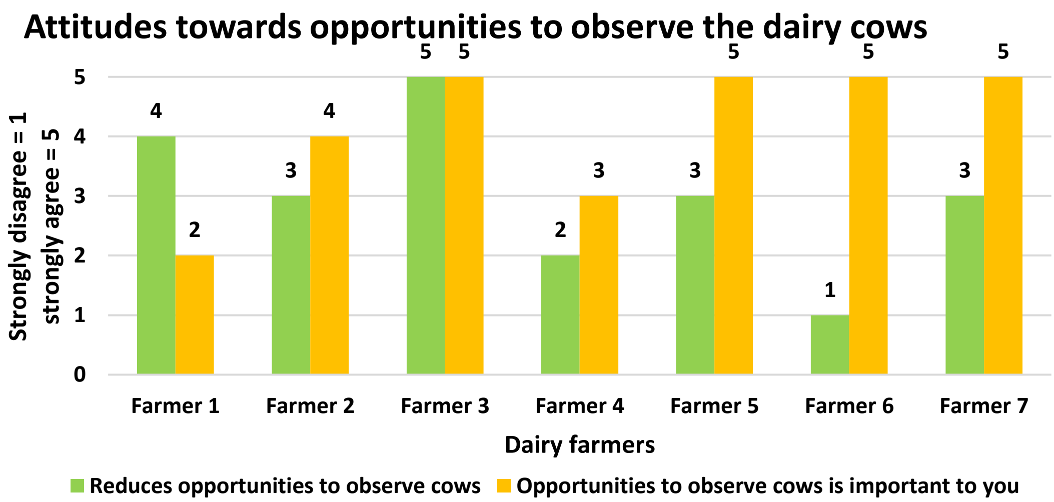

Figure 4.43: Attitudes towards opportunities to observe the dairy cows

Opportunities to spot problems in dairy cows in a timely fashion was important for all of the farmers, with one suggesting that AMS reduces the opportunities to spot problems in dairy cows (Figure 4.44).

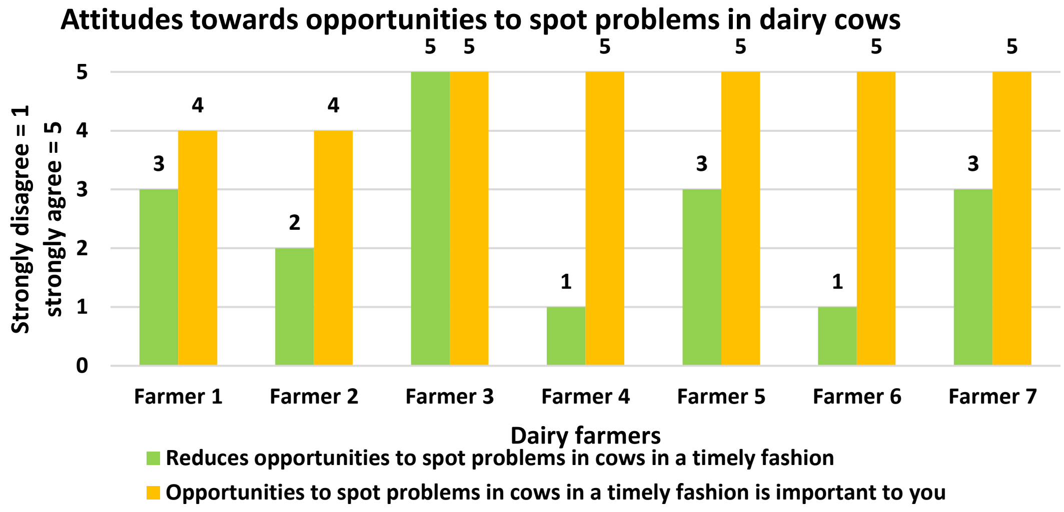

Figure 4.44: Attitudes towards opportunities to spot problems in dairy cows

Reduced rates of mastitis were important for all of the farmers. Four of them agreed that AMS provides this (Figure 4.45).

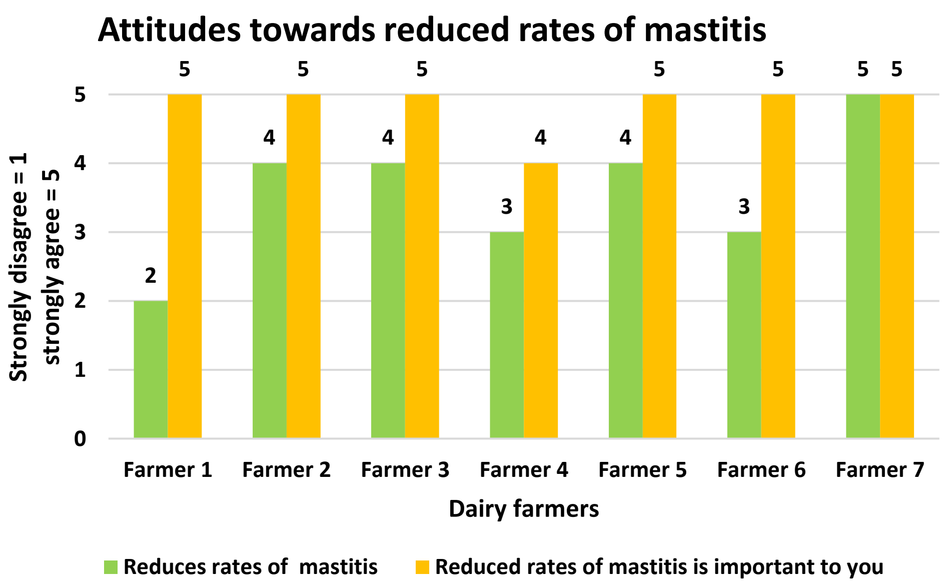

Figure 4.45: Attitudes towards reduced mastitis

A reduction in cases of lameness cases was important for all of the farmers. Five of them agreed that AMS provides this (Figure 4.46).

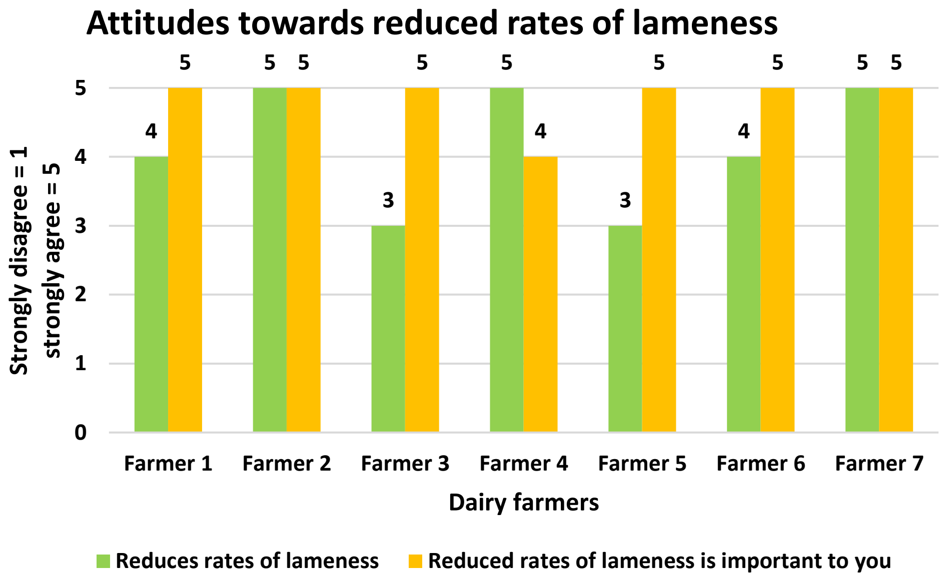

Figure 4.46: Attitudes towards reduced rates of lameness

In terms of animal health and welfare factors, better animal welfare, relaxed cows, treating cows as individuals rather than as a herd, and reduced rates of lameness, all had higher total rankings (Figure 4.47). These animal health and welfare factors were either more important to the farmers and/or they agreed that AMS provides them with these benefits. Other animal health and welfare factors, including reduced opportunities to spot problems in cows in a timely fashion, reduced opportunities to observe cows, and reduced rates of mastitis, were either less important to the farmers and/or they did not agree that AMS provides them with these benefits (Table 4.12).

Table 4.12: Total value of herd health and animal welfare factors

Animal health and welfare factors	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Total
Better animal welfare	20	20	25	25	25	25	25	**165**
Relaxed cows	20	20	25	20	25	25	25	**160**
Treating cows as individuals	25	16	25	15	25	25	25	**156**
Reducing opportunities to observe cows	8	12	25	6	15	5	15	**86**
Reduced opportunities to spot problems in cows in a timely fashion	12	8	25	5	15	5	15	**85**
Reduced rates of mastitis	10	20	20	12	20	15	25	**122**
Reduced rates of lameness	20	25	15	20	15	20	25	**140**

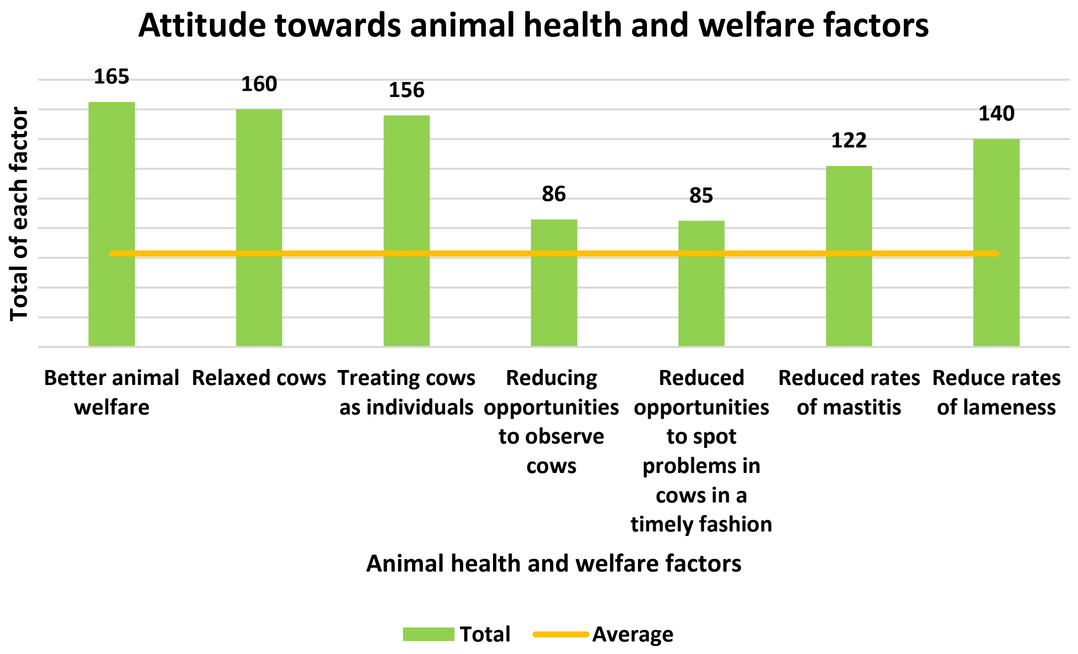

Figure 4.47: Total value of herd health and animal welfare factors

The herd data management section focused on animal health and welfare factors, including AMS' provision of detailed data and information for individual cow management, a better record of individual milk production, quality, feed intake, and better decision making for individual dairy cows and at the farm level.

More detailed data and information for individual cow management was important for four of the farmers and all of them agreed that AMS provides this (Figure 4.48).

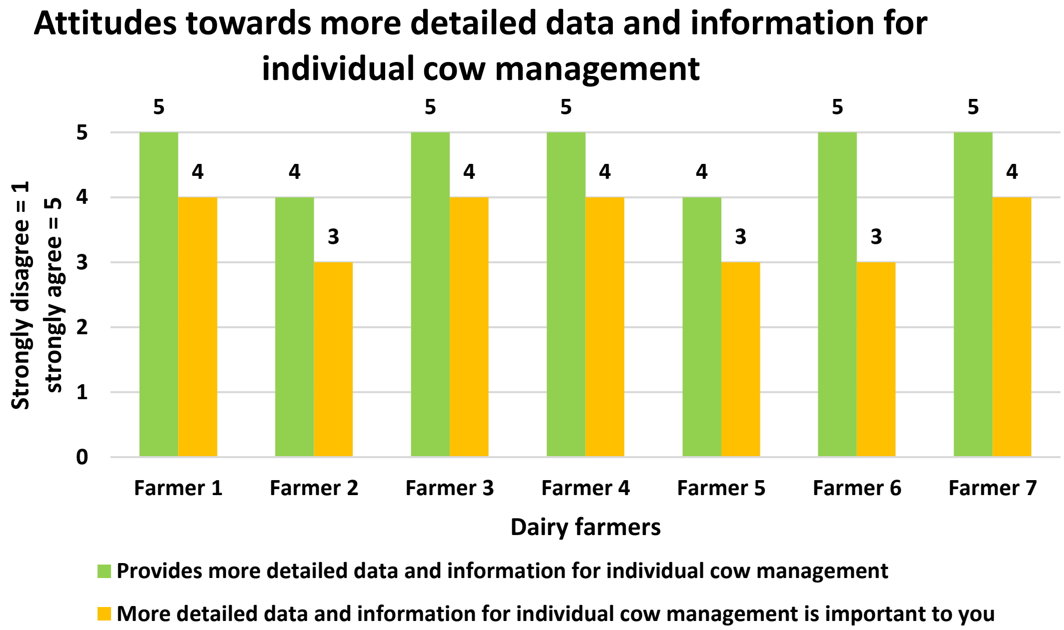

Figure 4.48: Attitudes towards more detailed data and information for individual cow management

Having a better record of individual milk production was important for three of the farmers. Five of them agreed that AMS provides this (Figure 4.49).

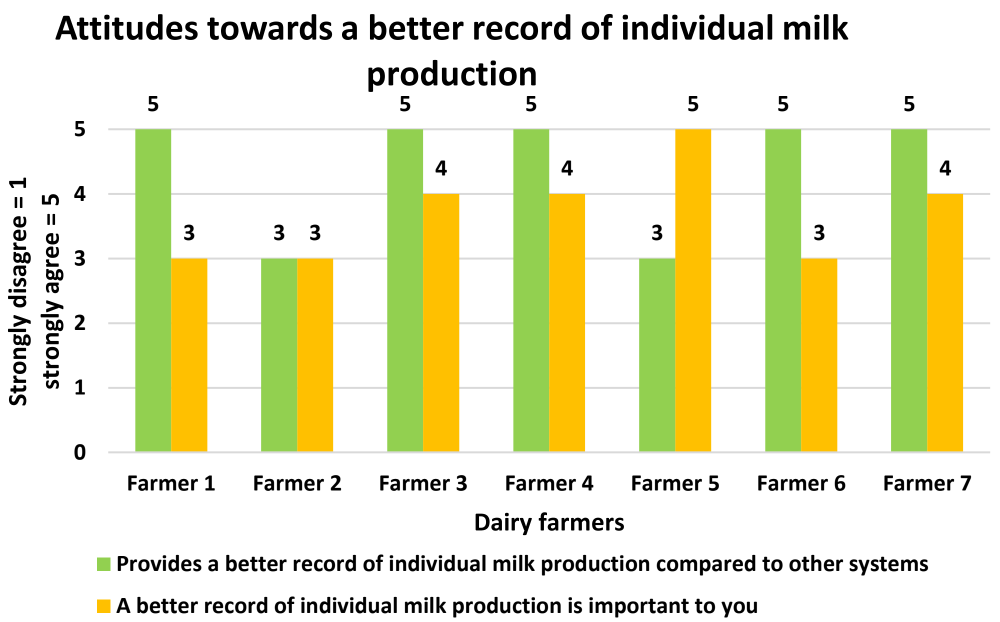

Figure 4.49: Attitudes towards a better record of individual milk production

While having a better record of individual milk quality was important for six of the farmers, only four of them agreed that AMS provides this (Figure 4.50).

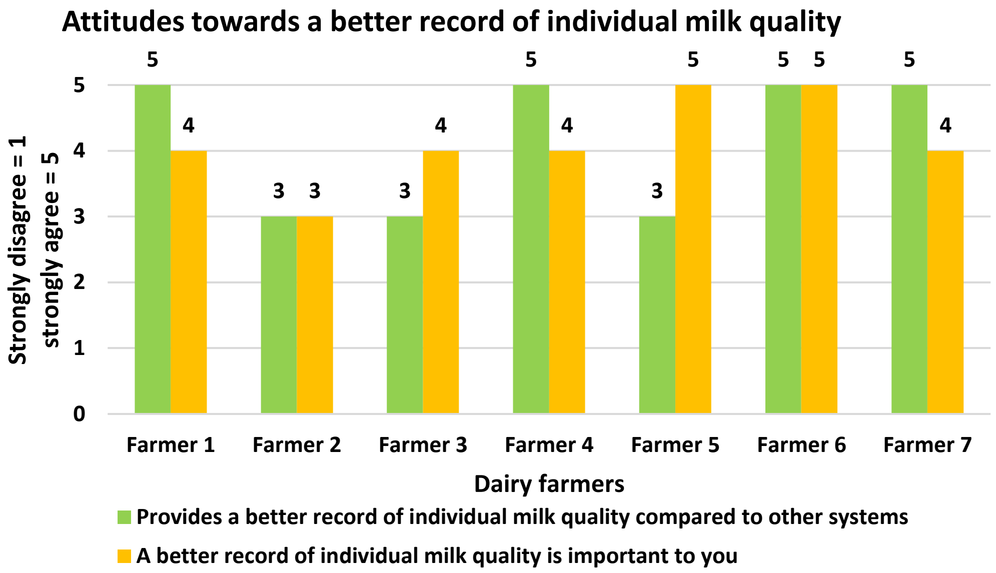

Figure 4.50: Attitudes towards a better record of individual milk quality

Having a better record of individual cow feed intake was important for one farmer. Four of them agreed that AMS provides this (Figure 4.51).

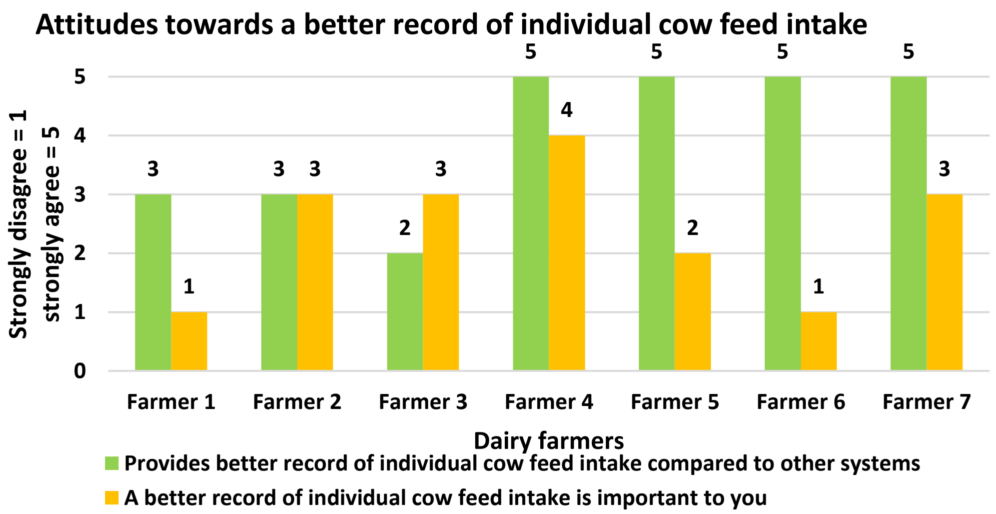

Figure 4.51: Attitudes towards a better record of individual cow feed intake

A better opportunity for individual feeding of cows was important to one of the farmers. Four of them agreed that AMS provides this (Figure 4.52). Three were neutral.

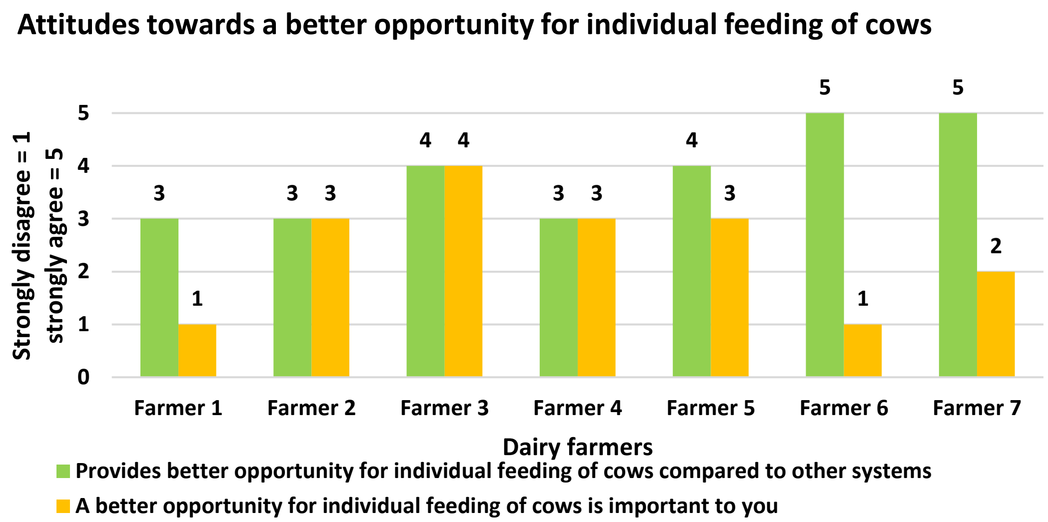

Figure 4.52: Attitudes towards a better opportunity for individual feeding of cows

Being able to make better decisions about individual cows was important to all of the farmers and six of them agreed that AMS provides this (Figure 4.53).

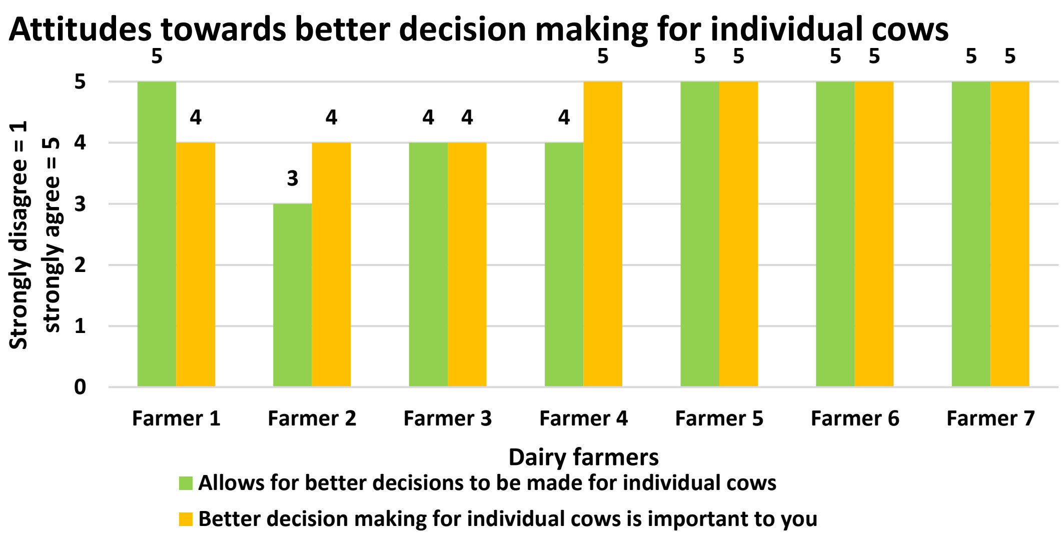

Figure 4.53: Attitudes towards better decision making for individual cows

Being able to make better decisions at a farm level was important for six of the farmers. Four of them agreed that AMS provides this (Figure 4.54).

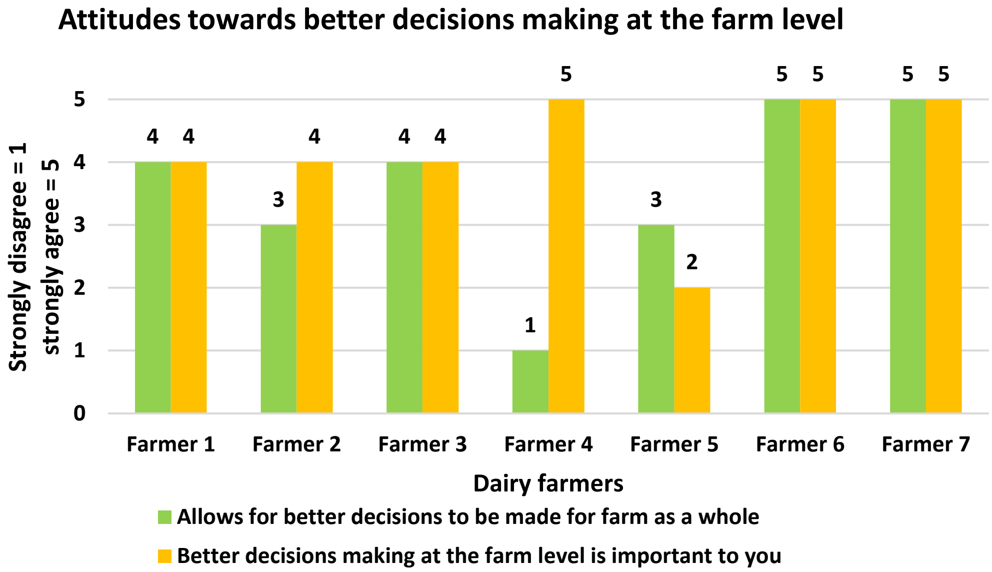

Figure 4.54: Attitudes towards better decisions making at the farm level

Most of the farmers agreed that AMS provides more detailed data, information, and records related to individual dairy cows, their milk quality and quantity. These factors were important to all of them (Figure 4.55). Being able to make better decisions at a farm level was important to most of the farmers. Four agreed that AMS provides this. Providing a better record of individual cow feed intake compared to other systems and providing a better opportunity to feed individual cows compared to other systems were less important to the farmers, but they agreed that AMS provides these benefits (Table 4.13).

Table 4.13: Total value of herd data management factors

Animal health and welfare factors	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**	**Farmer 6**	**Farmer 7**	**Total**
Provides more detailed data and information for individual cow management	20	12	20	20	12	15	20	**119**
Provides a better record of individual milk production compared to other systems	15	9	20	20	15	15	20	**114**
Provides a better record of individual milk quality compared to other systems	20	9	12	20	15	25	20	**121**
Provides a better record of individual cow feed intake compared to other systems	3	9	6	20	10	5	15	**68**
Provides a better opportunity for feed individual cows compared to other systems	3	9	16	9	12	5	10	**64**
Allows for better decisions to be made for individual cows	20	12	16	20	25	25	25	**143**
Allows for better decisions to be made for farm as a whole	16	12	16	5	6	25	25	**105**

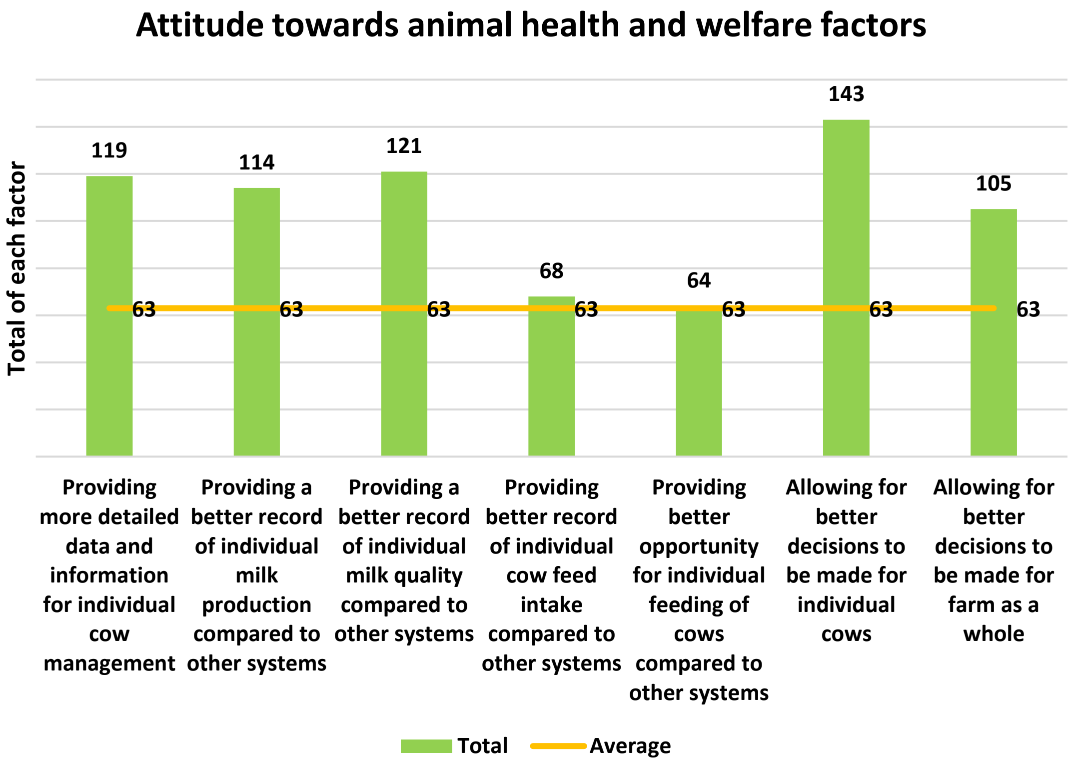

Figure 4.55: Total value of herd data management factors

The technology section focused on social factors including family history, new technologies, automation in farming system, and a new experience and challenges.

Family history was important for four farmers and unimportant for two. Three of the farmers agreed and three of them were neutral that their families had been at the forefront for adoption of new technologies (Figure 4.56).

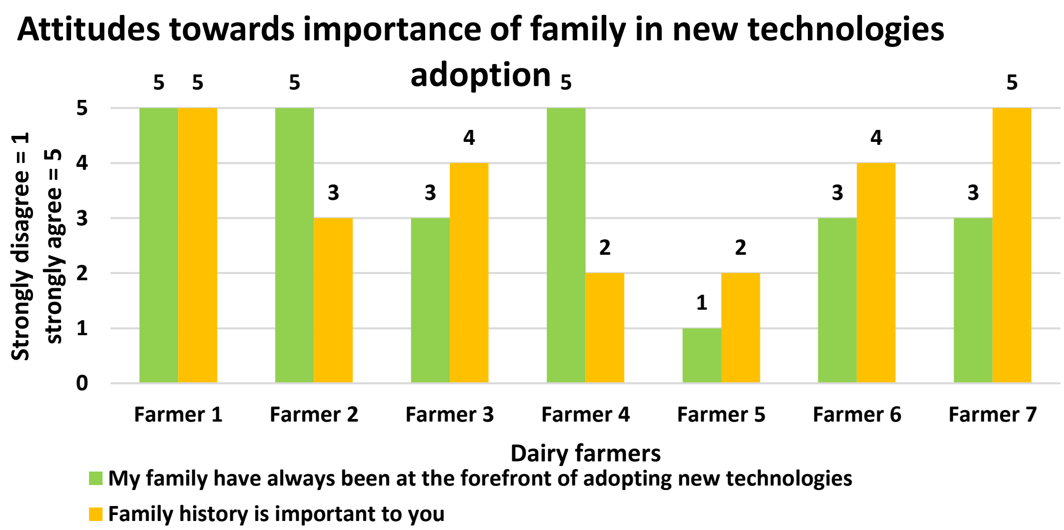

Figure 4.56: Attitudes towards importance of family in adoption of new technologies

New technologies were important for five of the farmers. All of them agreed that AMS is a useful new technology (Figure 4.57).

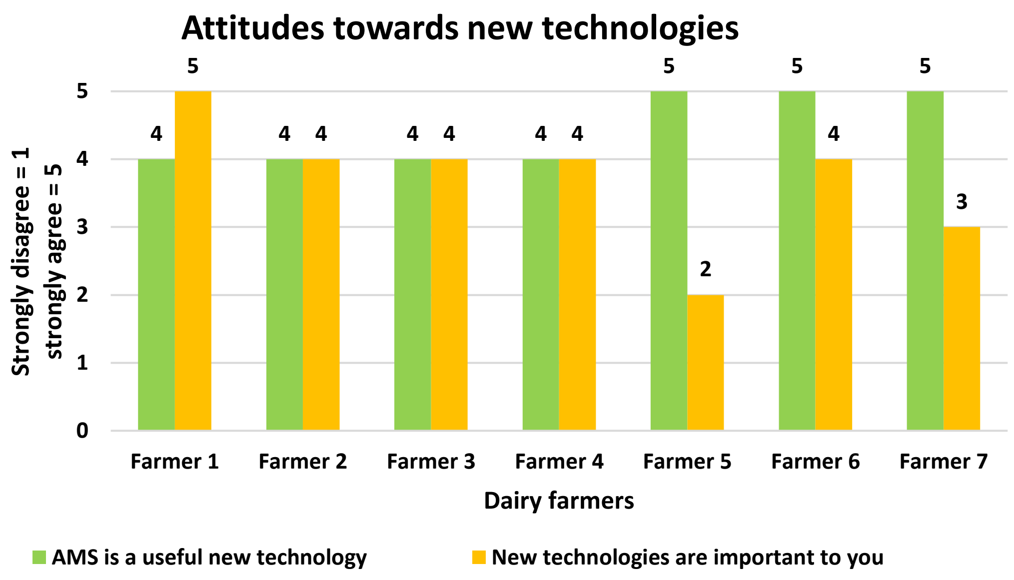

Figure 4.57: Attitudes towards new technologies

Automation within the dairy farming system was important for six of the farmers. Only five of them agreed that AMS allows for more automation. One farmer strongly disagreed about the level of automation (Figure 4.58).

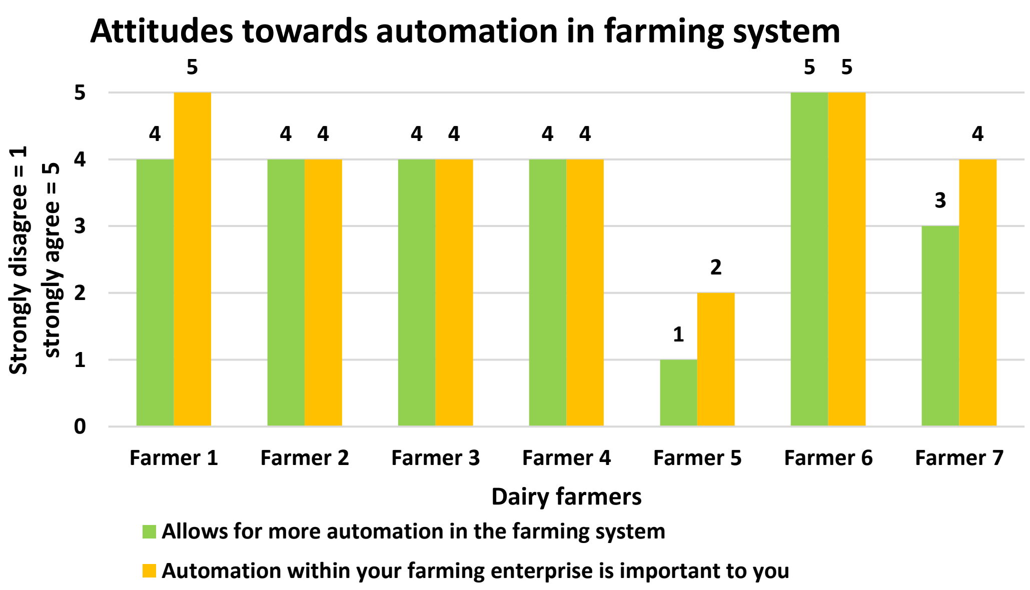

Figure 4.58: Attitudes towards automation in farming system

New experience and challenges were important to all the farmers. All of them agreed that AMS provides this (Figure 4.59).

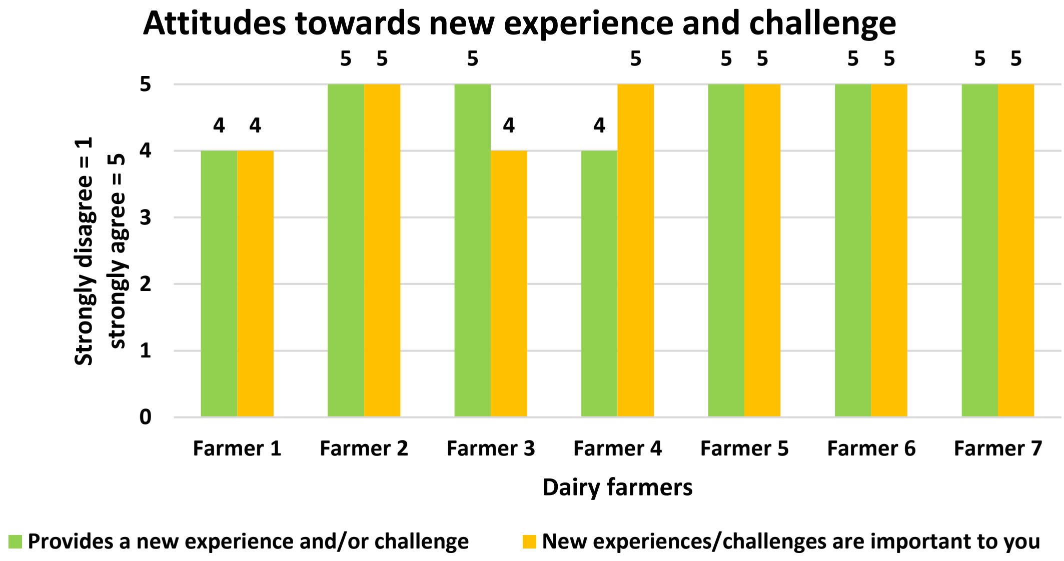

Figure 4.59: Attitudes towards a new experience and challenges

Among these social factors, having a new experience and challenge in pastoral-based dairy farming system were important to all of the farmers. All of them agreed that AMS provides a new experience and challenge (Figure 4.60). In addition, new technologies and automation within the dairy farm were of importance to most of the farmers. Most of them agreed that AMS is a useful technology which allows for automation in the farming system. The family's role in technology adoption was less important to the farmers. Very few of them agreed that AMS provides this (Table 4.14).

Table 4.14: Total value of technology factors

Social factors	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**	**Farmer 6**	**Farmer 7**	**Total**
Importance of family in technology adoption	25	15	12	10	2	12	15	**91**
New technologies	20	16	16	16	10	20	15	**113**
Automation in the farming system	20	16	16	16	2	25	12	**107**
A new experiences and challenge	16	25	20	20	25	25	25	**156**

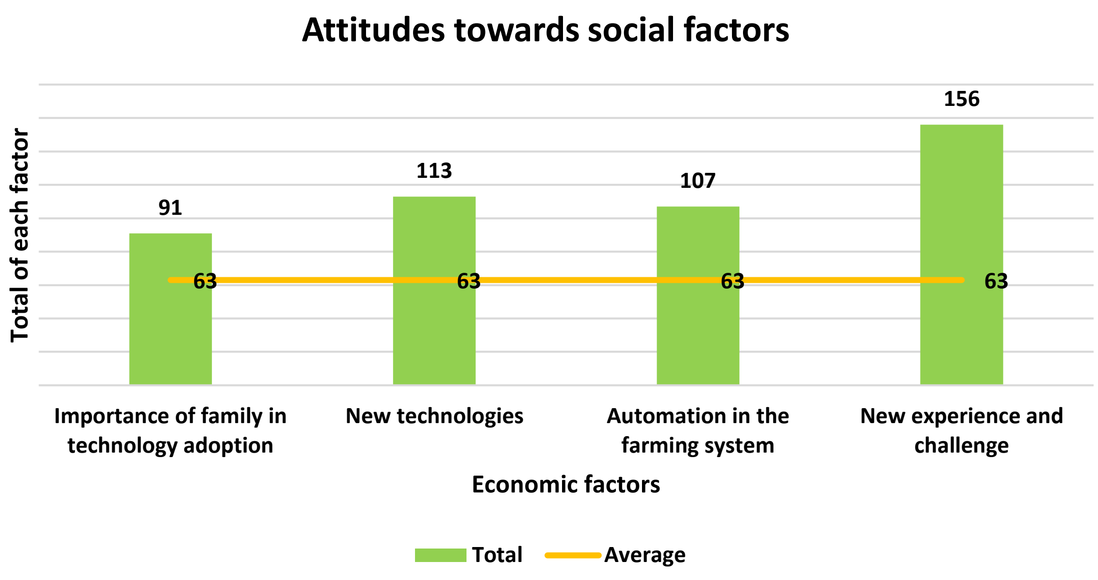

Figure 4.60: Total value of technology factors

4.2.2.2 Summary of attitude results

The attitude section included three social factor categories, two economic factor categories, and two animal health factor categories. The total value of each social, economic, animal health and welfare factors were calculated based on farmers' ranking. The responses showed that all categories were important in some form. The social, economic, and animal health and welfare factors are listed from the highest to the lowest rankings (see Table 4.15).

The factors which were important to all or most of the farmers and all or most agreed that AMS provides them with are listed in order of importance: better animal welfare, having more relaxed and calmer dairy cows, treating cows as individuals, having a new experience and challenge, providing a more relaxed operation system, making better decisions for individual dairy cows, and reduced rates of lameness, having a better lifestyle, providing better working condition, increased milk production, and flexible working hours. This is followed by the factors which were important to most of the farmers (none of them disagreed that AMS provides these benefits). These are improved milk quality, flexible working days, reduced rates of mastitis, a better record of individual milk quality, more up-to-date working conditions, a shift in tasks, providing more detailed data for individual cow management, providing a better record of individual milk production, useful new technology, and more attractive to future generation.

There is then the factors which were important to most of the farmers; however, most disagreed that AMS provided them with these benefits. These are economic ones, including increases in the farm's resale value, reduced milking shed servicing and maintenance costs, and reduced milking shed operating costs.

Finally, there are the factors which were important to the least number of the farmers, but they agreed that AMS provides them with these benefits: These features were, less working hours, help with succession planning, providing better record for individual cow feed intake and opportunities to feed individual cows compared to other systems.

Table 4.15: Social, economic, and animal health and welfare factors

Type of factors	**Factors**	**Score**	**Descriptions**
Animal health and welfare	Animal welfare	165	It was important for all the farmers. All of them strongly agreed that AMS is better for animal welfare.
Animal health and welfare	More relaxed/calm cows	160	It was important for all the farmers. All of them strongly agreed that AMS makes the dairy cows more relaxed.
Animal health and welfare	Treating cows as individuals	156	It was important for six of the farmers. All of them agreed that AMS treats cows as individuals rather than as a herd.
Social	New experience and challenge	156	It was important for all the farmers to experience a new challenge and/or challenge. All of them agreed that AMS provides this.
Social	Providing a more relaxed operating system	143	It was important for six of the farmers. All of them agreed that AMS provides a more relaxed operating system.
Animal health and welfare	Better decision to be made for individual cows	143	It was important for all the farmers. Six of them agreed that AMS allows for better decision making for individual cow, whilst none of them disagreed.
Animal health and welfare	Reduced rates of lameness	140	It was important for all the farmers. Five of them agreed that AMS reduces the rates of lameness.
Social	Better lifestyle	132	It was important for six of the farmers. Six of them agreed that AMS improves lifestyle.
Social	Better working conditions	130	It was important for five of the farmers. All of them agreed that AMS provides better working conditions.
Economic	Increased milk production	126	It was important for six of the farmers. Although only four of them agreed that AMS increases milk production, none of them disagreed that AMS provides this.
Social	Flexible working hours	125	It was important for four of the farmers. Six of them agreed that AMS provides more flexible working hours. Only one disagreed.
Economic	Improved milk quality	124	It was important for all the farmers. Only three of them agreed that AMS increases milk quality. None of them disagreed.
Social	Flexible working days	123	It was important for six of the farmers. Only three of them agreed that AMS provides this. None of them disagreed.
Animal health and welfare	Reduced rates of mastitis	122	It was important for all the farmers. Four of them agreed that AMS reduces the rates of mastitis. One disagreed.

Table 4.16: Social, economic, and animal health and welfare factors (cont.)

Type of factors	Factors	Score	Descriptions
Animal health and welfare	Better record of individual milk quality	121	It was important for six of the farmers. Four of them agreed that AMS provides this. None of them disagreed.
Social	More up-to-date working condition	120	It was important for five of the farmers. Six of them agreed that AMS provides this. None of them disagreed.
Social	Shift in tasks	120	It was important for five of the farmers. Six of them agreed that AMS leads to a shift in tasks. None of them disagreed.
Animal health and welfare	Providing more detailed data and information for individual cow management	119	It was important for four of the farmers. All of them agreed that AMS provides this. None of them disagreed.
Animal health and welfare	Providing a better record of individual milk production compared to other systems	114	It was important for four of the farmers. Four of them agreed that AMS provides this. None of them disagreed.
Social	Useful new technology	113	It was important for five of the farmers. All seven of them agreed that AMS is a useful new technology.
Social	More attractive to future generation	108	It was important for three of the farmers. Three agreed that AMS is more attractive to future generation. None of them disagreed.
Social	More automation in the farming system	107	It was important for six of the farmers. Five agreed that AMS provides more automation in the farming system. One strongly disagreed.
Animal health and welfare	Allowing for better decisions to be made for the farm as a whole	105	It was important for six of the farmers. Four of them agreed that AMS allows for better decisions for the farm as a whole. One strongly disagreed.
Social	Frees up time	104	It was important for five of the farmers. Only three of them agreed that AMS frees up time. One strongly disagreed.
Social	Less physical work	99	It was important for four of the farmers. Five of them agreed that AMS provides less physical work. One strongly disagreed.
Economic	Improved profit	98	It was important for six of the farmers. Only three of them agreed that AMS improves profit.
Economic	Improved financial returns	95	It was important for six of the farmers. Only two agreed that AMS improves financial returns.
Social	Family at the forefront of technology adoption	91	It was important for four of the farmers. Only three strongly agreed that family have been at forefront of new technology adoption. One strongly disagreed.

Table 4.17: Social, economic, and animal health and welfare factors (cont.)

Type of factors	Factors	Score	Descriptions
Animal health and welfare	Reduced opportunities to observe cows	86	It was important for five of the farmers. Two agreed and two disagreed that AMS reduces the opportunities to observe the cows.
Animal health and welfare	Reduced opportunities to spot problems in cows	85	It was important for all the farmers. Three of them disagreed and one agreed that AMS reduces opportunities to spot problems in the cows. Three were neutral.
Social	Reduced requirement for labour unit	79	It was important for five of the farmers. Four of them agreed that AMS reduces requirements for labour unit One strongly disagreed.
Economic	Reduced labour costs	76	It was important for five of the farmers. Five agreed that AMS reduces labour costs.
Social	Helps with labour recruitment	74	It was important for three of the farmers. Two agreed that AMS helps with labour recruitment. One strongly disagreed.
Social	Less work hours	73	It was important for one farmer. Three of them agreed that AMS provides less working hours. Three disagreed and one was neutral.
Social	Helps with succession planning	73	It was important for two of the farmers. Only three of them agreed that AMS helps with succession planning. One strongly disagreed.
Animal health and welfare	Providing better record for individual cow feed intake compared to other systems	68	It was important for one farmer. Four farmers strongly agreed that AMS provides a better record of individual cow feed intake. One disagreed.
Animal health and welfare	Provides a better opportunity for individual feeding of cows compared to other systems	64	It was important for one farmer. Four of them agreed that AMS provides better opportunities for individual feeding of cow. None of them disagreed.
Social	Less working days	55	It was important for two of the farmers. Three of them disagreed that AMS provides this. Only one agreed.
Economic	Increases resale value of the dairy farm	55	It was important for four of the farmers. Three of them disagreed that AMS increases the farm’s resale value. None of them agreed.
Economic	Reduced milking shed servicing and maintenance costs	50	It was important for six of the farmers. Six of them disagreed that AMS reduces milking shed servicing and maintenance costs. None of them agreed.
Economic	Reduced milking shed operation costs	47	It was important for six of the farmers. Six of them disagreed that AMS reduces milking shed operating costs. None of them agreed.

4.2.2.3 Results from subjective norms

The subjective norm results helped to identify the individuals who had the most influence on the farmers in terms of their decision making related to the adoption of AMS. This covered the other individuals' beliefs and whether or not they had an influence on individual farmers and the extent of that influence. Individuals included both those directly and indirectly related to the farmers and their farm business.

One farmer agreed that his spouse/partner thought he should install AMS on his farm; her opinion motivated him to install the system (Figure 4.61).

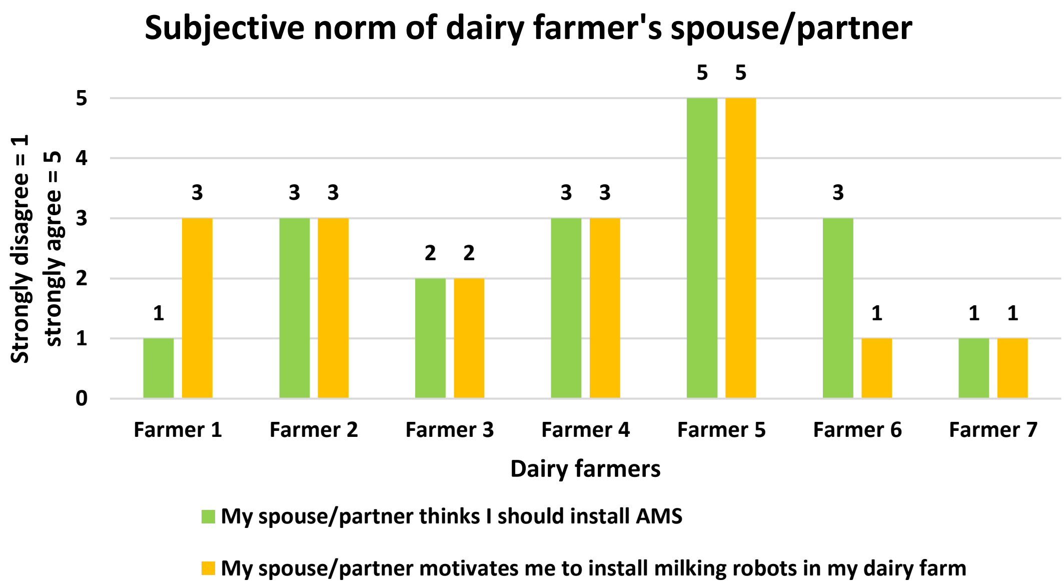

Figure 4.61: Subjective norm of dairy farmer's spouse/partner

None of the farmers agreed that their children thought they should install AMS, nor motivated them to do so (Figure 4.62).

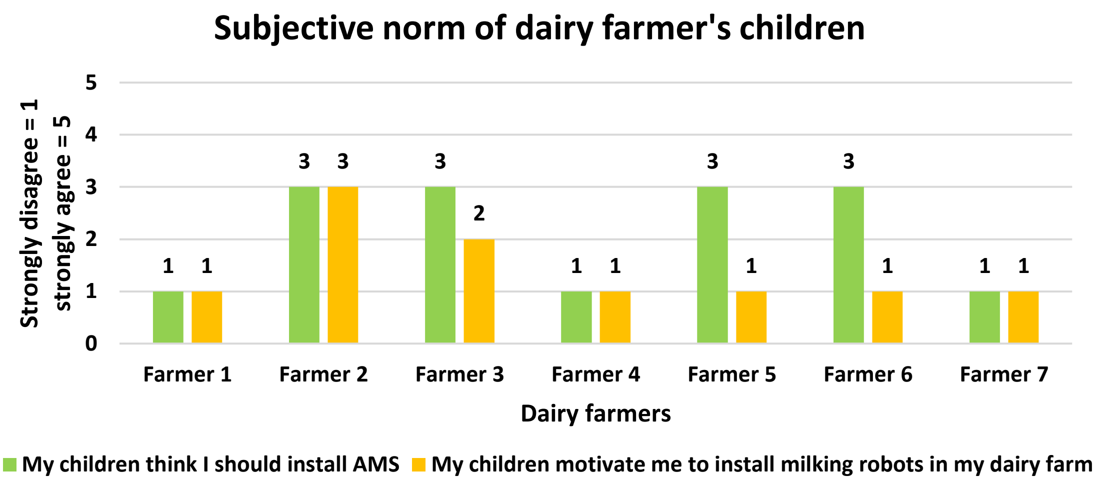

Figure 4.62: Subjective norm of dairy farmer's children

Only one farmer agreed that other family members thought he should install AMS. Two of them agreed that other family members had motivated them to install AMS (Figure 4. 63).

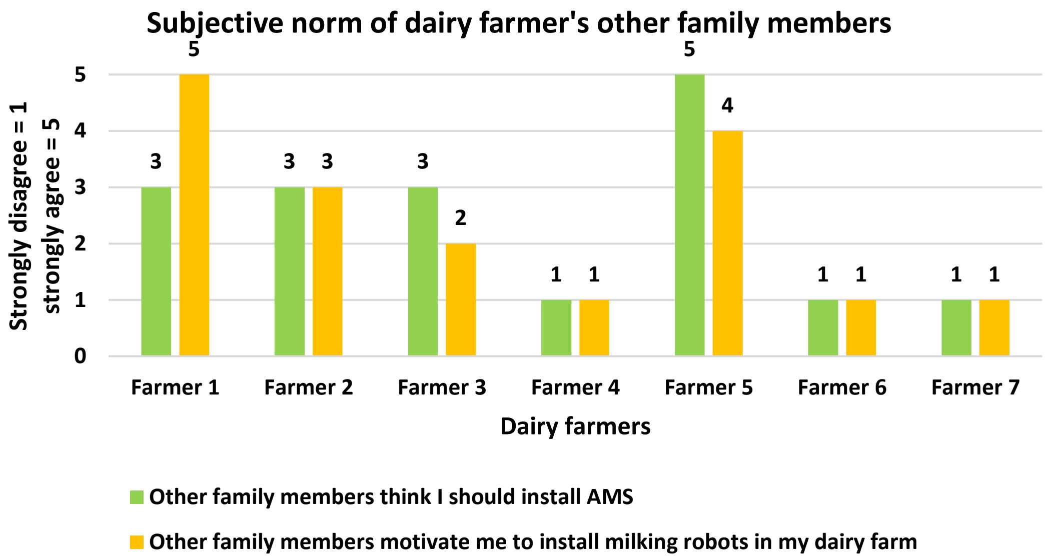

Figure 4.63: Subjective norm of dairy farmer's other family members

Only one farmer agreed that his staff thought he should install AMS, but he was neutral that the staff motivated him to install AMS (Figure 4.64).

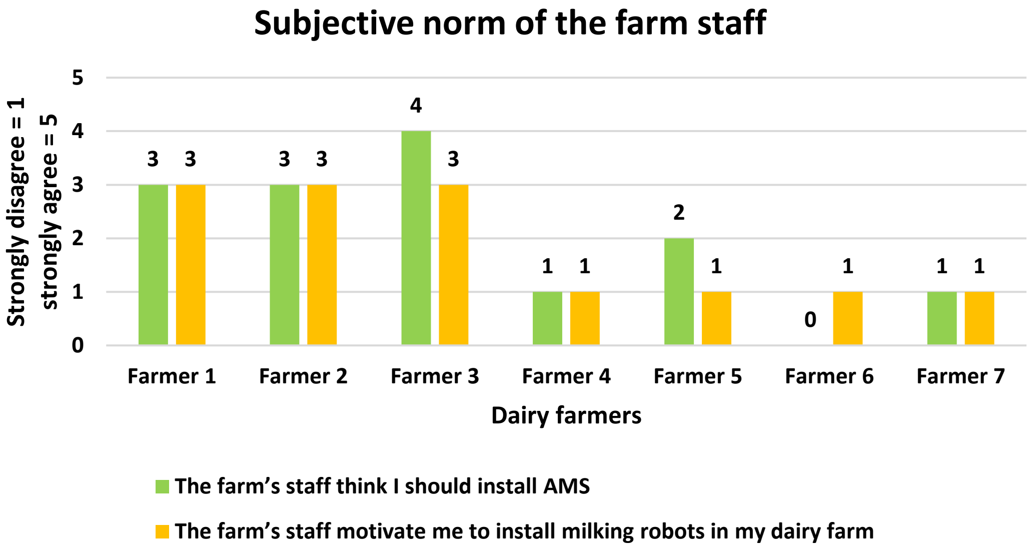

Figure 4.64: Subjective norm of the farm staff

Two farmers agreed that other dairy farmers with AMS thought they should install AMS. Both of them agreed that they were motivated by other dairy farmers to install AMS (Figure 4.65).

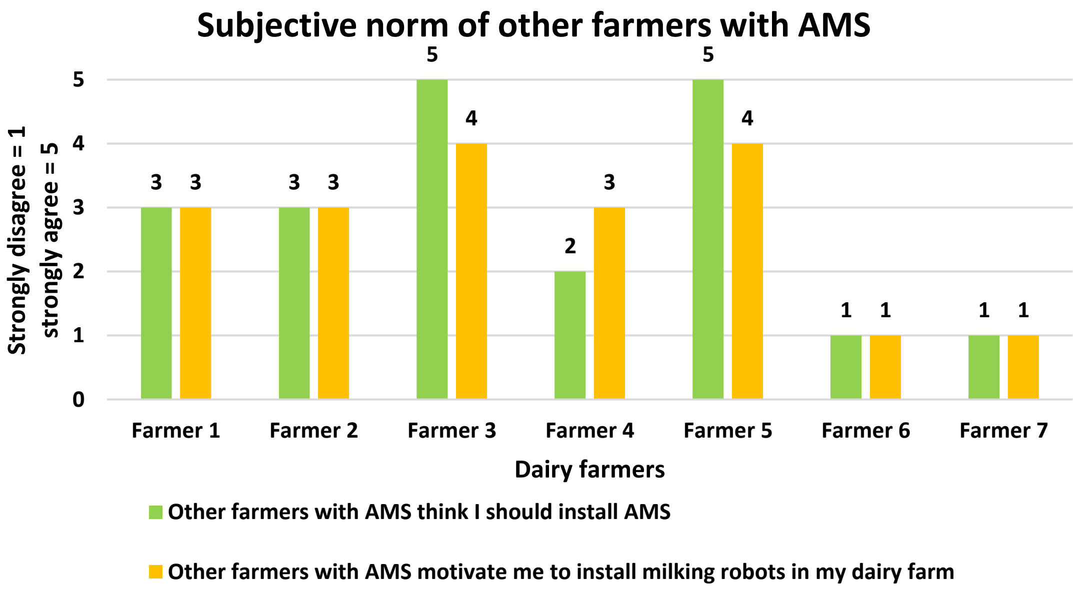

Figure 4.65: Subjective norm of other farmers with AMS

None of the farmers agreed that other dairy farmers without AMS thought they should install AMS, nor motivated them to do so (Figure 4.66).

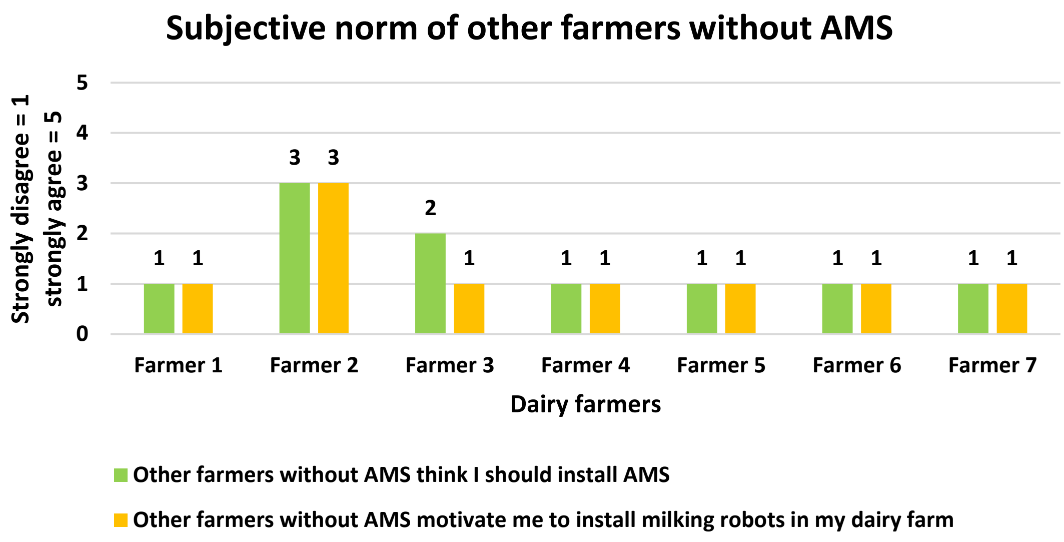

Figure 4.66: Subjective norm of other farmers without AMS

None of the farmers agreed that the milk processor thought they should install AMS, nor had they motivated them to do so (Figure 4.67).

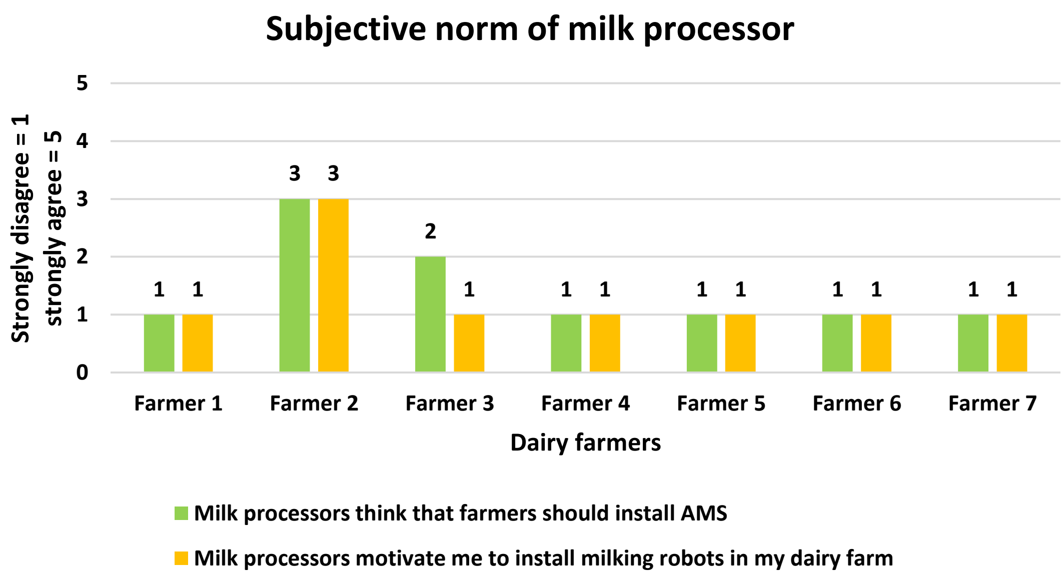

Figure 4.67: Subjective norm of milk processor

Only one farmer agreed that good industry bodies (DairyNZ) thought he should install AMS, and that he was also motivated by them to install AMS (Figure 4.68).

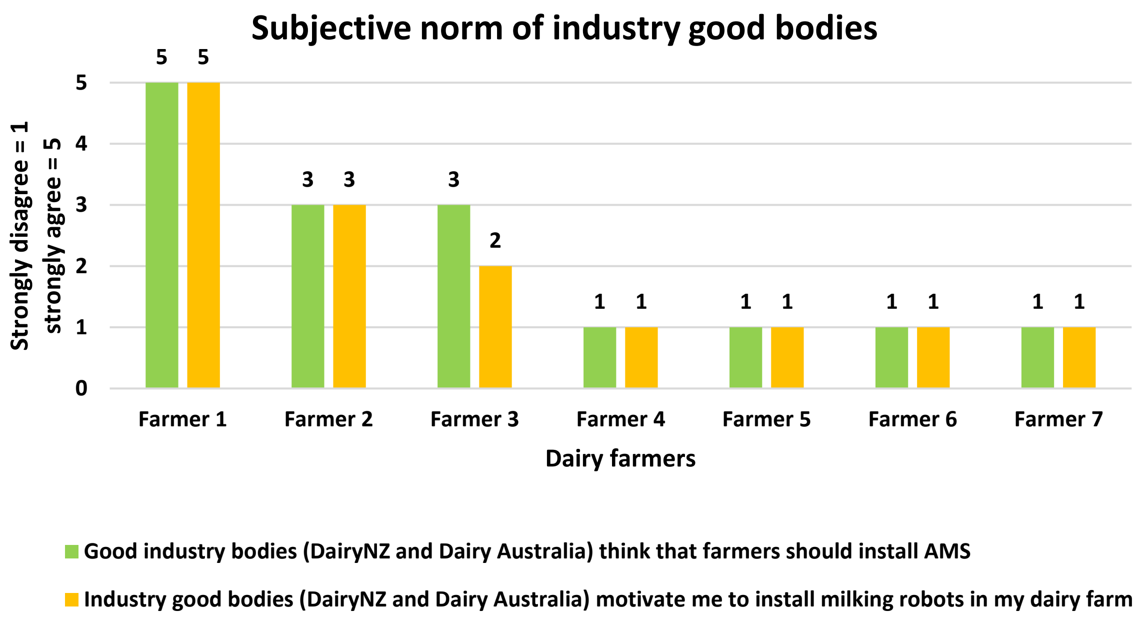

Figure 4.68: Subjective norm of good industry bodies

None of the farmers agreed that private consultants thought they should install AMS, nor motivated them to do so (Figure 4.69).

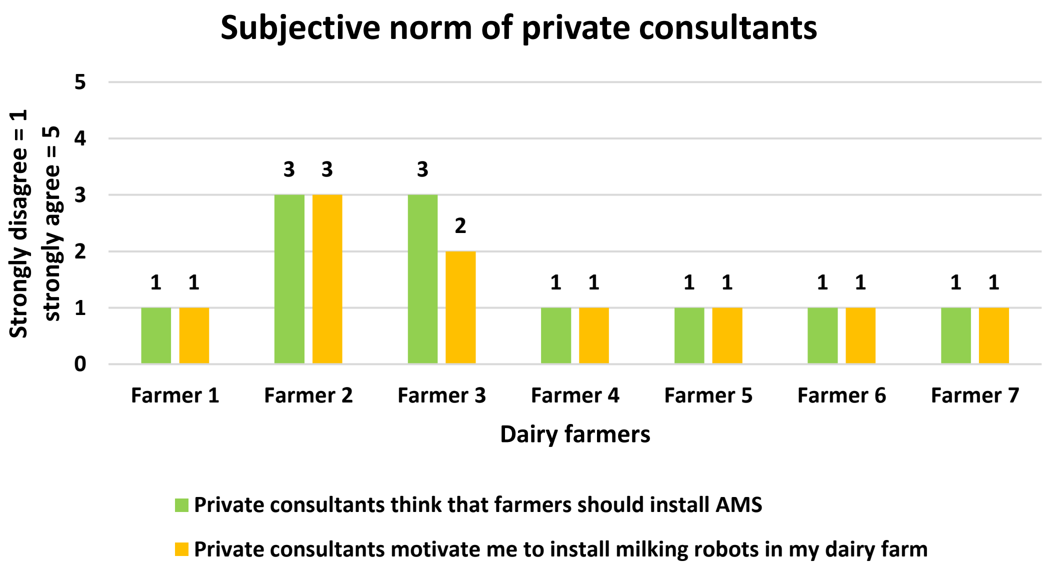

Figure 4.69: Subjective norm of private consultants

Only one farmer agreed that printed media made him think that he should install AMS, but he was not motivated by this (Figure 4.70).

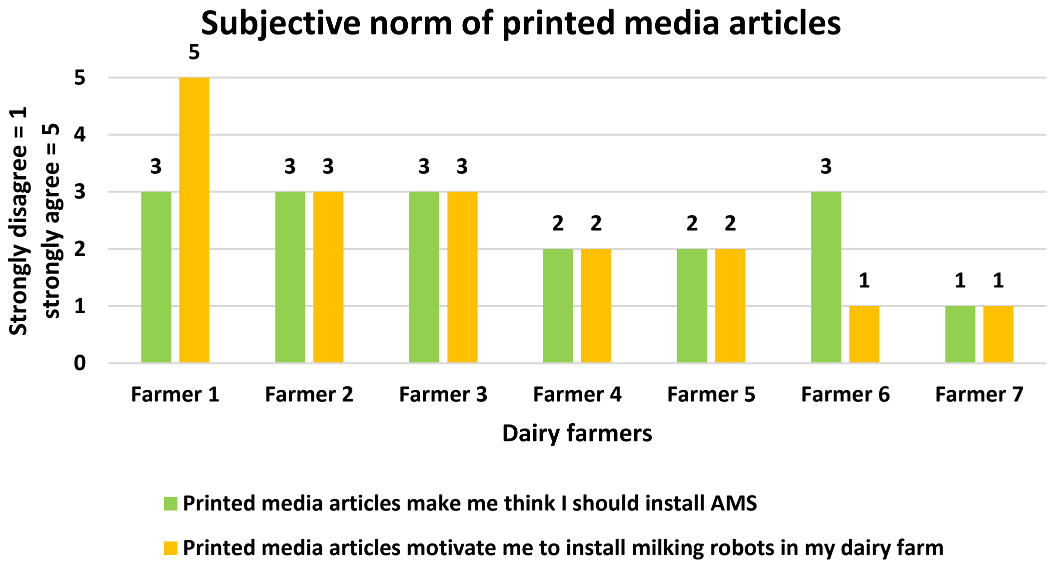

Figure 4.70: Subjective norm of printed media articles

None of the farmers agreed that online media made them think that they should install AMS, nor were they motivated by this (Figure 4.71).

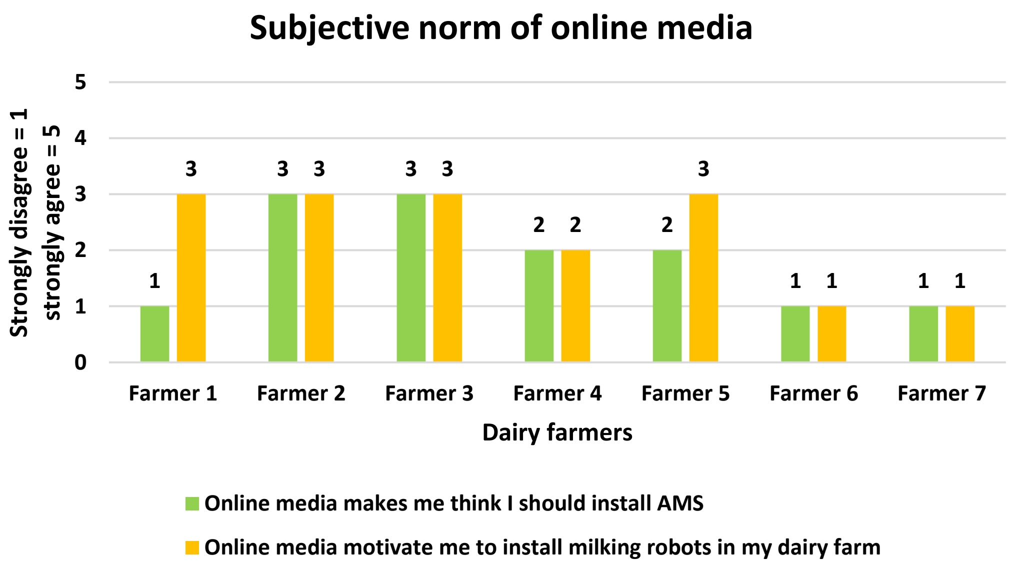

Figure 4.71: Subjective norm of online media

Only one farmer agreed that resources from good industry bodies (DairyNZ) made him think that he should install AMS. Two of them were motivated by industry bodies (Figure 4.72).

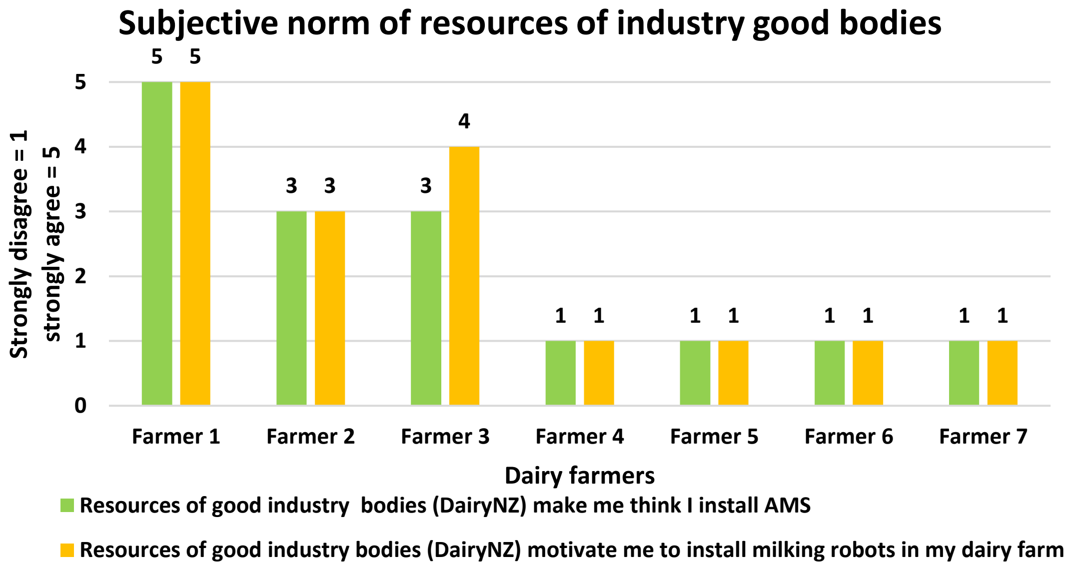

Figure 4.72: Subjective norm of resources of good industry bodies

Four farmers agreed that resources or publicity materials provided by AMS suppliers made them think they should install AMS. Four of them were motivated by the publicity material to install AMS (Figure 4.73).

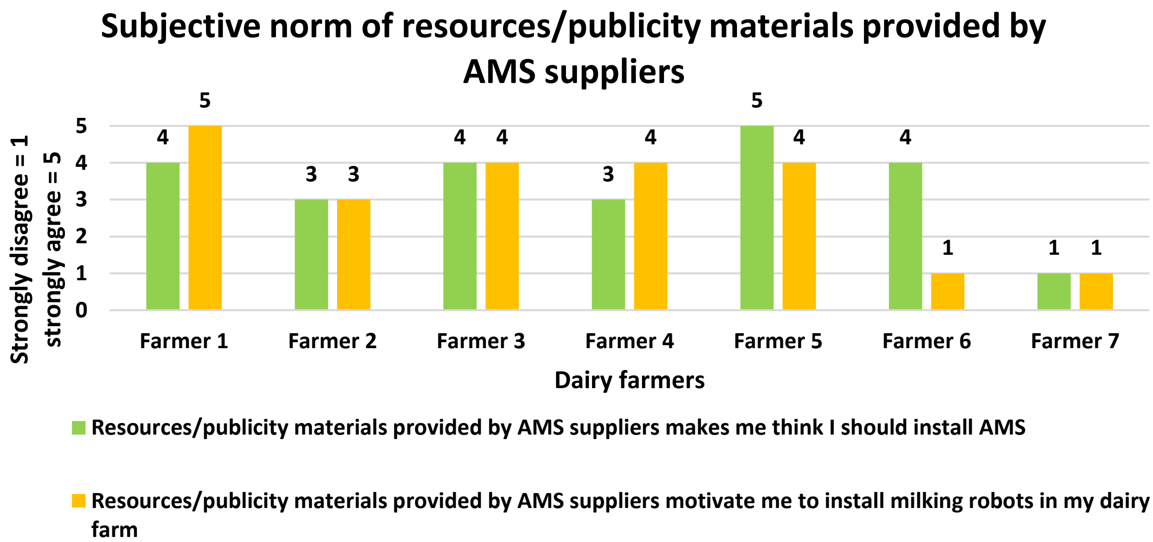

Figure 4.73: Subjective norm of resources/publicity materials provided by AMS suppliers

4.2.2.4 Summary of subjective norm

The results show that individuals, organisations, and resources had very little to no influence or dairy farmers in terms of their decision to install AMS (Figure 4.74). Once the interest was there for the farmer, it was just the supplier resources that were used. Everyone else, apart from one farmer who was influenced by another famer with AMS, was neutral or disagreed that others had motivated them to install AMS (Table 4.16).

Table 4.18: Individuals influencing farmers' decision making about AMS adoption

Individuals	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**	**Farmer 6**	**Farmer 7**	**Total**
Farmer's spouse/partner	3	9	4	9	25	3	1	**54**
Farmer's children	1	9	6	1	3	3	1	**24**
Other family members	15	9	6	1	20	1	1	**53**
Farm's staff	9	9	12	1	2	0	1	**34**
Other farmers with AMS	9	9	20	6	20	1	1	**66**
Other farmers without AMS	1	9	2	1	1	1	1	**16**
Milk processor	1	9	2	1	1	1	1	**16**
Good industry bodies	25	9	6	1	1	1	1	**44**
Private consultants	1	9	6	1	1	1	1	**20**
Printed media articles	15	9	9	4	4	3	1	**45**
Online media	3	9	9	4	6	1	1	**33**
Resources of good industry bodies	25	9	12	1	1	1	1	**50**
Resources from AMS suppliers	20	9	16	12	20	4	1	**82**

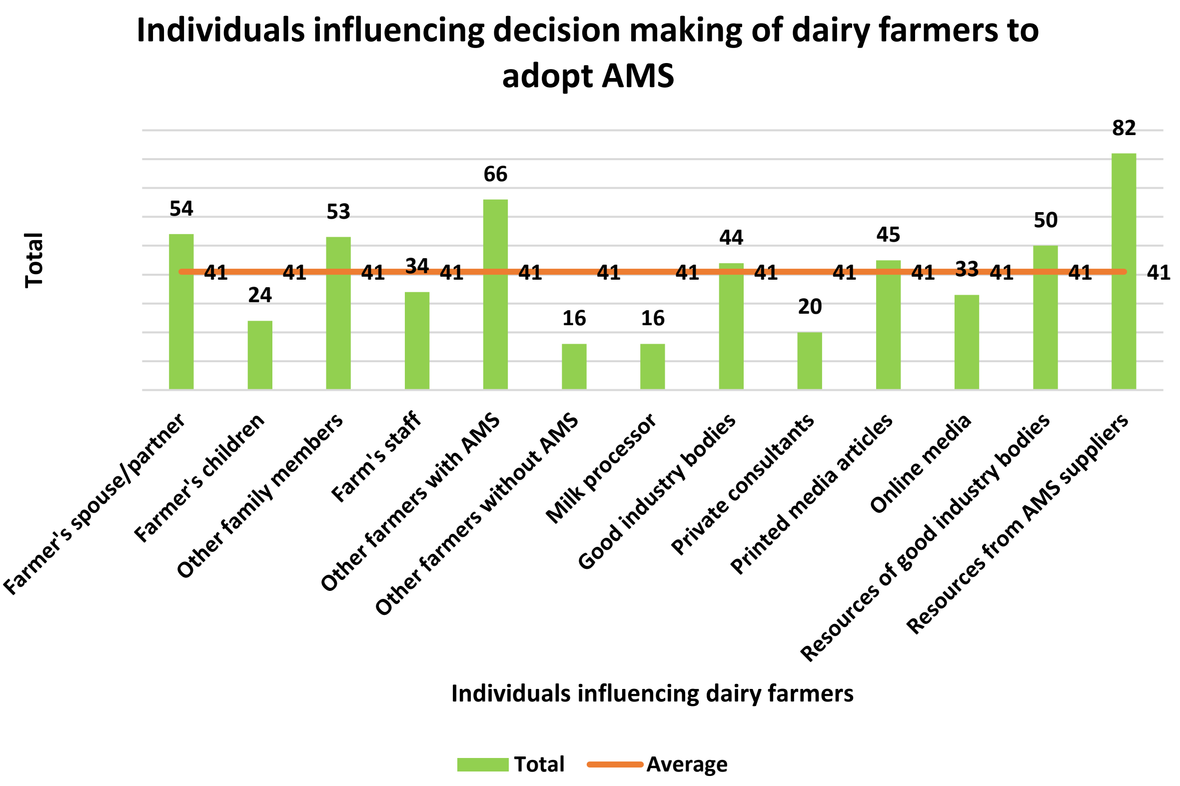

Figure 4.74: Individuals influencing farmers' decision to adopt AMS

4.2.2.5 Results from perceived behavioural control

The perceived behavioural control section of the interviews consisted of control beliefs and perceived power. It included questions about the complexity of AMS installation, the capital cost associated with AMS, the changes required to farm layout, infrastructure and grazing systems, the implications for seasonal calving, the requirement for more skilled labour, the need for labour to be on call 24/7, ongoing support from dealers, and the requirement for more technology.

Five farmers agreed that AMS could be complex to install. The other two farmers were neutral. Four farmers agreed that for them AMS was complex to install, one was neutral and two disagreed (Figure 4.75).

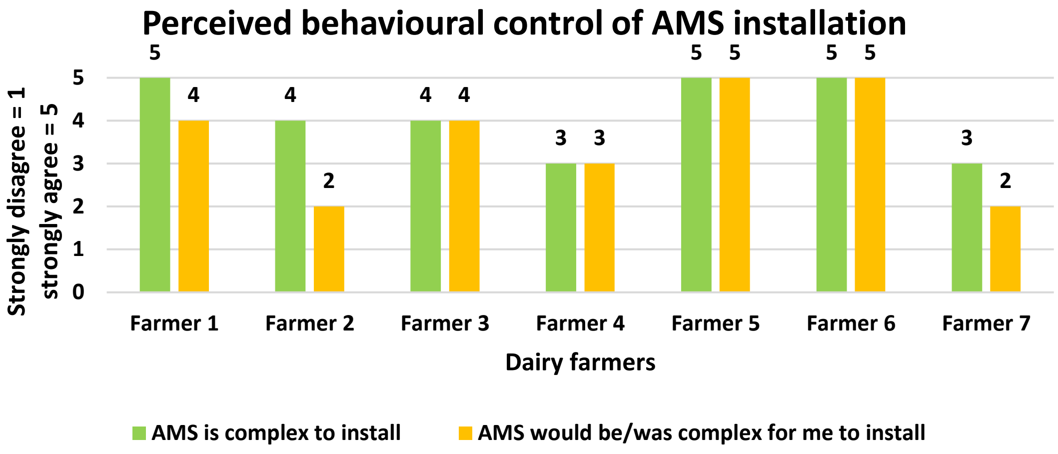

Figure 4.75: Perceived behavioural control of AMS installation

Four farmers agreed that AMS has high capital cost. The other three farmers were neutral on this. However, none of them found the costs prohibitive (Figure 4.76).

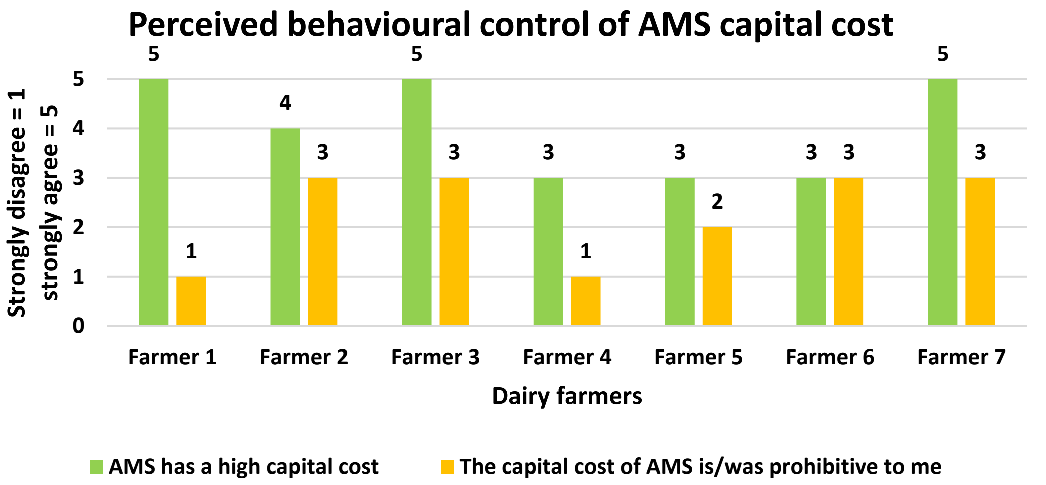

Figure 4.76: Perceived behavioural control of AMS capital cost

Three farmers agreed that AMS requires changes in farm layout, but none of them agreed it was difficult to change the farm layout (Figure 4.77).

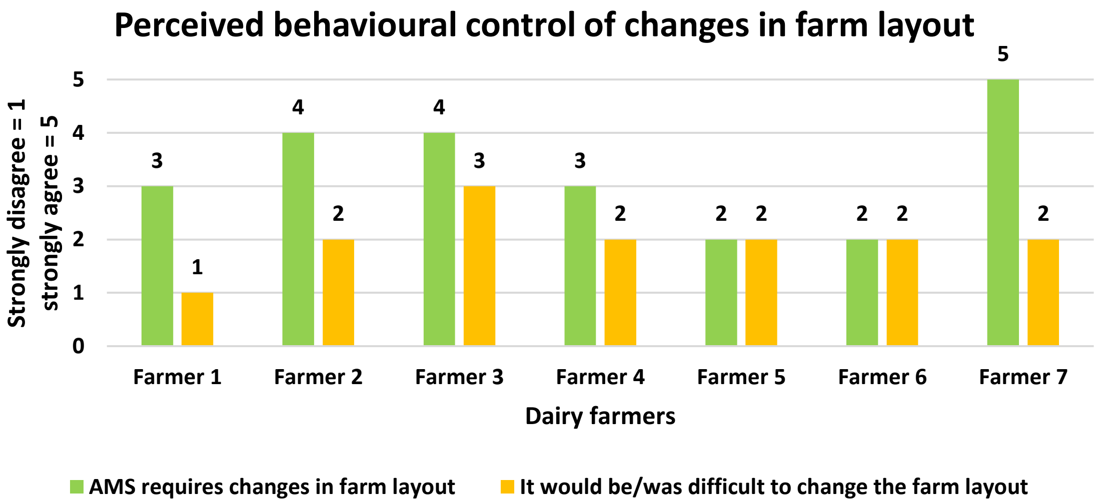

Figure 4.77: Perceived behavioural control of changes in farm layout

Only one farmer agreed that AMS requires changes to the farm infrastructure. None of them agreed that it was difficult to change the farm infrastructure (Figure 4.78).

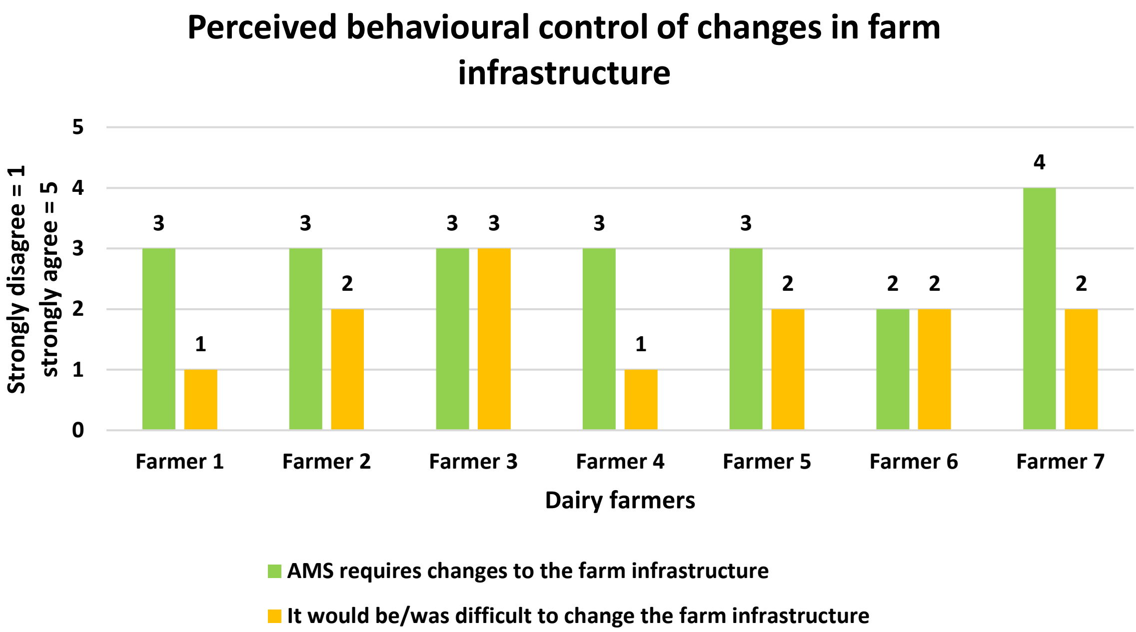

Figure 4.78: Perceived behavioural control of changes in farm infrastructure

Four farmers agreed that AMS requires changes in grazing systems. None of them agreed that it was difficult to change the grazing system (Figure 4.79).

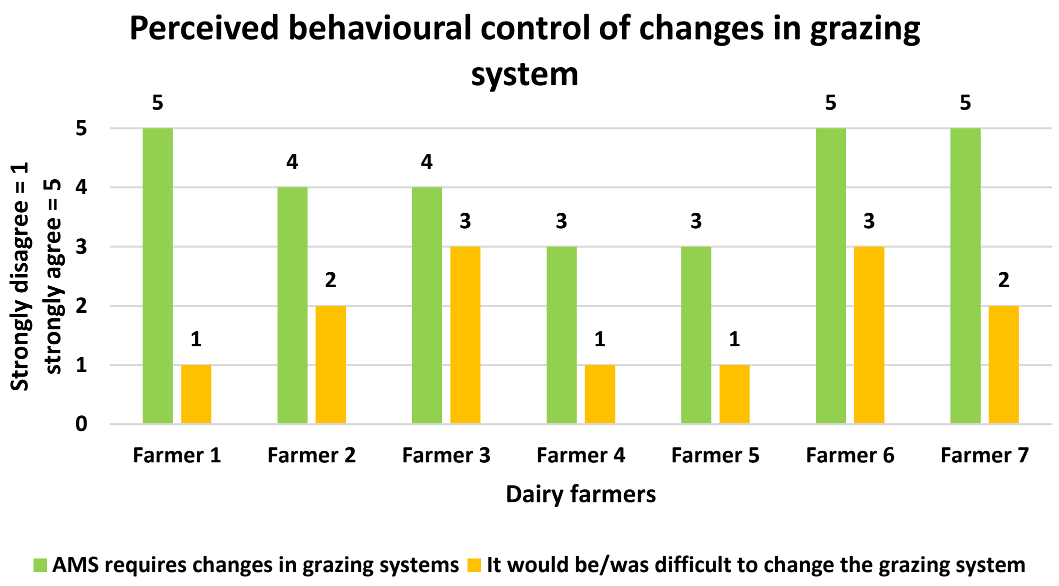

Figure 4.79: Perceived behavioural control of changes in grazing system

Five farmers agreed that AMS has implications for seasonal calving. The other two farmers disagreed. However, one farmer agreed that it was difficult for seasonal calving (Figure 4.80).

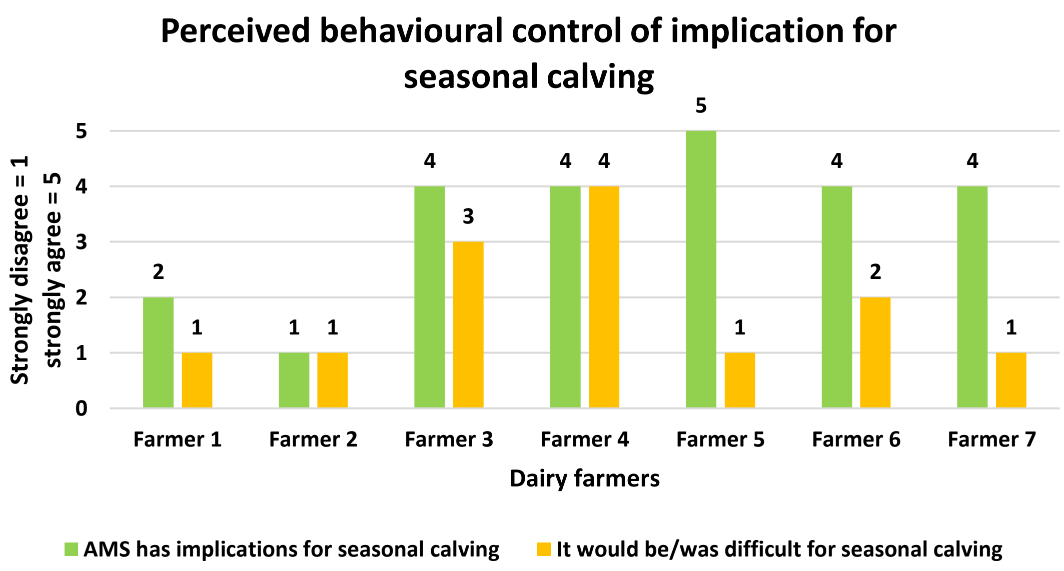

Figure 4.80: Perceived behavioural control of implication for seasonal calving

Four farmers agreed that AMS requires more skilled labour. The other three farmers disagreed. Two of the farmers agreed that it was difficult to find skilled labour (Figure 4.81).

Figure 4.81: Perceived behavioural control of skilled labour

Six farmers agreed that AMS requires someone to be on call 24/7. The other one farmer was neutral. Only one farmer agreed that it was difficult to have labour on call 24/7 (Figure 4.82).

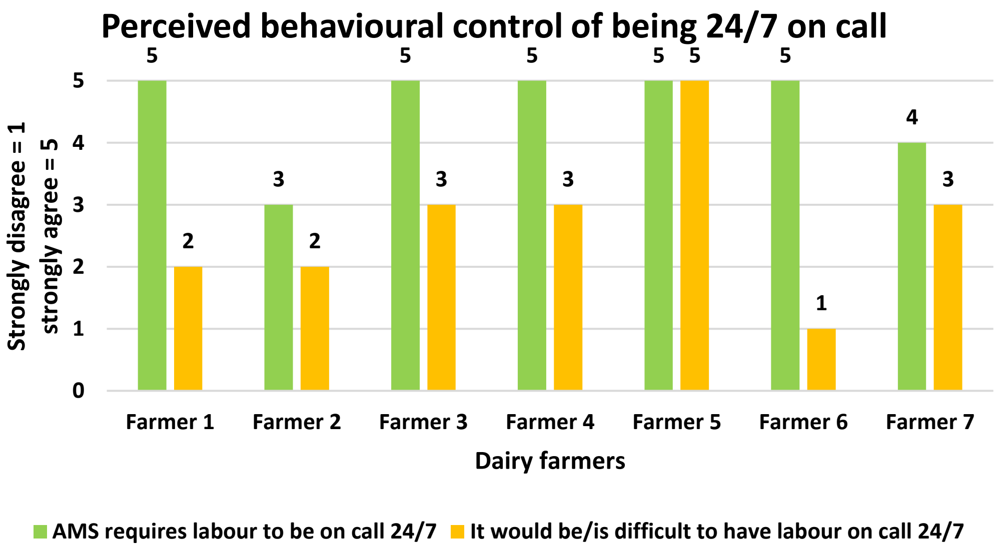

Figure 4.82: Perceived behavioural control of being 24/7 on call

All of the farmers agreed that AMS requires ongoing support from manufacturers and dealers. All of them disagreed that it was difficult to access ongoing support from manufacturers and dealers (Figure 4.83).

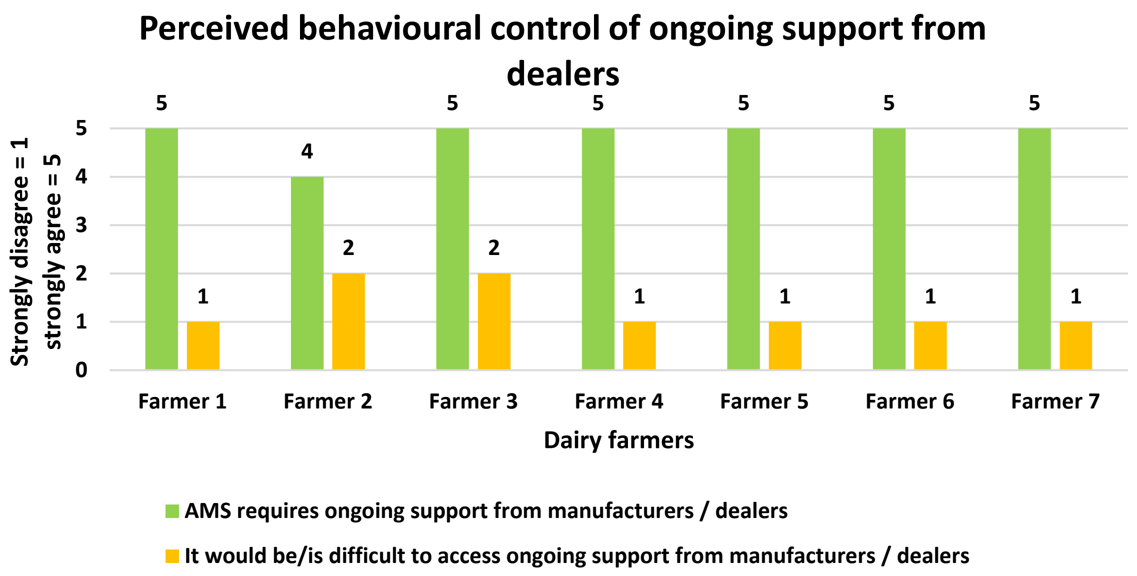

Figure 4.83: Perceived behavioural control of ongoing support from dealers

Four farmers agreed that AMS requires additional technology. The other two disagreed. However, none of them agreed it was difficult to access or use the additional technology (Figure 4.84).

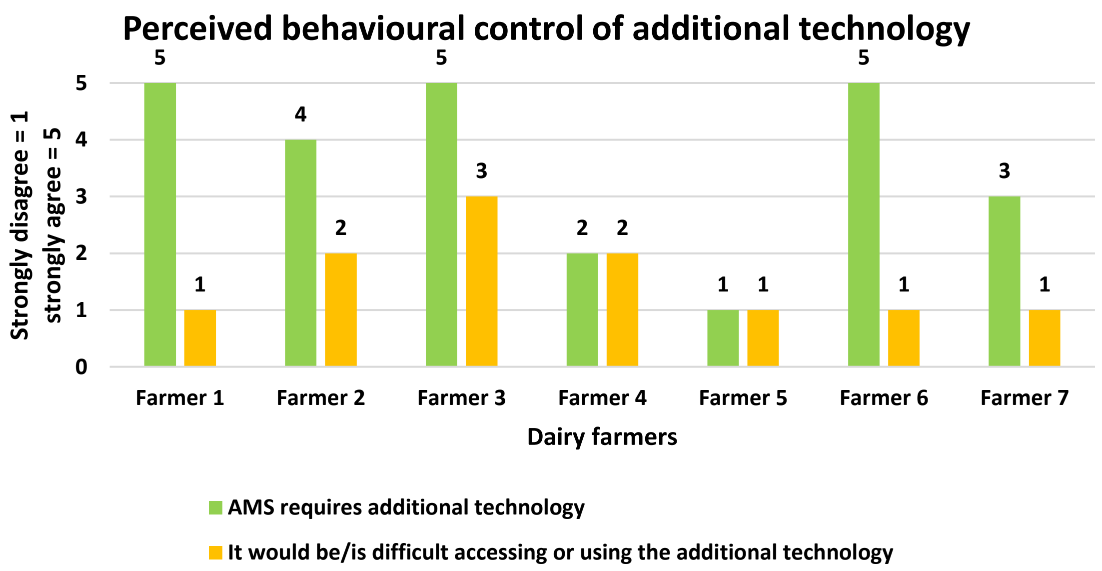

Figure 4.84: Perceived behavioural control of additional technology

4.2.2.6 Summary of perceived behavioural control

Most of the farmers perceived that AMS is complex to install. Four stated that it was complicated to install AMS. While the farmers agreed that the capital cost of AMS is high, they were neutral or disagreed that the costs would stop them from installing AMS. Four of the farmers agreed that AMS requires skilled labour. Two of them agreed that it is difficult to find skilled labour. While most of the farmers agreed that AMS requires being available (or having someone) 24/7, having access to additional technology and ongoing support from the supplier, they did not find these features difficult (Figure 4.85). In terms of changes in the farm layout and infrastructure, AMS did not necessarily require these changes. While AMS requires changes to the traditional grazing system, most of the farmers noted that these changes were not difficult to make. While most of the farmers agreed that AMS has implications for seasonal calving, they did not find these changes to be difficult (Table 4.17).

Table 4.19: Total value of perceived behavioral factors

Factors	**Farmer 1**	**Farmer 2**	**Farmer 3**	**Farmer 4**	**Farmer 5**	**Farmer 6**	**Farmer 7**	**Total**
Complex to install	20	8	16	9	25	25	6	**109**
High capital cost	5	12	15	3	6	9	15	**65**
Changes to farm layout	3	8	12	6	4	4	10	**47**
Changes to farm infrastructure	3	6	9	3	6	4	8	**39**
Changes in grazing system	5	8	12	3	3	15	10	**56**
Implications for seasonal calving	2	1	12	16	5	8	4	**48**
Requirement for skilled labour	16	4	16	12	15	2	6	**71**
Requirement for labour to be on call 24/7	10	6	15	15	25	5	12	**88**
Requirement for ongoing support from the dealers	5	8	10	5	5	5	5	**43**
Requirement for additional technology	5	8	15	4	1	5	3	**41**

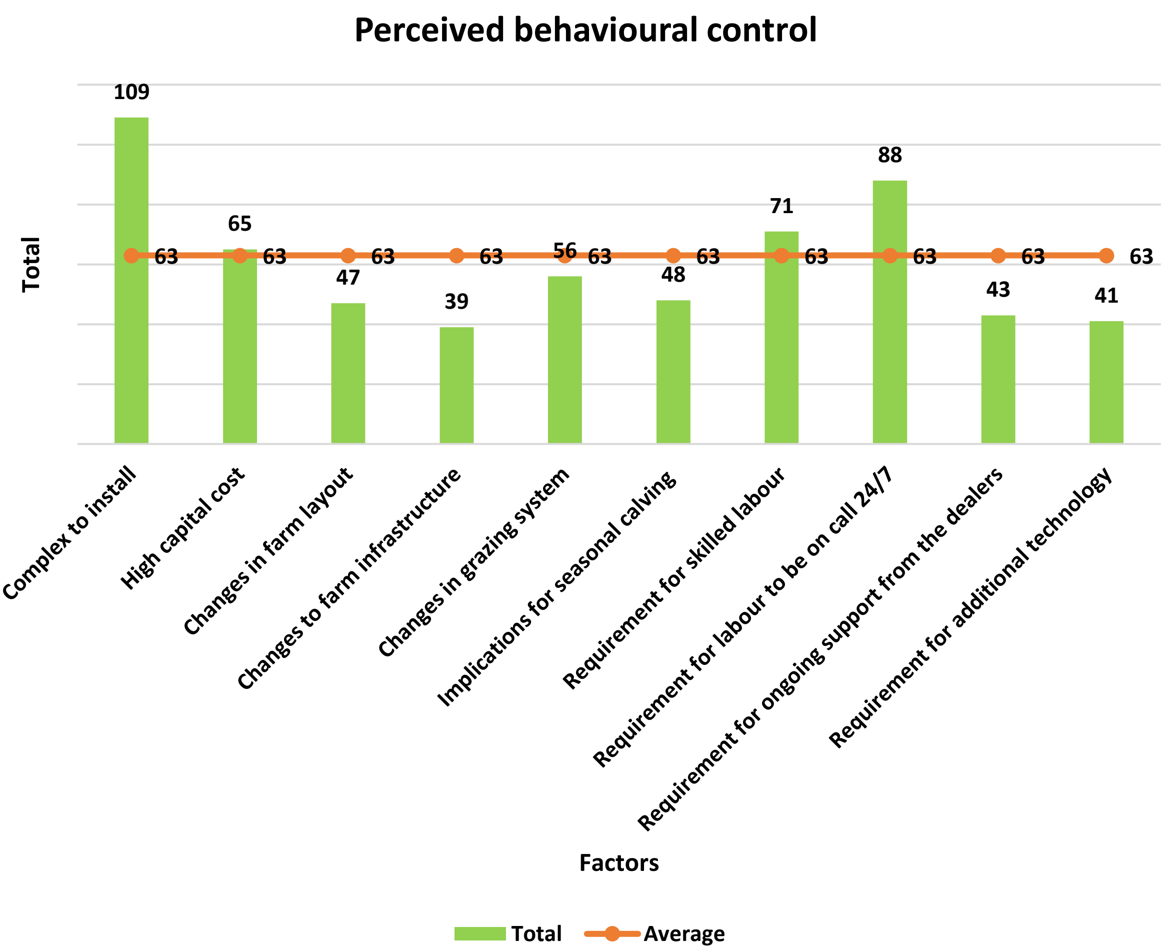

Figure 4.85: Total value of perceived behavioral factors

4.2.3 Results from section 5: Operations and labour before and after AMS adoption

This section of the interview included a few sub-sections designed to understand the impact of AMS on farm operation and labour. These sections covered problems before and after AMS installation, including training the cows, changes in workload, tasks, the farm system and the cows.

The main problems farmers faced before AMS adoption were related to upgrading old rotary milking shed, issues with labour (recruitment, retention and dealing with unreliable workers), and long days and hours of work (up to 70 fixed hours/week).

The main problems associated with AMS include the age of the robots and the inability of technicians to fix problems in a timely fashion. Other problems include an incomplete milking event which can be caused by a number of factors: these include an inability to detect a teat, loose rubber causing the milk cup to come off, power cuts, dirty sensors, low air pressure, poor maintenance of the robot arm, and the cups getting tangled up as a result of a nervous cow, a cow who keeps kicking or is new to AMS.

The frequency of problems can be daily, weekly or monthly. Daily problems tend to be non-critical ones. The farmer is usually able to fix these problems quite easily. Less regular issues tend to be more critical and may require a technician to fix them. A farmer may take a few seconds or up to four hours to fix a problem. Problems which require a technician can take longer to fix (in some cases up to 12 hours).

Training the cows takes approximately two weeks. In one case, it took the farmer six months to train the cows. Subsequent training of the heifers usually takes approximately three days. Activities involved in training included grazing heifers with dry cows, manually operating the system for the first 2 – 3 days, offering feed, being patient, and putting the cows through the AMS process without milking them so that they get use to the cups and the noise. Activities which made the training process more difficult for the farmers were the need for labour, learning how to use the new technology, and dealing with nervous cows (especially in autumn when flies bite the cows making them move and kick more).

Farmers used a variety of techniques to deal with cows who were hesitant to use AMS. These included pushing them through, sending them to other farms, or putting them down.

In terms of labour requirements, only one farmer did not experience any change, as he ran the farm by himself. For the rest of them, the labour unit dropped by 20% to 50%. In terms of workload after AMS adoption, farmers had shorter and more flexible work hours (these varied from 70h/week to 40h/week). However, all had to be on call 24/7. Additionally, farmers all noted the extra time they had to spend training the cows. Tasks which are not required after AMS adoption included fetching the cows from the pasture and attaching the milking cups to them. These tasks were replaced with new tasks such as data entry and analysis, maintaining the equipment, cleaning the AMS, changing gates, fencing, working more with the computer, and calving year-round.

All of the farmers practiced a three-way grazing system and free traffic system which required them to add new races or extend the existing ones with new fences and the installation of gates. The gates were changed three times a day, every eight hours. Farmers also noted changes in cow's behaviour, with farmers commenting that they were calmer, more relaxed, contented, chilled and independent.

4.2.4 Results from section 6: Changes as a result of AMS

This section of the interview asked the farmers what changes they expected as a result of installing AMS and whether the system performed in the way they thought it would (Table 4.18).

Four of the farmers expected data provision, and all of them got it. Six of them expected improvements in the milking process and production and were satisfied with the result. Four of them liked these changes. None of the farmers expected improvements in the milk quality, nor did they find any.

Six of the farmers expected benefits in terms of cow welfare and were satisfied with the result. Four of them expected health improvements in terms of reduced rates of mastitis and lameness, and five of them experienced these benefits.

Four of the farmers expected high capital costs but found that it was not prohibitive to adopt AMS. Three of them expected reduced labour costs; four of them got it. None of the farmers expected reduced operational and maintenance costs.

Four of the farmers expected reduced work hours, but only two experienced this. Five of them expected reduced workloads and a shift in tasks. Four of them experienced these benefits.

Four of them expected to adopt further software and mobile apps. Five of them adopted further technology.

Five of the farmers expected changes in the milking shed infrastructure and traffic system, and four of them had to make these changes. Four of them expected changes in the grazing system and also had to make changes. In terms of achieving their goals, almost all of the farmers achieved their goals and planned to continue dairy farming.

Table 4.20: Factors dairy farmers expected the most

Type of factor	Factors	No. of farmers (Expected)	No. of farmers (got)
Economic	Increased milk production	6	5
Economic	Improved milking process	6	4
Animal health and welfare	Benefits to cow welfare	6	6
Social	Reduced workload	5	4
Social	Changes in tasks	5	4
Social	Adaptions to milking shed infrastructure	5	4
Social	Adapt traffic system	5	4
Social	Additional features/functions provided by the robotic milking system (e.g., data provision)	4	7
Animal health and welfare	Reduced rates of mastitis	4	5
Animal health and welfare	Reduced rates of lameness	4	5

Farmers had low expectations of reduced operation, maintenance, and labour costs (Table 4.19).

Table 4.21: Factors dairy farmers expected the least

Type of factor	Factors with lowest expectations	No. of farmers
Economic	Reduced operational costs	0
Economic	Reduced maintenance costs	0
Economic	Reduced labour costs	3

4.2.5 Conclusion

The farmers who adopted AMS were located in different regions across both the North and South Islands of New Zealand. While four of the farmers were owners, the remaining ones were sharemilkers. They had more than 20 years of experience in the farming industry. The results indicated that adoption of technology does not necessarily require a high level of education with two of them having no formal education. The rest of them had at least a high school level education.

They all agreed that AMS provides them with better animal welfare, having more relaxed and calmer dairy cows, treating cows as individuals, having new experience and challenge, providing a more relaxed operation system, making better decisions about individual dairy cows, and reduced rates of lameness, a better lifestyle, working conditions, increased milk production, and flexible working hours.

These factors are, in broad order of importance, from the animal health and welfare, social and economic.

The only factor that influenced the farmers to adopt AMS were the resources and publicity materials provided by AMS suppliers.

AMS requires many changes, including changes to the farm layout, infrastructure, and grazing system, and other requirements such as the need for a farmer to be on call 24/7, the need for skilled labour, and support from AMS suppliers; however, farmers did not find it difficult to make changes or to deal with the other requirements.

There were some social, economic, and animal health and welfare factors that the farmers expected from AMS adoption and which they experienced. These factors include an increase in milk production, improvements in the milking process, benefits associated with cow welfare, a reduced workload, changes in tasks, adaptions in the milking shed infrastructure and traffic system, data provision, and reduced rates of mastitis and lameness. In terms of achieving their goals, almost all of the farmers achieved their goals and planned to continue dairy farming.

Chapter 5

Results from interviews with farmers who had not adopted AMS

This chapter present the results from the face-to-face interviews conducted with 13 dairy farmers who had not adopted AMS in their pastoral-based dairy farming system. The results cover the characteristics of the dairy farms and farmers and their perceptions of AMS in pastoral-based dairy farms.

5.1 Characteristics of the dairy farms and farmers who have not adopted AMS

5.1.1 Results from section 1: General information

This section included questions related to the farmer, including their job role and years in farming.

Four farmers were from the North Island and nine from the South Island (Figure 5.1).

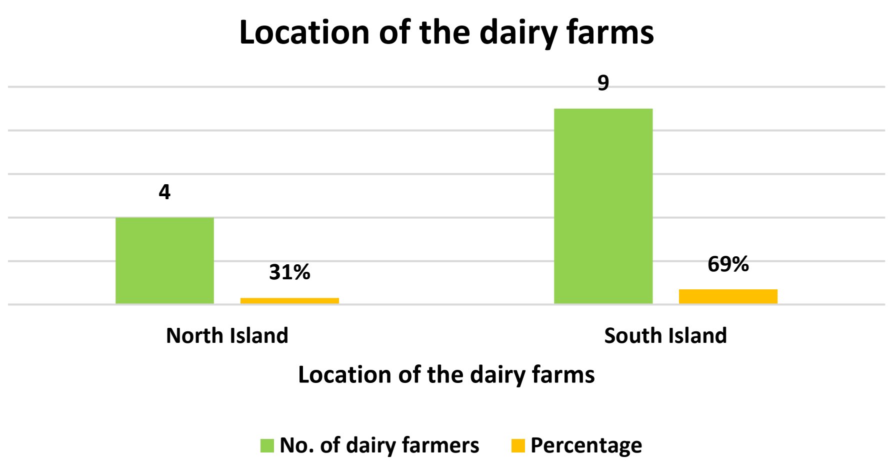

Figure 5.1:: Location of dairy farmers

Seven farmers were owners, two were sharemilkers, and the remaining four were managers (Figure 5.2).

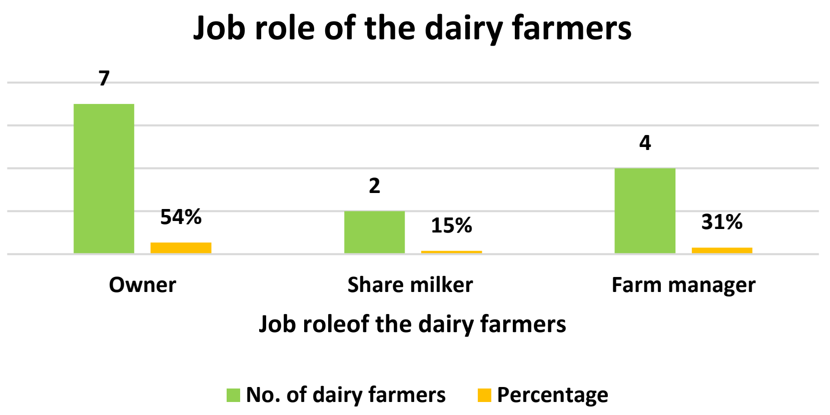

Figure 5.2: Job role of the dairy farmers

Six farmers had 20 years' experience or more. Seven of them had less than 20 years' experience (Figure 5.3).

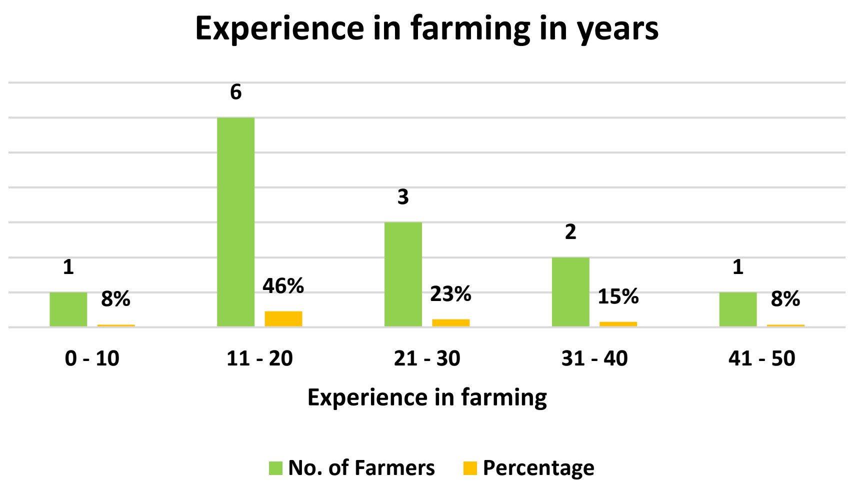

Figure 5.3: Experience in farming

Six farmers had worked on the current farm for less than 10 years. Another six farmers had worked 11 to 30 years (Figure 5.4).

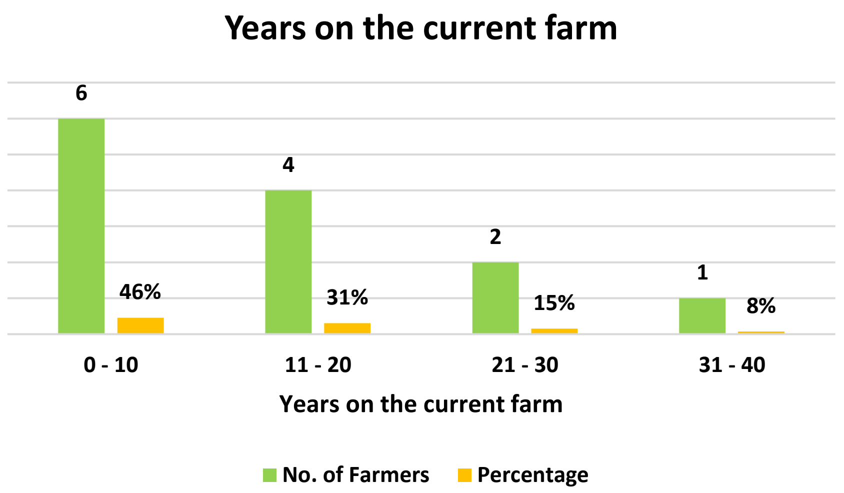

Figure 5.4: Years of experience on the current farm

Two farmers had definitely identified a successor, a further four had possibly identified a successor, and four had not. For three this was not relevant (Figure 5.5).

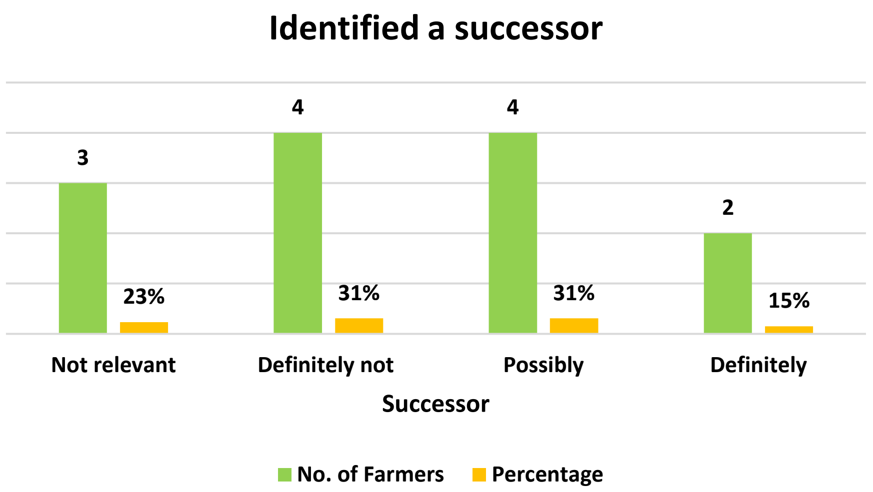

Figure 5.5: Identified a successor

While eight farmers had worked on more than one dairy farm, five farmers had only worked on one dairy farm (Figure 5.6).

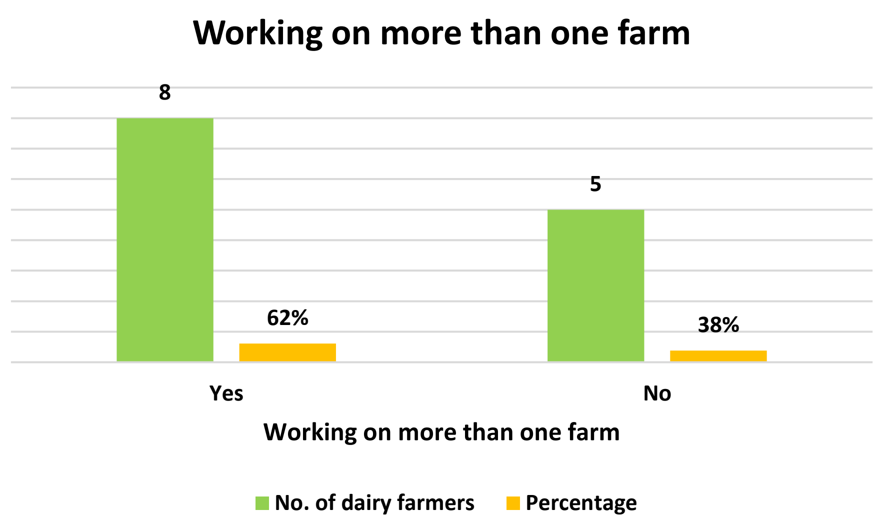

Figure 5.6: Dairy farmers working on more than one farm

5.1.2 Results from section 2: Details of farm business

This section consisted of questions related to the location of the dairy farm, farm size, effective hectares, milk production, the milk buyer, grazing support, the production system, the number of FTE staff, herd details, and the calving system.

The farmers were all from either Waikato in the North Island or Canterbury in the South Island of New Zealand (Table 5.1).

Table 5.1: Regions of the dairy farms

Farmers	Regions
Farmer 1	Canterbury, South Island
Farmer 2	Waikato, North Island
Farmer 3	Canterbury, South Island
Farmer 4	Canterbury, South Island
Farmer 5	Canterbury, South Island
Farmer 6	Canterbury, South Island
Farmer 7	Canterbury, South Island
Farmer 8	Canterbury, South Island
Farmer 9	Waikato, North Island
Farmer 10	Canterbury, South Island
Farmer 11	Waikato, North Island
Farmer 12	Waikato, North Island
Farmer 13	Canterbury, South Island

The farm size ranged from 94 to 1800 ha, with effective hectares ranging from 90 to 560 ha. The herd size ranged from 310 to 1750, whilst the range of young stock ranged from 50 to 120 for rising 1-year-olds (R1) and 50 to 256 for rising 2-year-olds (R2). The dairy cows' milk production ranged from 125 to 780KgMS/cow/year. One farmer chose not to respond to this question (Table 5.2). Ten farmers sell their milk to Fonterra. The remaining three sell their milk to Open Country Dairy, Synlait, and Westland. In terms of herd breed, 10 of the farmers had crossbred cows (Figure 5.7).

Table 5.2: Farm details

Farmer	Farm Size	Effective hectares	Herd size	Rising 1-year-olds (R1)	Rising 2-year-olds (R2)	Milk produced (KgMS/Cow/Yr)
Farmer 1	200	200	680	150	150	480
Farmer 2	94	92	310	64	65	125
Farmer 3	216	200	720	-	-	315
Farmer 4	1800	560	1750	-	-	-
Farmer 5	170	160	640	150	150	450
Farmer 6	170	160	560	160	101	520
Farmer 7	263	258	500	120	120	430
Farmer 8	250	240	780	180	180	450
Farmer 9	145	132	390	-	-	142
Farmer 10	225	210	470	115	123	183
Farmer 11	110	90	270	50	50	780
Farmer 12	280	160	480	90	90	350
Farmer 13	306	296	1090	256	271	502

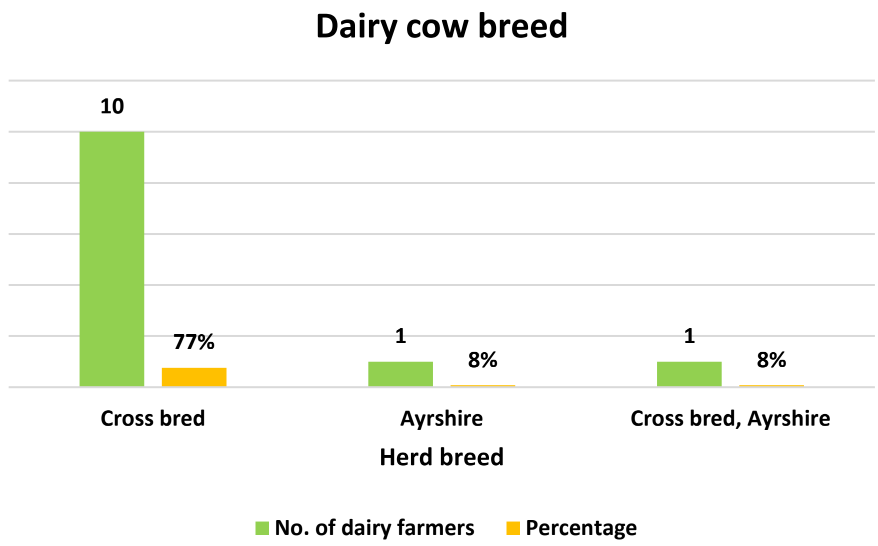

Figure 5.7: Dairy cow breed

Eight of the farmers did not answer the question about grazing support. The remainder were either self-sufficient or supplemented feed with maize silage. None of the farmers practised systems 1 and 5 of dairy production. Eleven of them practiced systems 2 and 3. Two were more intensive and used system 4 (Figure 5.8).

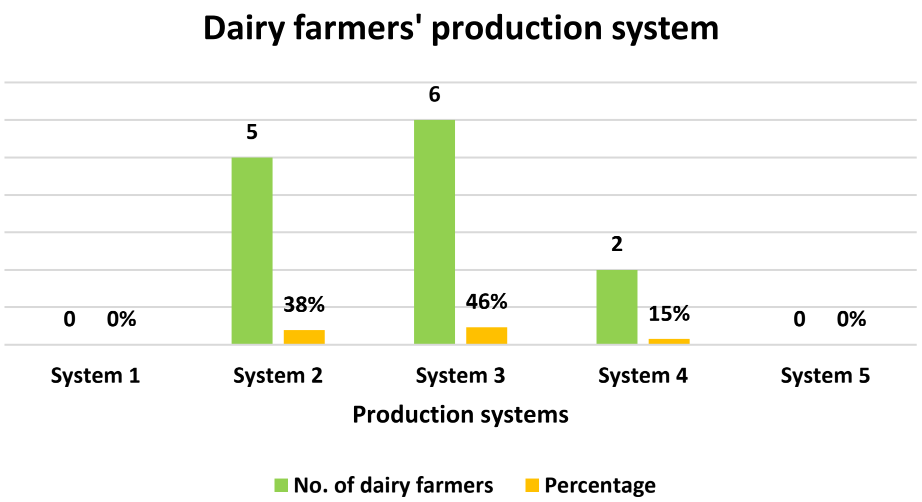

Figure 5.8: Production systems used by the dairy farmers

The farmers employed between two and eight FTE staff (Figure 5.9).

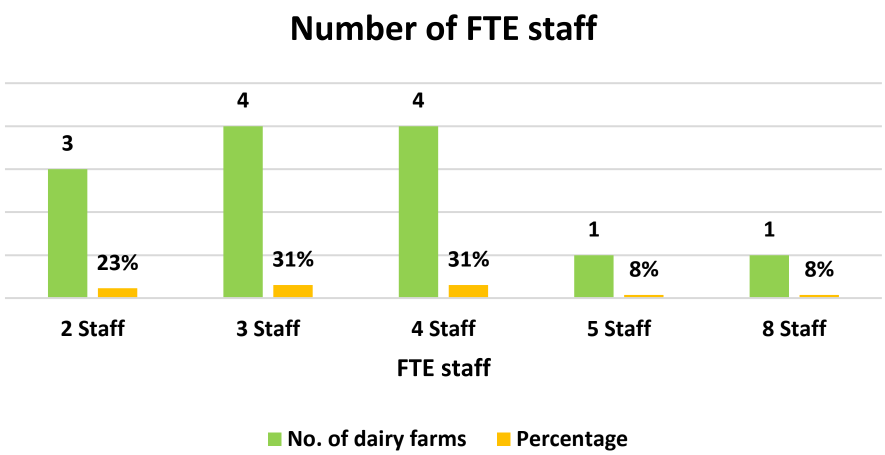

Figure 5.9: Number of FTE staff

In terms of the calving system, most were seasonal. Three had a split calving system. None used a year-round calving system (Figure 5.10).

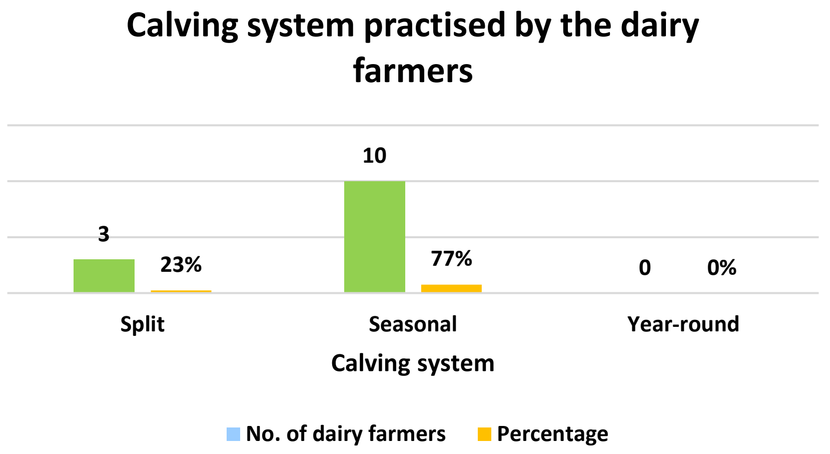

Figure 5.10: Calving system practised by the dairy farmers

5.1.3 Results from section 7: Personal information

This section asked the farmers to provide personal information, including their age, level of education and gender.

In terms of education, there was a wide range of responses; from no education all the way through to doctoral degrees in both agricultural and non-agricultural subjects (Figure 5.11).

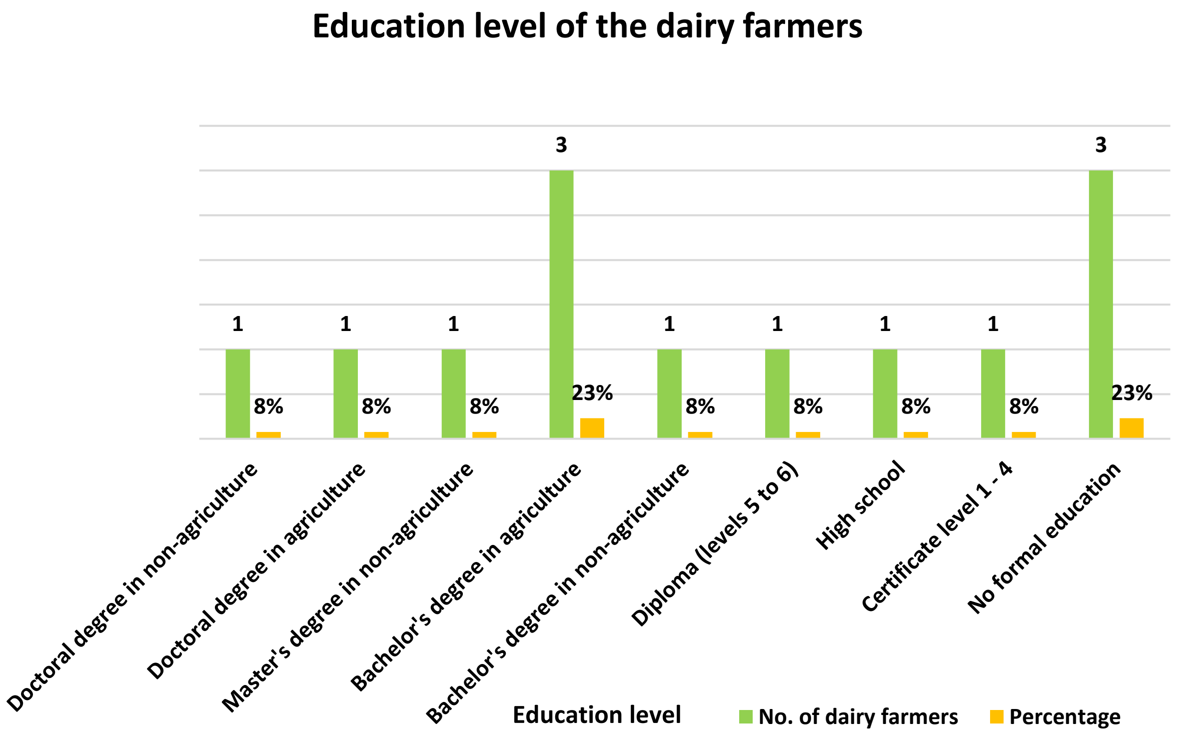

Figure 5.11: Dairy farmers' levels of education

The farmers ranged in age from 25 to more than 64 years old (Figure 5.12).

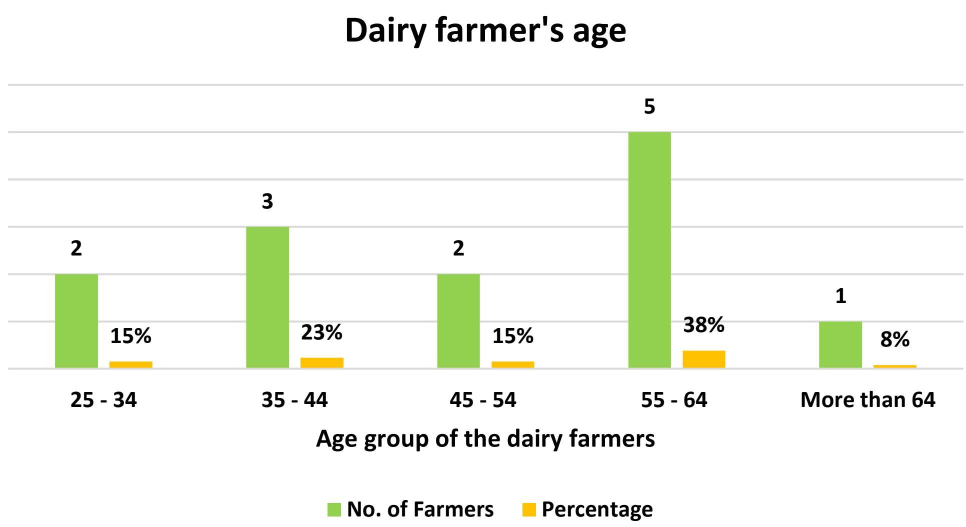

Figure 5.12: Dairy farmer's age

Eleven of the respondents were male, two were female (Figure 5.13).

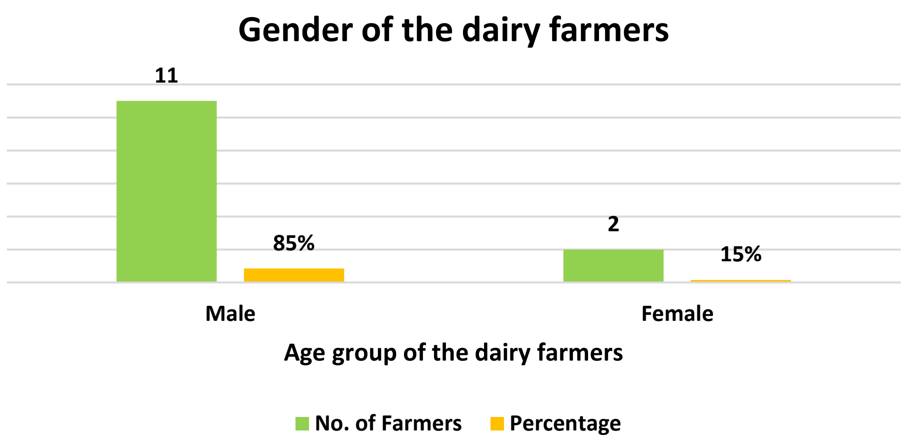

Figure 5.13: Gender of dairy farmers

5.1.4 Summary of the results from demographic sections

The findings showed that the farms were located in both the North and South Islands of New Zealand, in the Waikato and Canterbury regions. Seven of them were owners. Most had more than ten years of experience in farming and had worked on more than one dairy farm. Only two of them had definitely identified a successor to take over their business, and a further four possibly. Farm sizes ranged from 94 to 1800 hectares. Effective hectares ranged from 90 to 560. Herd size ranged from 310 to 1750. The farmers employed between two and eight FTE. Of the farmers that answered this question, most were self-sufficient in terms of grazing support, others used maize silage. The farmers practised systems two to four. Ten farmers had cross-bred dairy cows. The majority of them followed a seasonal calving system. None of them used a year-round calving system. In terms of education, there was a wide variation, with some having a high-school level education and others having doctoral degrees (both in agriculture and non-agricultural subjects). Three of them had no formal education. Only a few were over 64 years old. Five of them were aged between 55 to 64 years old. Most of them were male.

5.2 Results from section 4: Behaviour towards AMS adoption in pastoral-based dairy farming system

This section of the interviews, which followed TPB, was comprised of three main sub-sections: attitude, subjective norms, and perceived behavioural control. The attitude sub-section contained two sections: behavioural beliefs and evaluation of behavioural outcomes. The second sub-section consisted of normative beliefs and motivation to comply. The last sub-section included control beliefs and perceived power. The aim was to understand the dairy farmers' perceptions towards AMS in a pastoral-based dairy farming system.

5.2.1 Results from attitude

Both behavioural beliefs and evaluation of behavioural outcomes had seven factors: farm working environment, labour management, milk production, cost of AMS, herd health and animal welfare, herd data management, and technology.

The farm working environment section considered social factors including providing a better lifestyle, freeing up time, less physical work, better working conditions, more up-to-date working conditions, and a more relaxed operating system.

A better lifestyle was important for 12 farmers; however, only four thought AMS would provide this (Figure 5.14).

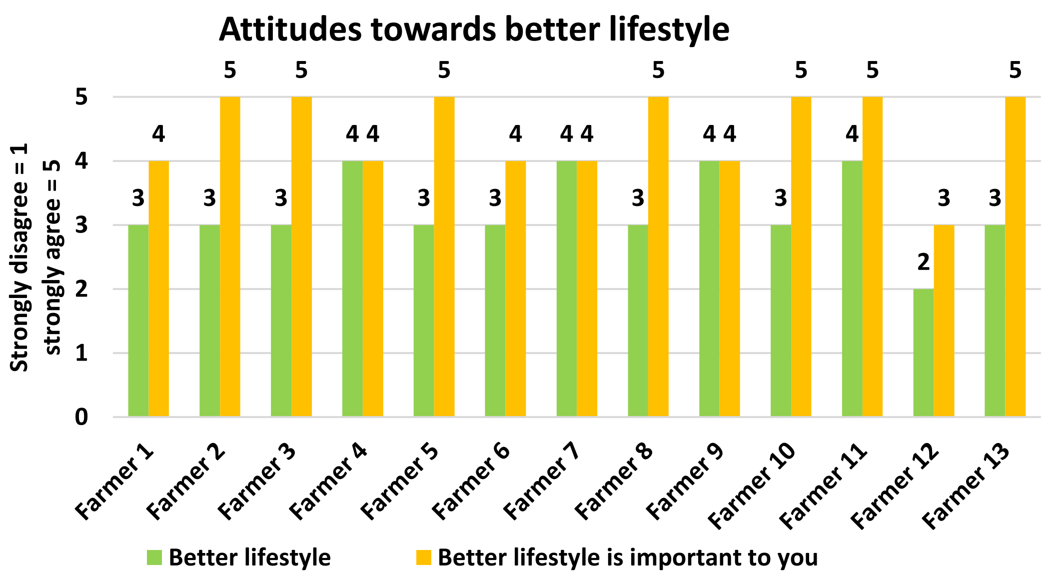

Figure 5.14: Attitudes towards better lifestyle

While freeing up time was important for all of the farmers, only five thought AMS would provide this (Figure 5.15).

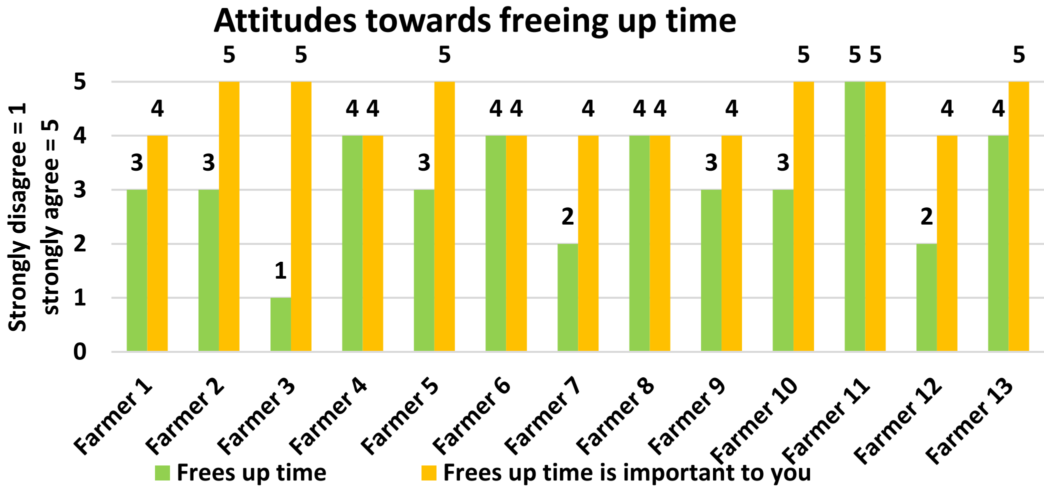

Figure 5.15: Attitudes towards freeing up time

Less physical work was important for seven farmers. Seven stated that AMS would provide this (Figure 5.16).

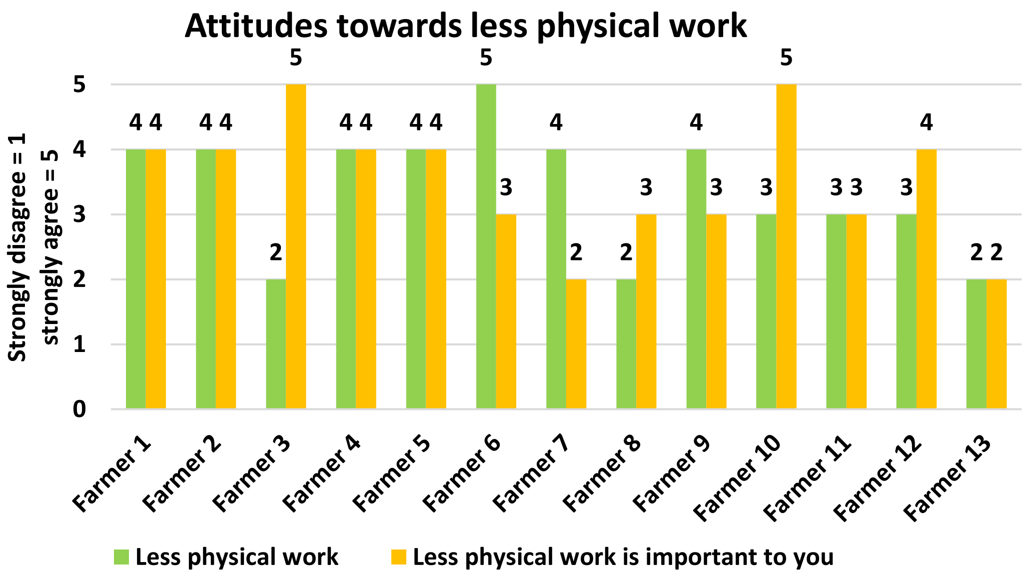

Figure 5.16: Attitudes towards less physical work

Better working conditions was important for 10 famers. Eight thought that AMS would provide this (Figure 5.17).

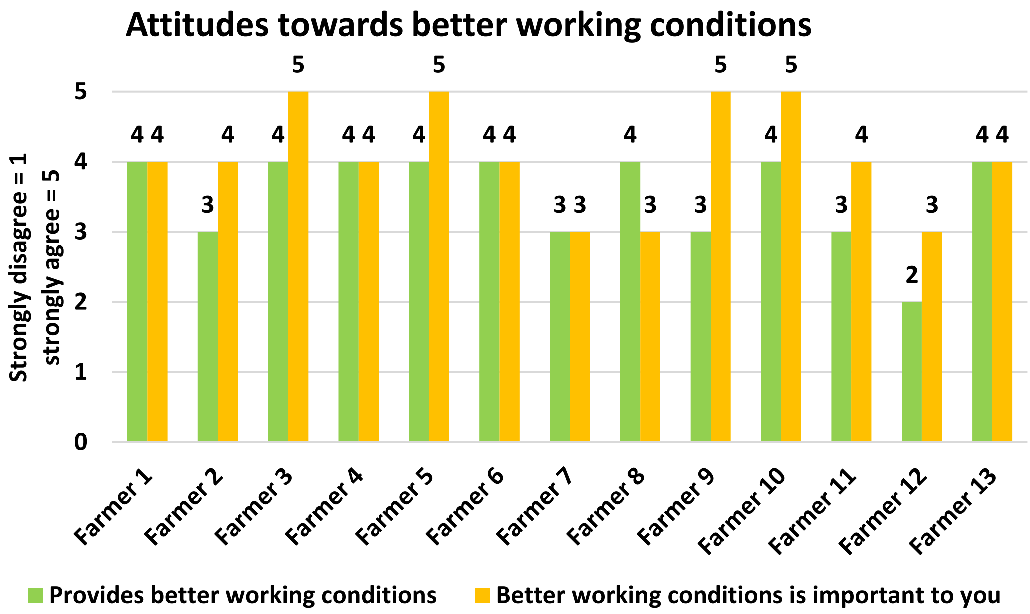

Figure 5.17: Attitudes towards better working condition

More up-to-date working conditions was important for eight farmers, with 10 farmers suggesting that AMS would provide this (Figure 5.18).

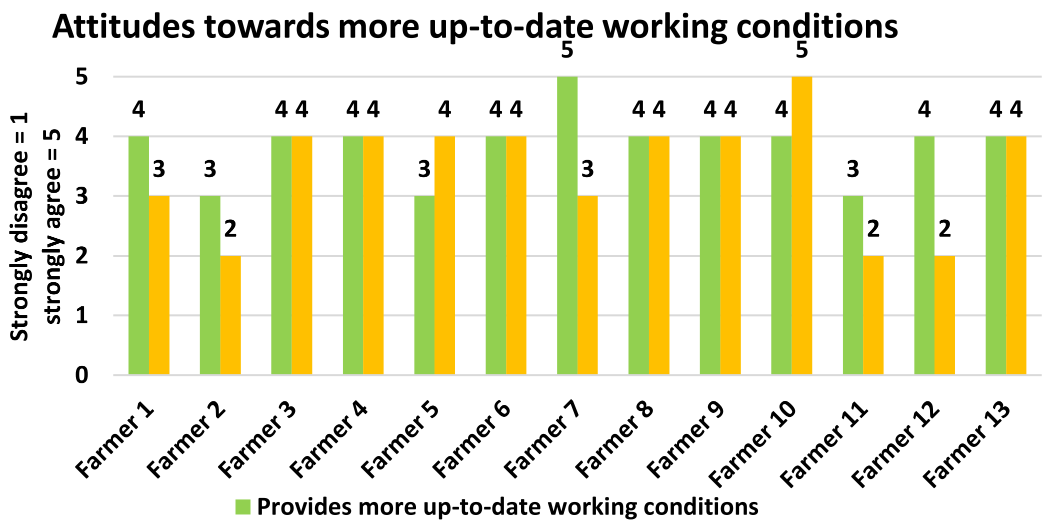

Figure 5.18: Attitudes towards more up-to-date working conditions

While a relaxed operating system was important for 11 farmers, only five agreed that AMS would provide this (Figure 5.19).

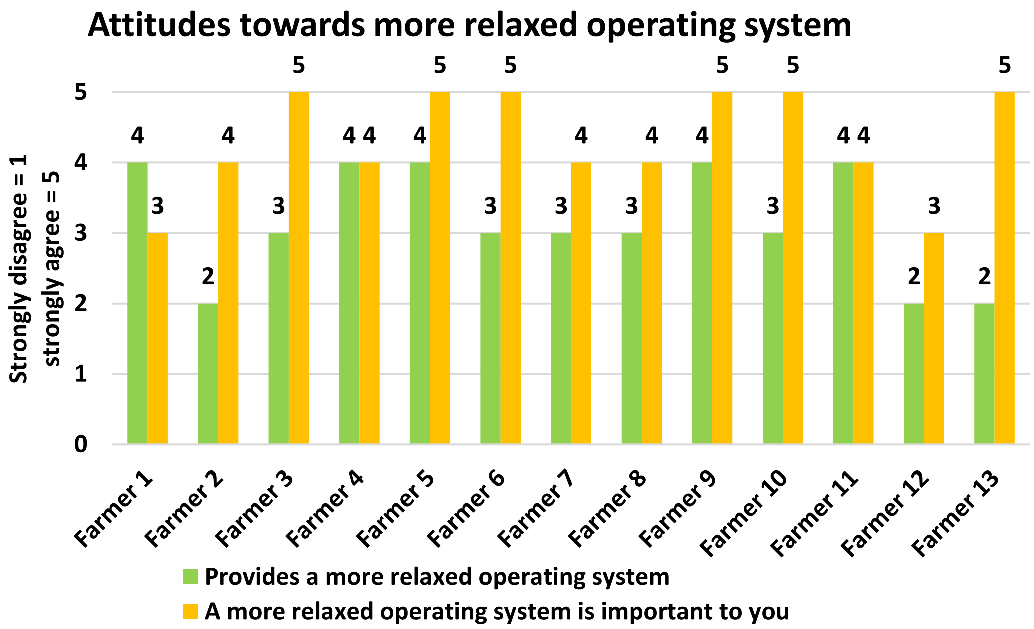

Figure 5.19: Attitudes towards more relaxed operating system

The farm working environment factors were important for all or most of the farmers. Most of them agreed that AMS provides better working conditions, better lifestyle, and frees up time (Figure 5.20). Smaller number of them agreed that AMS provides less physical work, more up-to-date working conditions, and relaxed operating system (table 5.3).

Table 5.3: Total value of farm working environment factors

Social factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Better lifestyle	12	15	15	16	15	12	16	15	16	15	20	6	15	**188**
Frees up time	12	15	5	16	15	16	8	16	12	15	25	8	20	**183**
Less physical work	16	16	10	16	16	15	8	6	12	15	9	12	4	**155**
Better working conditions	16	12	20	16	20	16	9	12	15	20	12	6	16	**190**
More up-to-date working conditions	12	6	16	16	12	1	15	16	16	20	6	8	16	**175**
Relaxed operating system	12	8	15	16	20	15	12	12	20	15	16	6	10	**177**

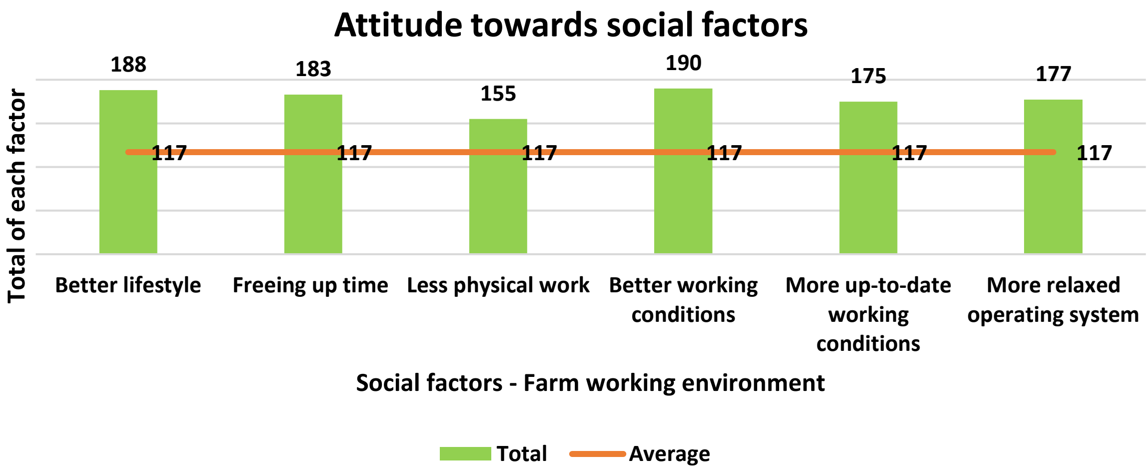

Figure 5.20: Total value of farm working environment factors

The labour management section focused mainly on social factors, including less working days, flexible working days, less working hours, flexible working hours, a shift in tasks, reduction in requirement for labour, attractiveness to future generations, help with succession planning, and help with labour recruitment.

Less working days was important for eight farmers, but none thought AMS would provide this (Figure 5.21).

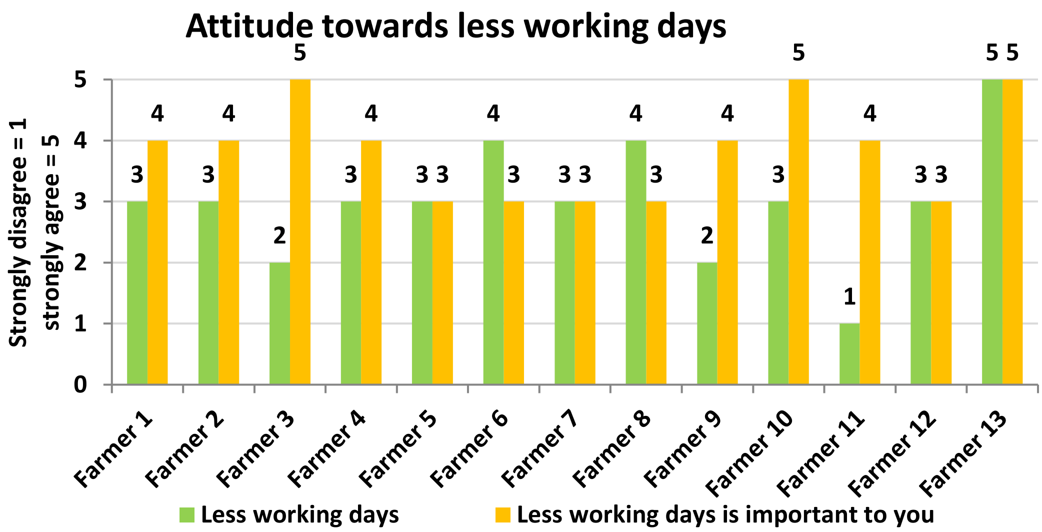

Figure 5.21: Attitudes towards less working days

More flexible working days was important for all farmers and eight thought AMS would provide this (Figure 5.22).

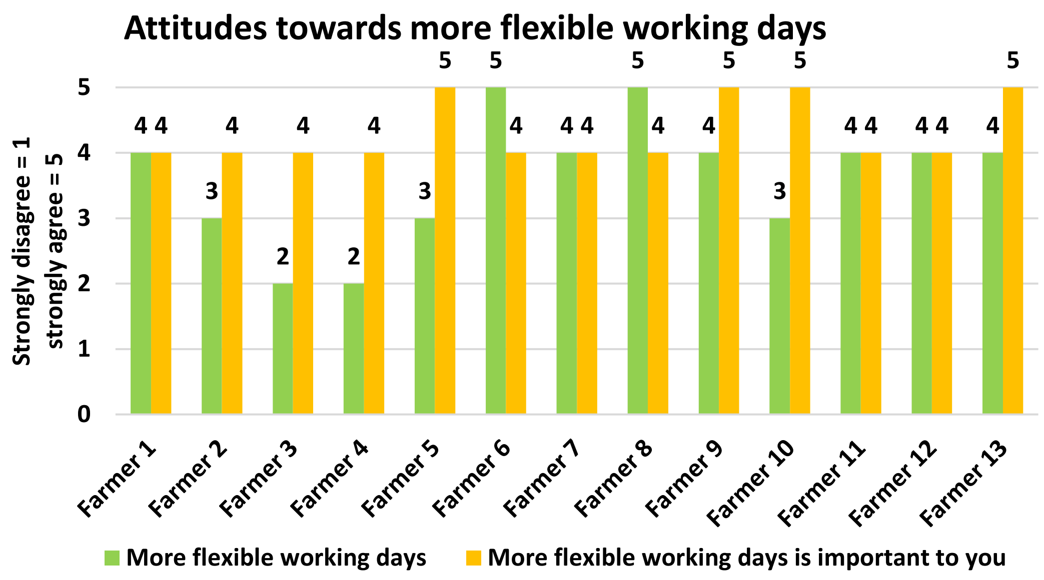

Figure 5.22: Attitudes towards more flexible working days

Less working hours was important for ten farmers. Six thought that AMS would provide this (Figure 5.23).

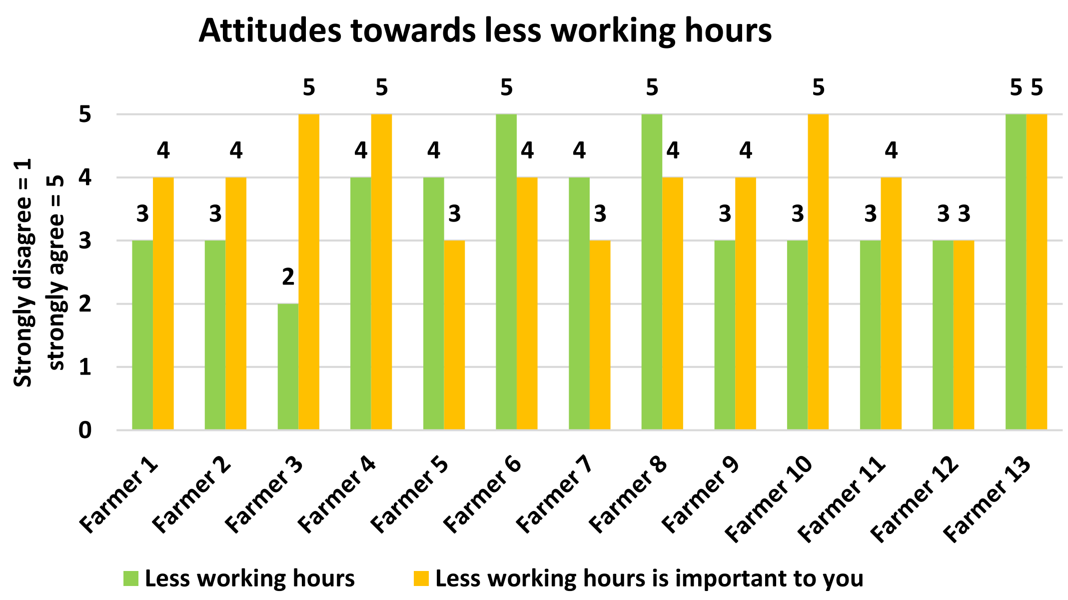

Figure 5.23: Attitudes towards less working hours

More flexible working hours was important for all of the farmers. Nine thought that AMS would provide this (Figure 5.24).

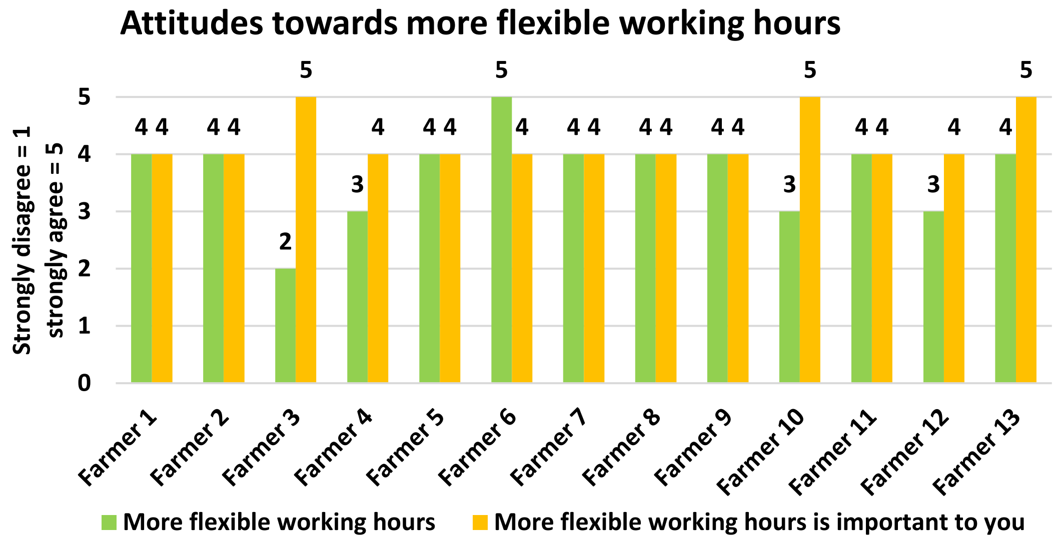

Figure 5.24: Attitudes towards more flexible working hours

A shift in tasks was important for four farmers. All of them agreed that AMS would provide this (Figure 5.25).

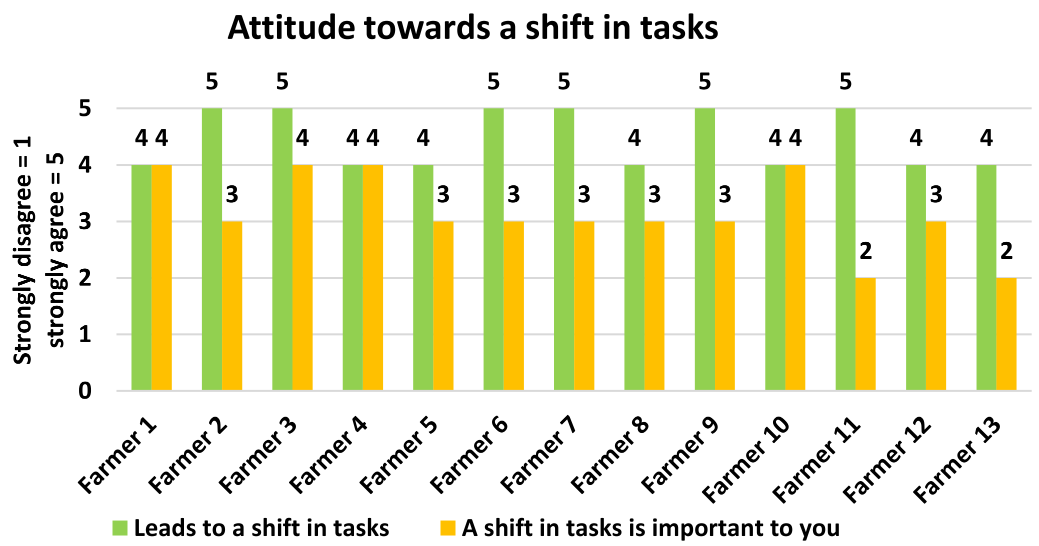

Figure 5.25: Attitudes towards a shift in tasks

Reducing the requirement for labour was important for eight farmers and seven thought AMS would provide this (Figure 5.26).

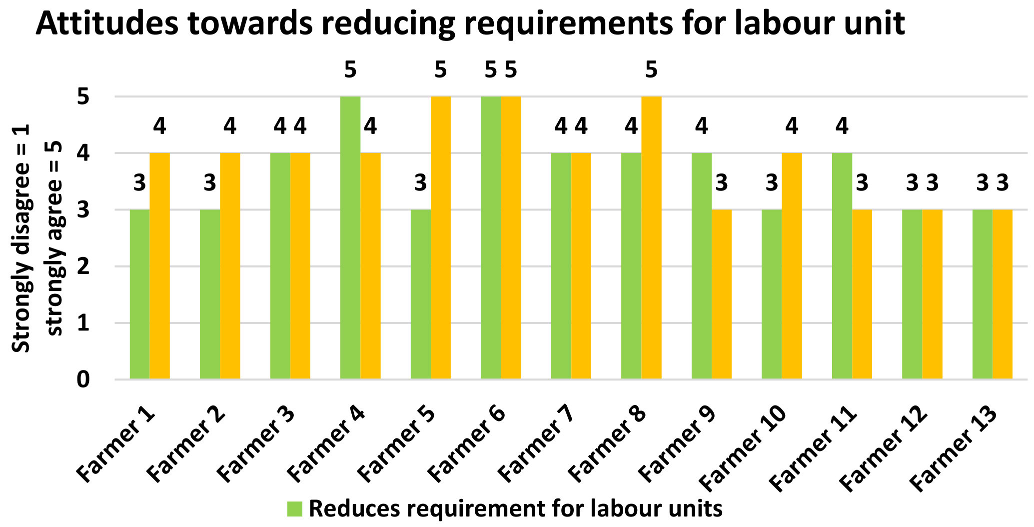

Figure 5.26: Attitudes towards reducing requirement for labour unit

Being more attractive to future generation was important for 10 farmers and nine thought that AMS would provide this. The rest were neutral (Figure 5.27).

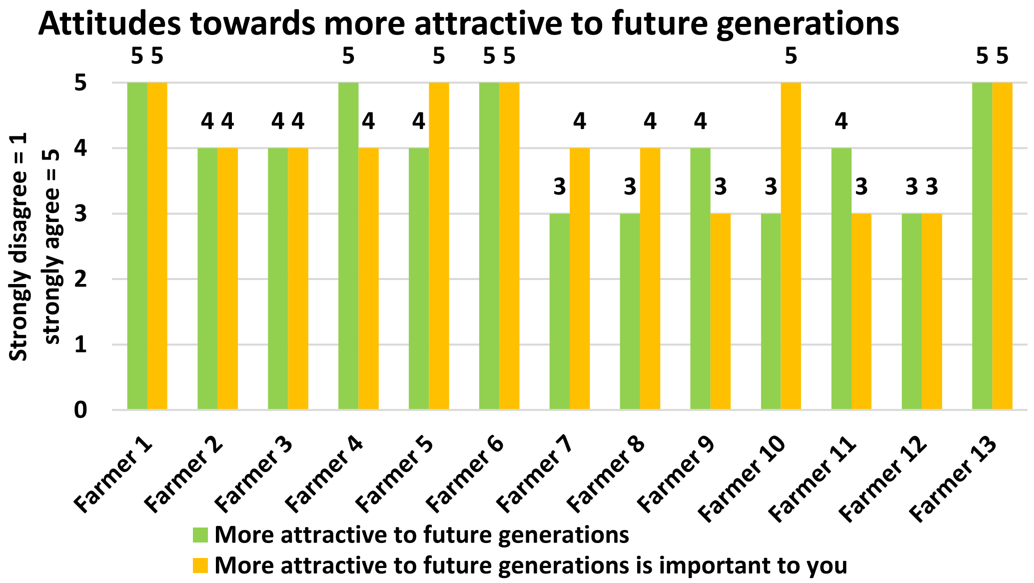

Figure 5.27: Attitudes towards more attractive to future generation

While succession planning was important for six farmers, only two thought AMS would provide this (Figure 5.28).

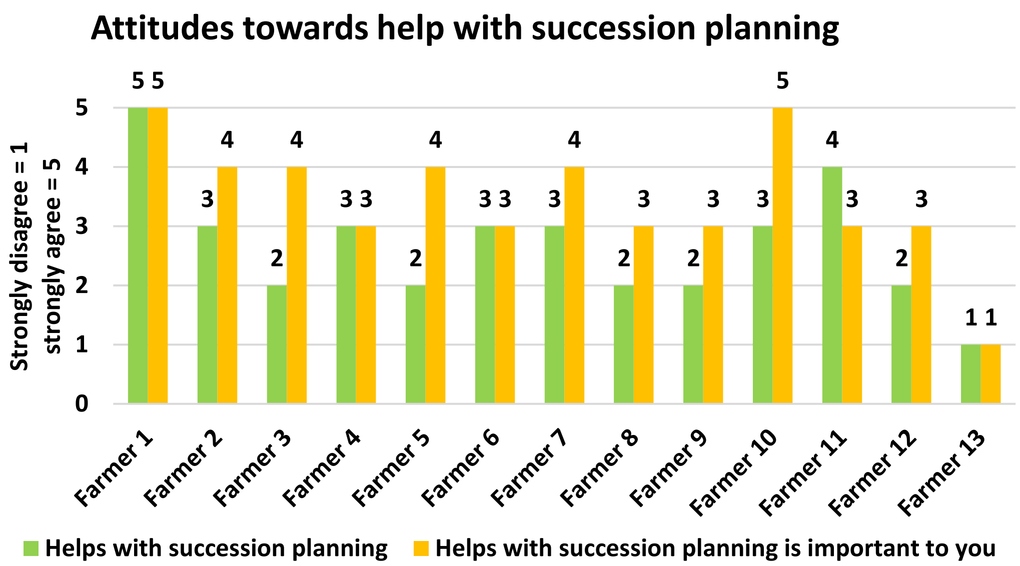

Figure 5.28: Attitudes towards succession planning

Help with labour recruitment was important for eight farmers. Six thought that AMS would provide this (Figure 5.29).

Figure 5.29: Attitudes towards help with labour recruitment

Factors including attractive to future generation, and more flexible working hours and days were important for either all or most of the farmers. Most of them agreed that AMS provides them these benefits (Figure 5.30). the other factors including less working hours, reduced requirement for labour, and help with labour requirements were important for either all or most of the farmers, but smaller number of them agreed that AMS provides them these benefits. The remaining factors including less working days, a shift in tasks, and help with succession planning were less important for them. (Table 5.4).

Table 5.4: Total value of labour management factors

Social factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Less working days	12	121	10	12	9	12	9	12	8	15	4	9	25	**149**
Flexible working days	16	12	8	8	15	20	16	20	20	15	16	16	20	**202**
Less working hours	12	12	10	20	12	20	12	20	12	15	12	9	25	**191**
Flexible working hours	16	16	10	12	16	20	16	16	16	15	16	12	20	**201**
A shift in tasks	16	15	20	16	12	15	15	12	15	16	10	12	8	**182**
Reduce in requirement for labour unit	12	12	16	20	15	25	16	20	12	12	12	9	9	**190**
Attractiveness to future generations	25	16	16	20	20	25	12	12	12	12	12	9	25	**219**
Help with succession planning	25	12	8	9	8	9	12	6	6	15	12	6	1	**129**
Help with labour recruitment	20	8	12	20	8	25	12	8	12	15	9	6	12	**167**

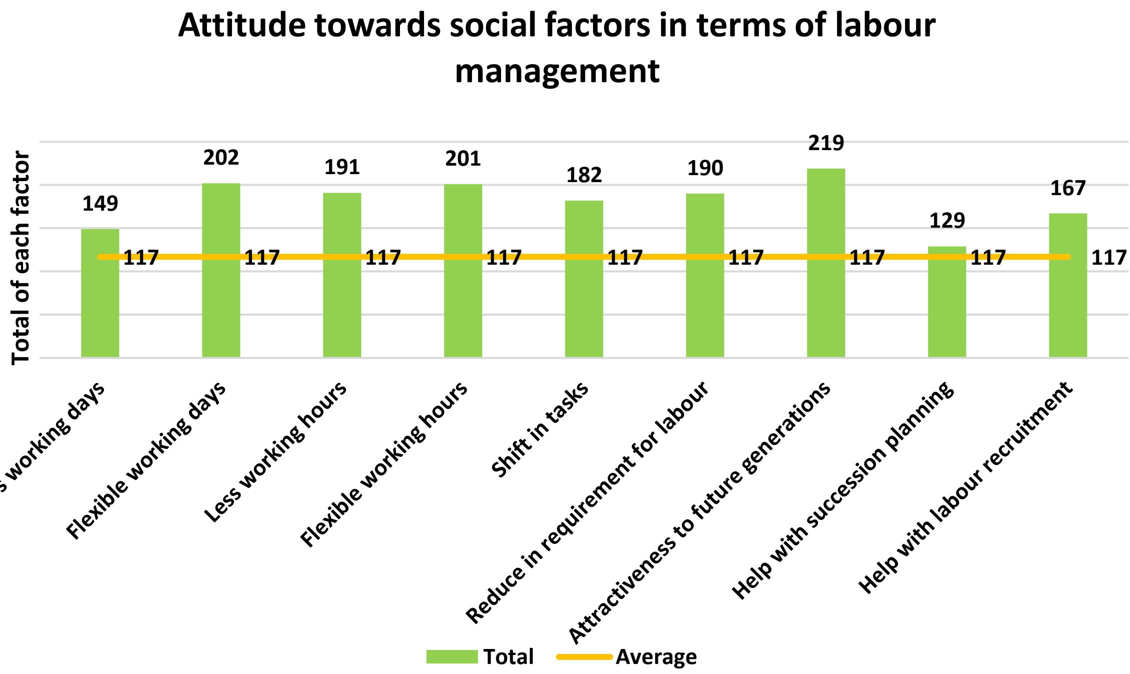

Figure 5.30: Total value of labour management factors

The milk production section focused on economic factors, including milk production and quality. While an increase in milk production was important for seven farmers, only four thought AMS would provide this (Figure 5.31).

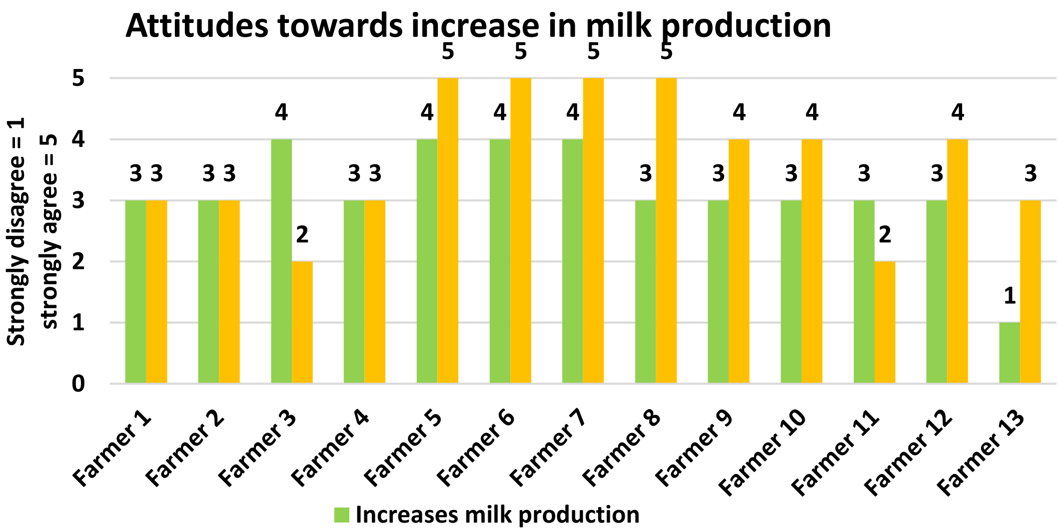

Figure 5.31: Attitudes towards an increase in milk production

Improved milk quality was important for 10 farmers. Seven thought AMS would provide this (Figure 5.32).

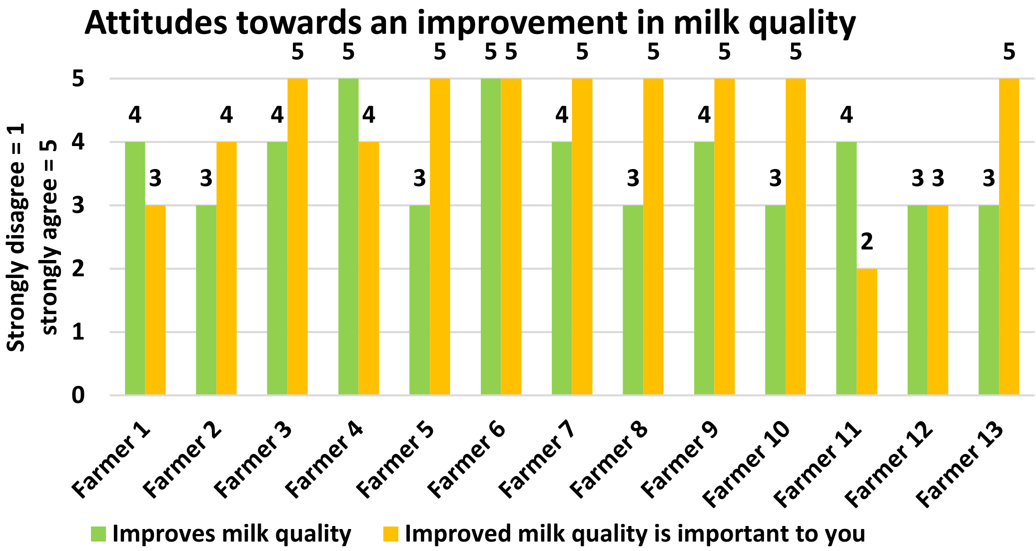

Figure 5.32: Attitudes towards improvement in milk quality

Improved milk quality was more important to the farmers than increased milk production. More than half of them agreed that AMS improves milk quality, whilst less than one-third agreed that AMS increases milk production (Table 5.5).

Table 5.5: Total value of milk production factors

Economic factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Increased milk production	9	9	8	9	20	20	20	15	12	12	6	12	3	155
Improved milk quality	12	12	20	20	15	25	20	15	20	15	8	9	15	206

The cost of AMS section focused on economic factors: improvement in profit and financial returns, a reduction in operating and milking shed maintenance costs, the cost of labour, and the farm's resale value.

While profit improvement was important for all of the farmers, none of them agreed that AMS would provide this. Six were neutral and seven disagreed (Figure 5.33).

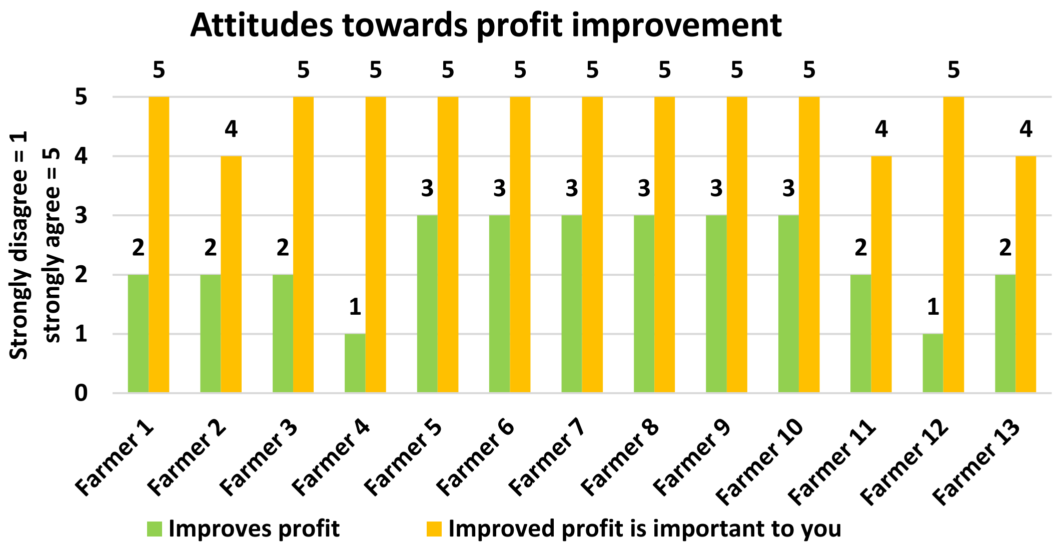

Figure 5.33: Attitudes toward profit improvement

While improved financial returns was important for all of the farmers, only one thought that AMS would provide this. Three were neutral and nine disagreed (Figure 5.34).

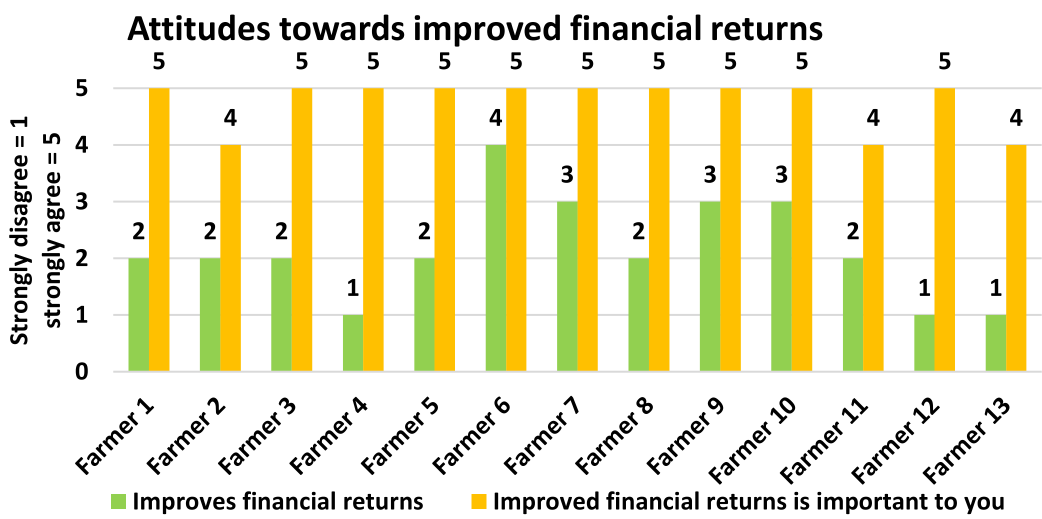

Figure 5.34: Attitudes towards improved financial returns

Reduced milking shed operation costs were important for eight farmers. Four were neutral. For one farmer reduced milking shed operation costs were unimportant. Only one thought AMS would provide this. Three were neutral and eight disagreed (Figure 5.35).

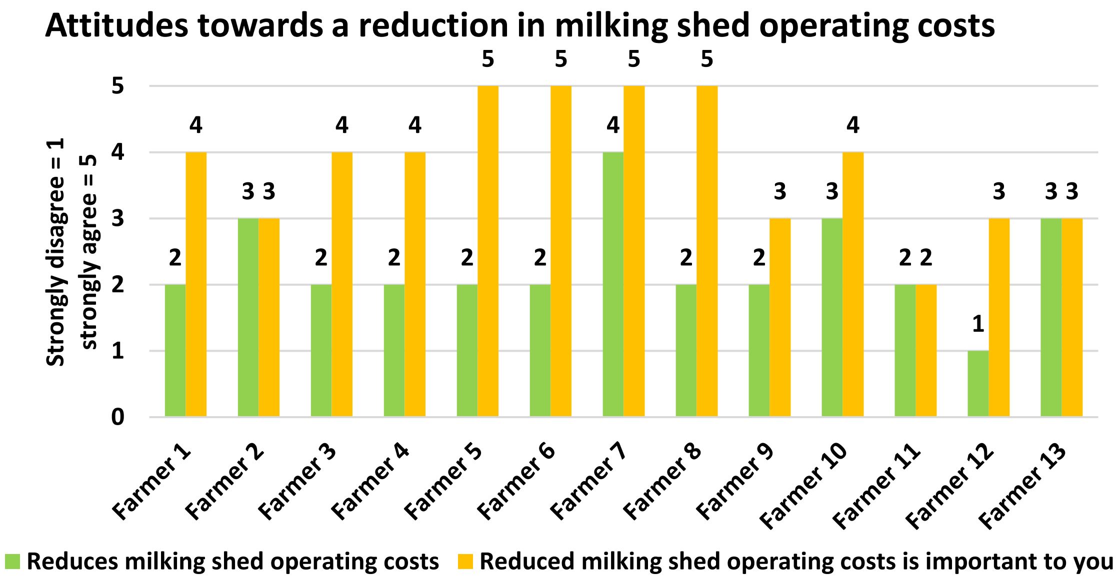

Figure 5.35: Attitudes towards reduced milking shed operation costs

While reduced milking shed maintenance and servicing costs was important for nine farmers, none thought AMS would provide this (Figure 5.36).

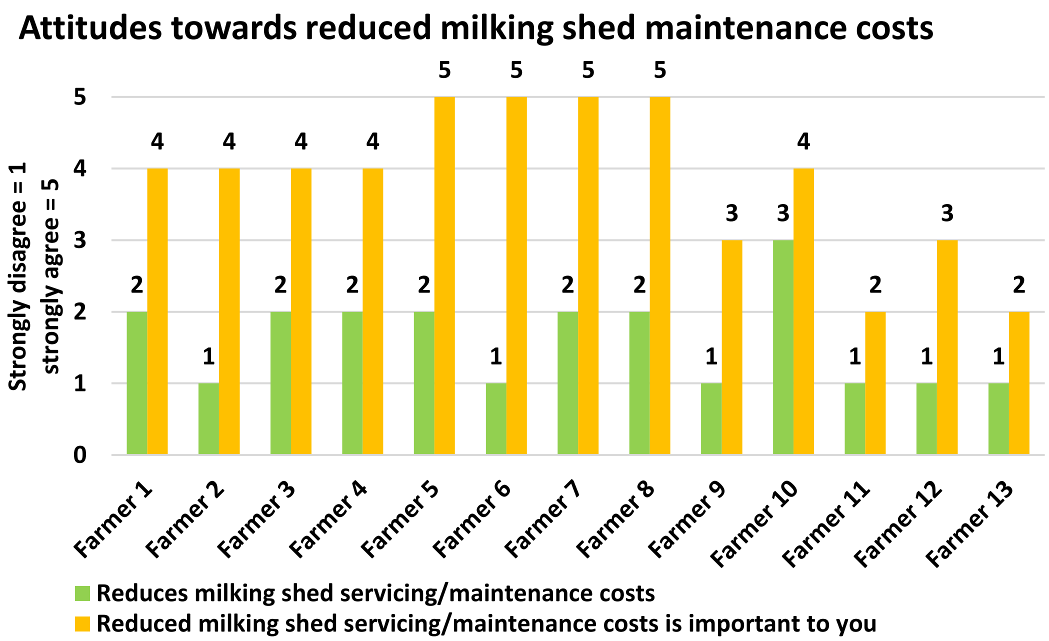

Figure 5.36: Attitudes toward reduced milking shed maintenance costs

Reduced labour costs were important for 10 farmers. Five thought AMS would provide this, four were neutral, and four disagreed (Figure 5.37).

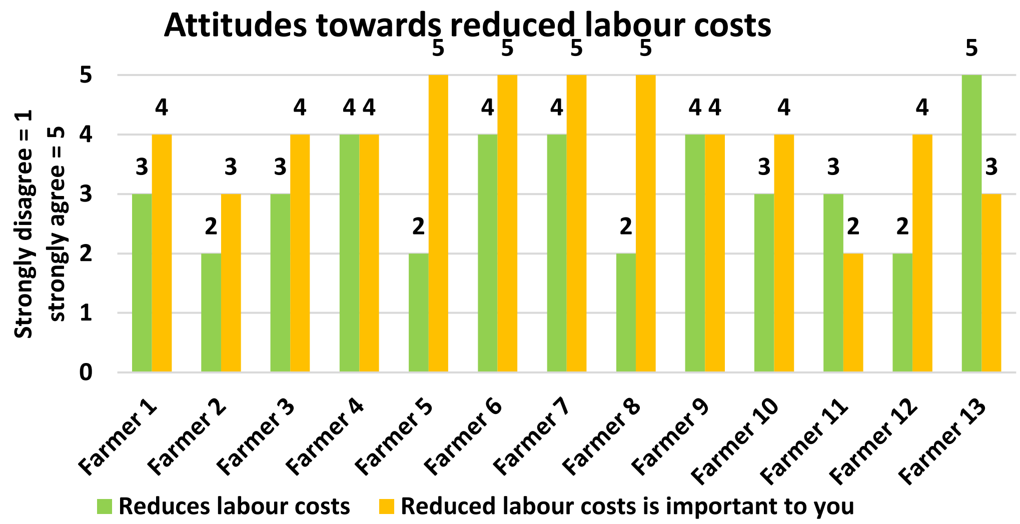

Figure 5.37: Attitudes towards reduced labour costs

Increased resale value of the dairy farm after AMS installation was important for 10 of the farmers. Three of the farmers stated that this was not important. Only two thought AMS would provide this, four were neutral, and the rest disagreed (Figure 5.38).

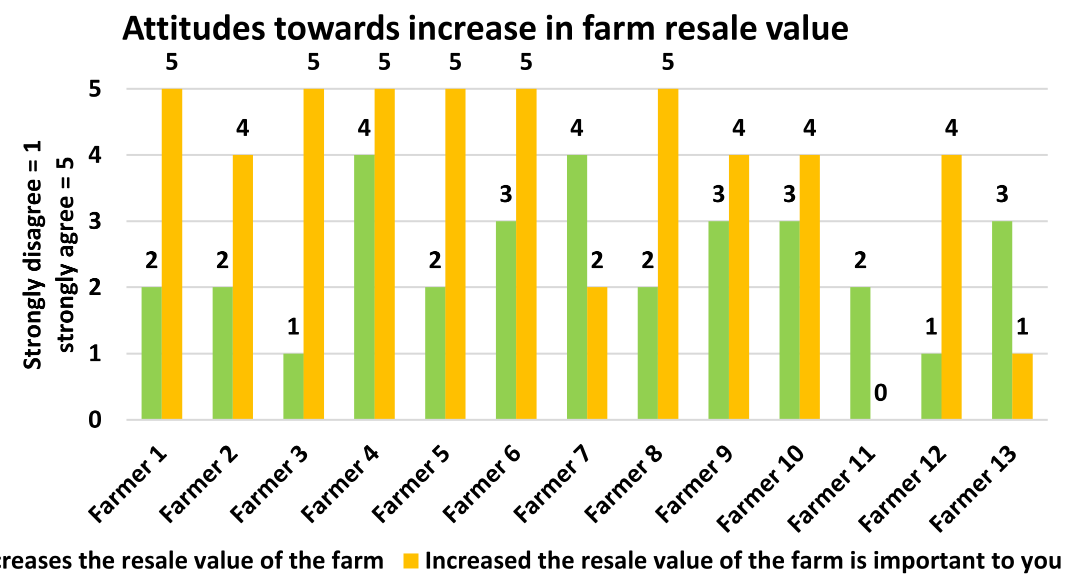

Figure 5.38: Attitudes towards increases in farm resale value

All of the factors, including improved profit and financial returns, reduced labour costs, reduced milking shed operation and maintenance costs, and increased resale value of the farm were important to all or most of the farmers. However, most believed that AMS would not provide these benefits (Figure 5.39). There were some differences in perceptions regarding reduced labour costs, with five thinking it would reduce labour costs and the remaining eight equally split between being neutral or disagreeing (Table 5.6).

Table 5.6: Total value of cost of AMS factors

Economic factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Profit improvement	10	8	10	5	15	15	15	15	15	15	8	5	8	144
Financial returns improvement	10	8	10	5	10	20	15	10	15	15	8	5	4	135
Reduced milking shed operating costs	8	9	8	8	10	10	20	10	6	12	4	3	9	117
Reduced milking shed maintenance costs	8	4	8	8	10	5	10	10	3	12	2	3	2	85
Reduced labour costs	12	6	12	16	10	20	20	10	16	12	6	8	15	163
Increased resale value of the farm	10	8	5	20	10	15	8	10	12	12	0	4	3	117

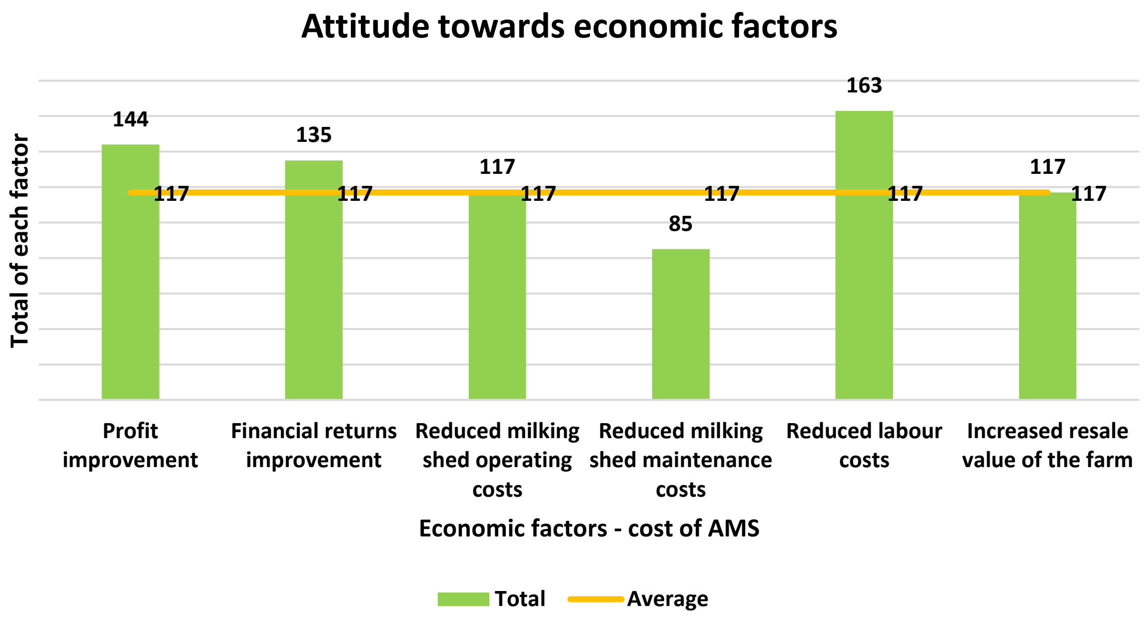

Figure 5.39: Total value of cost of AMS factors

The herd health and animal welfare section focused on animal health and welfare factors: better animal welfare, more relaxed dairy cows, treating cows as individuals rather than a herd, opportunities to observe the cows, opportunities to spot problems in cows, and reduced rates of mastitis and lameness.

Better animal welfare was important for all of the farmers. Nine of the farmers thought that AMS would provide this, one disagreed, and the rest were neutral (Figure 5.40).

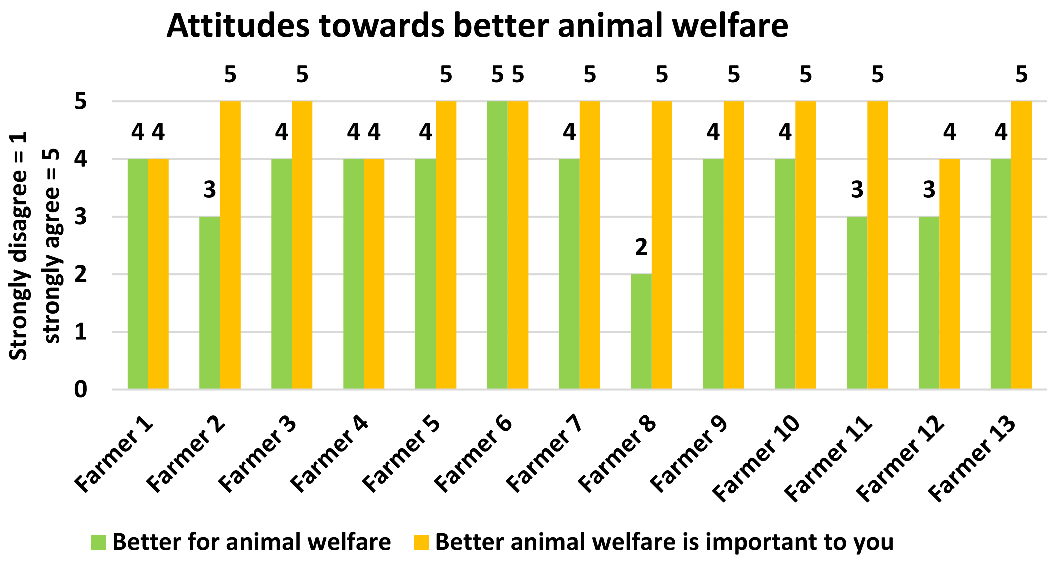

Figure 5.40: Attitudes towards animal welfare

Having more relaxed and calm cows was important for all of the farmers. Nine of them thought AMS would provide this (Figure 5.41).

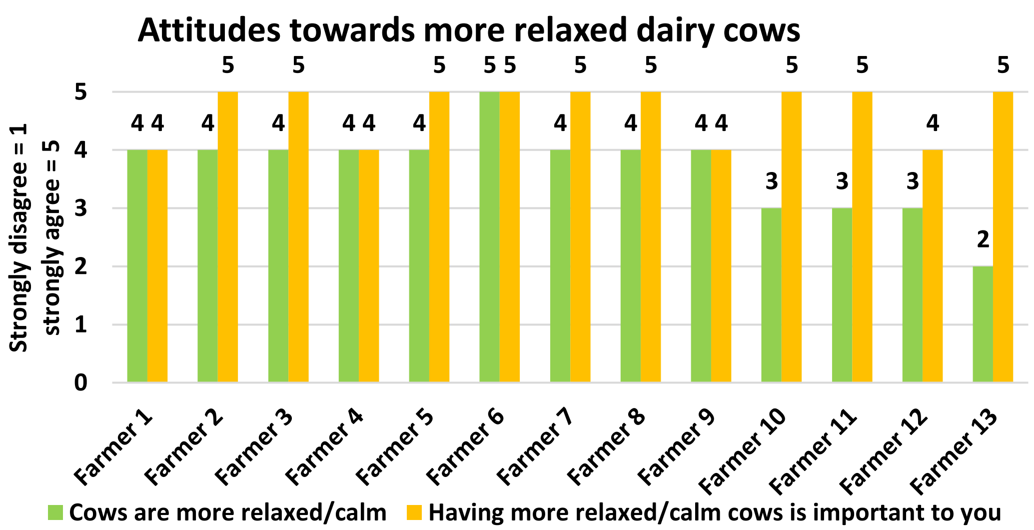

Figure 5.41: Attitudes towards more relaxed dairy cows

Treating the dairy cows as individuals rather than as a herd was important for 11 farmers. Twelve of the farmers thought that AMS would provide this (Figure 5.42).

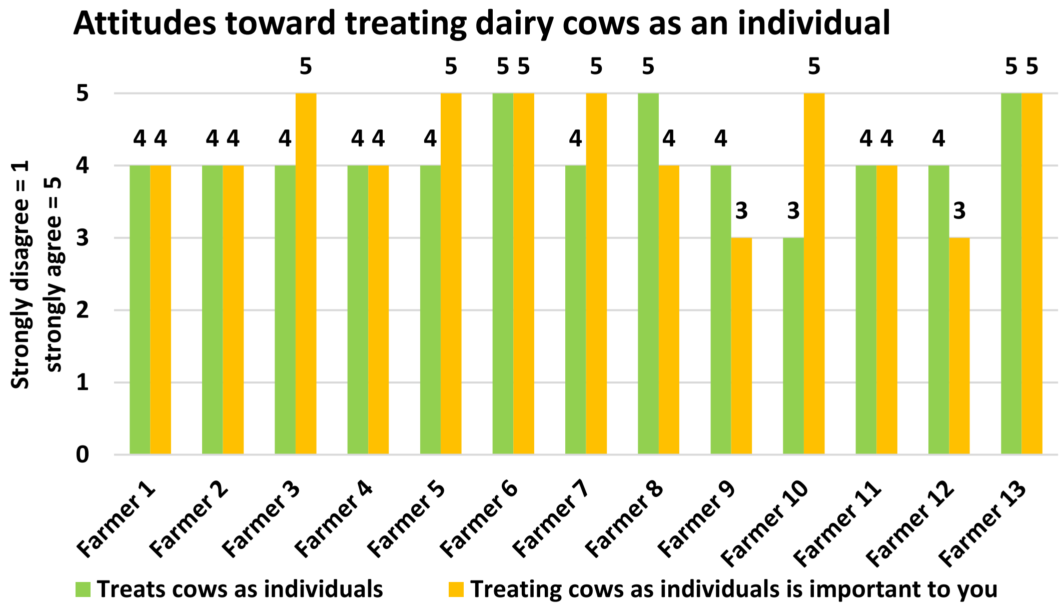

Figure 5.42: Attitudes towards treating dairy cows as individuals

While 11 farmers thought that opportunities to observe the dairy cows was important, nine thought that AMS would reduce the opportunities to do this (Figure 5.43).

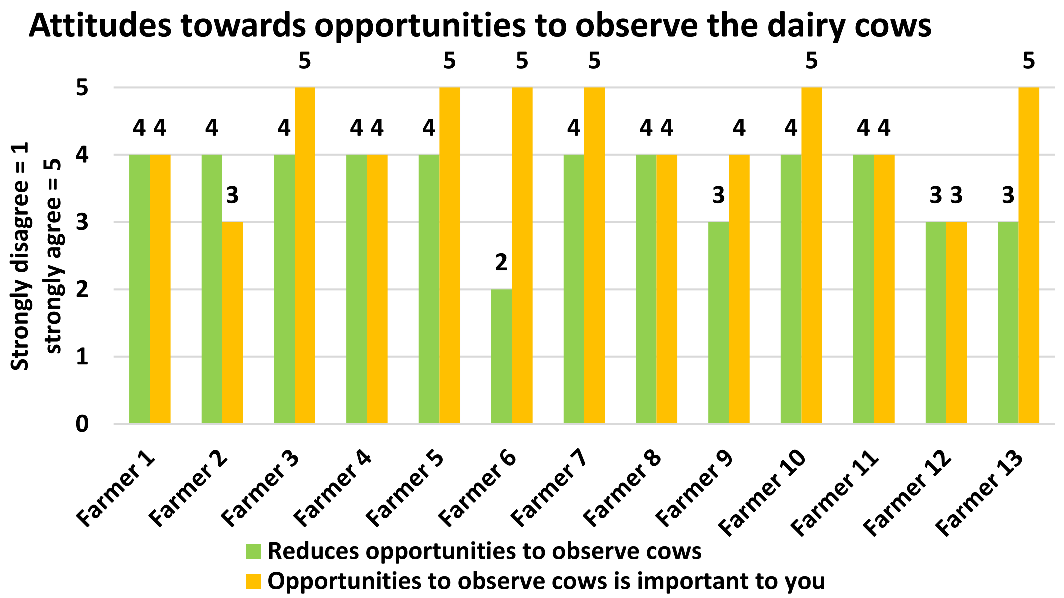

Figure 5.43: Attitudes towards opportunities to observe the dairy cows

Opportunities to spot problems in dairy cows in a timely fashion was important to all the farmers, six believed that AMS would reduce the opportunities to do so, six were neutral and one disagreed (Figure 5.44).

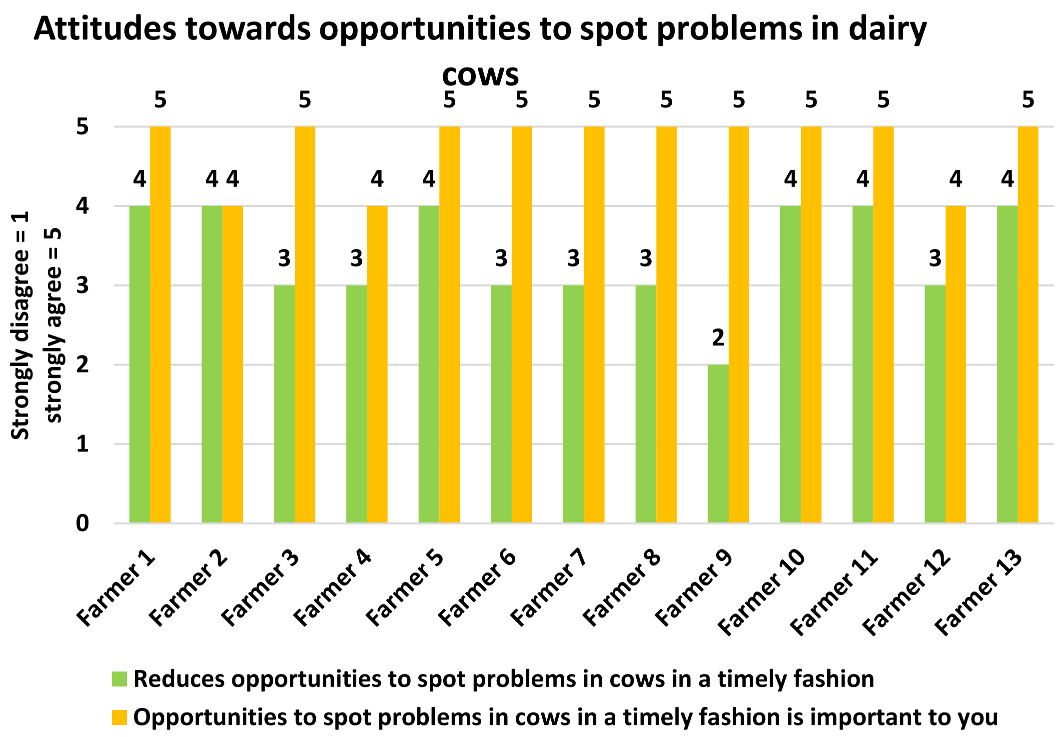

Figure 5.44: Attitudes towards opportunities to spot problems in dairy cows

Reduced rates of mastitis were important for 12 farmers. Seven believed that AMS would provide this (Figure 5.45).

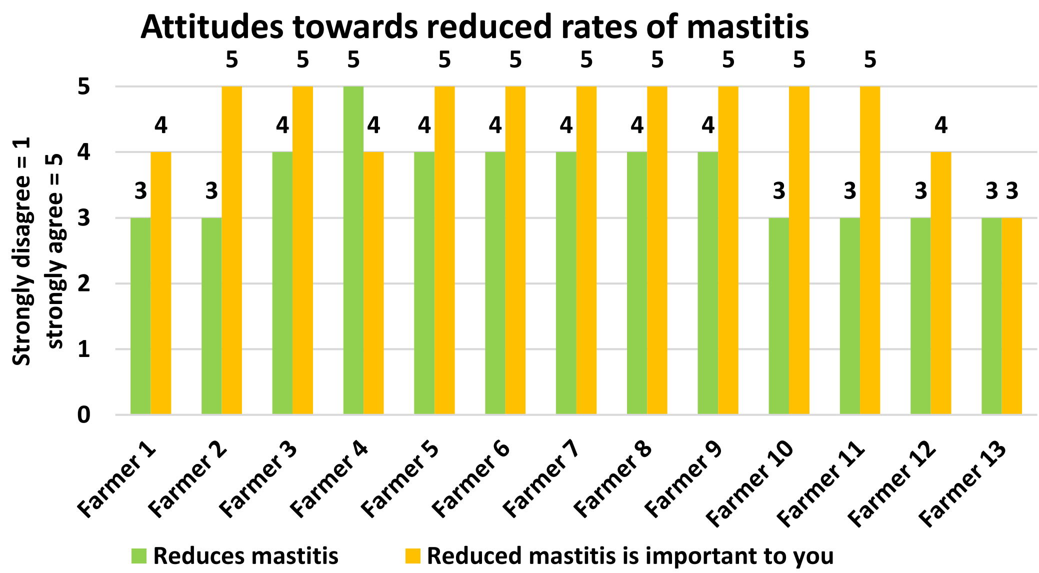

Figure 5.45: Attitudes towards reduced rates of mastitis

Reduced rates of lameness were important for 12 farmers, with 10 believing that AMS would provide this (Figure 5.46).

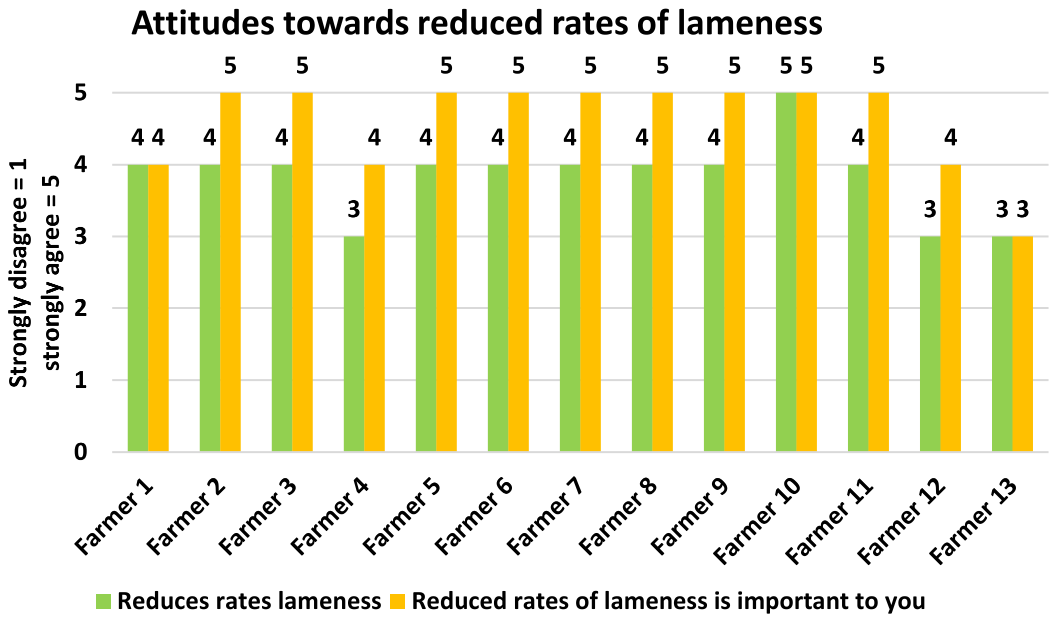

Figure 5.46: Attitudes toward reduced lameness

Animal health and welfare was important to all the farmers, with most indicating that AMS provides the opportunity for cows to be treated as individuals rather than a herd (Figure 5.47). Most of the farmers believed that AMS would reduce the rates of lameness. Some thought it would also reduce the rates of mastitis (Table 5.7).

Table 5.7: Total value of herd health and animal welfare factors

Animal health and welfare factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Better animal welfare	16	15	20	16	20	25	20	10	20	20	15	12	20	**229**
Relaxed cows	16	20	20	16	20	25	20	20	16	15	15	12	10	**225**
Treating cows as individuals	16	16	20	16	20	25	20	20	12	15	16	12	25	**233**
Reducing opportunities to observe cows	16	12	20	16	20	10	20	16	12	20	16	9	15	**202**
Reduced opportunities to spot problems in cows in a timely fashion	20	16	15	12	20	15	15	15	10	20	20	12	20	**210**
Reduced rates of mastitis	12	15	20	20	20	20	20	20	20	15	15	12	9	**218**
Reduce rates of lameness	16	20	20	12	20	20	20	20	20	25	20	12	9	**234**

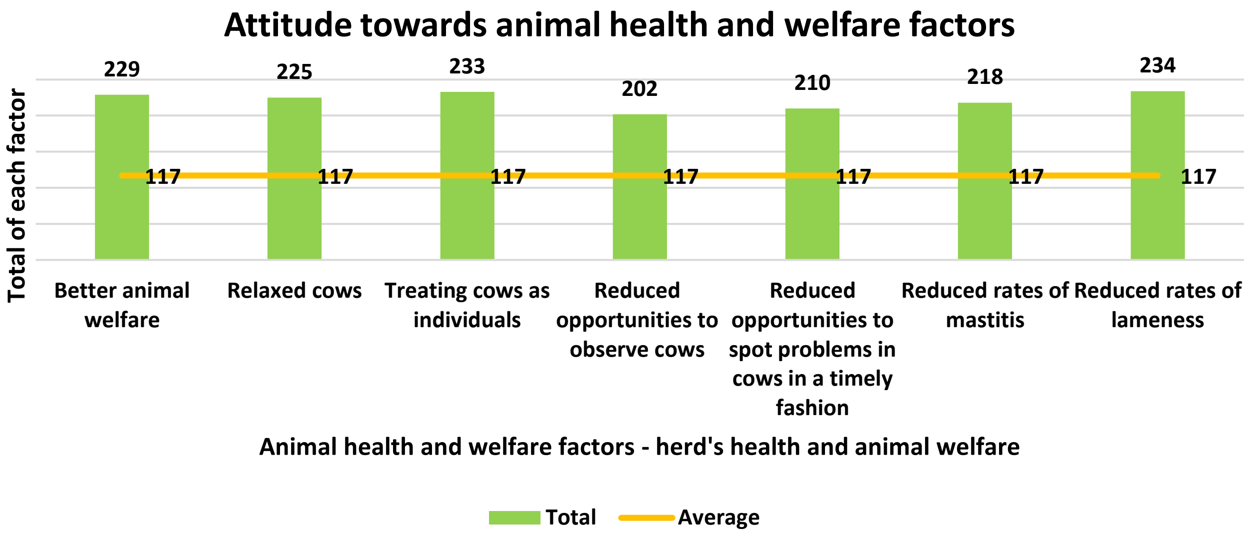

Figure 5.47: Total value of herd health and animal welfare factors

The herd data management section focused on the detailed data and information that AMS provides for the management of individual cows, the better record of individual milk production, quality, feed intake, and the impact of this data: the ability to make better decisions related to individual dairy cows and at the farm level.

More detailed data and information for individual cow management was important for nine farmers. All of them agreed that AMS would provide this (Figure 5.48).

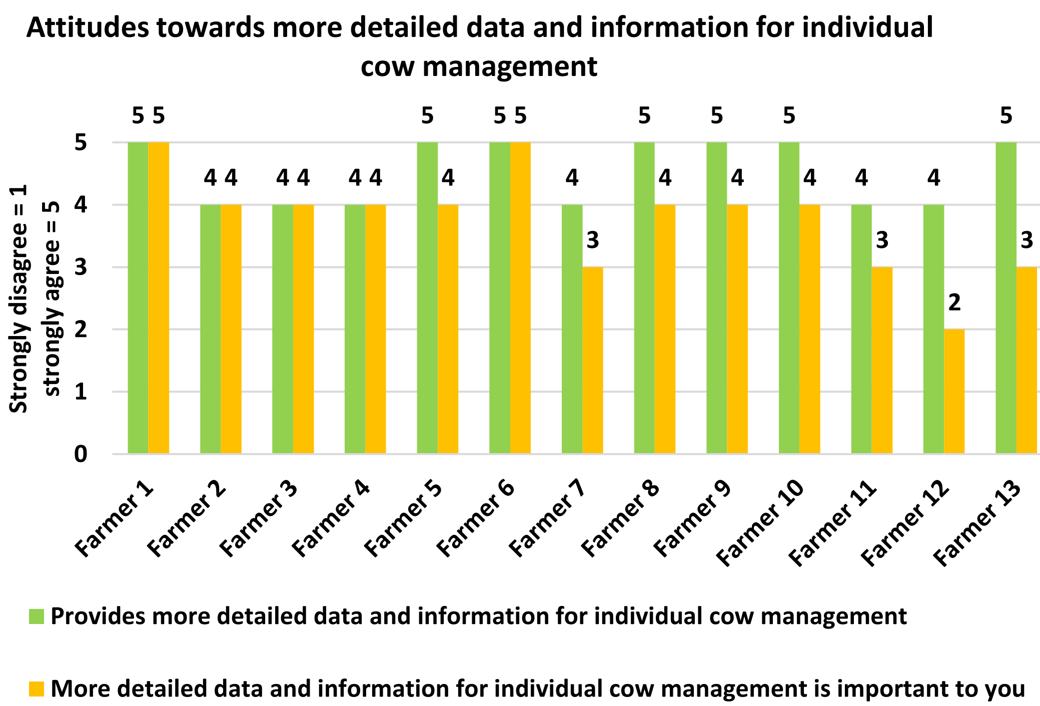

Figure 5.48: Attitudes towards more detailed data and information for individual cow management

A better record of individual milk production was important for seven farmers. All the farmers agreed that AMS would provide this (Figure 5.49). This was the same for a better record of individual milk quality (Figure 5.50).

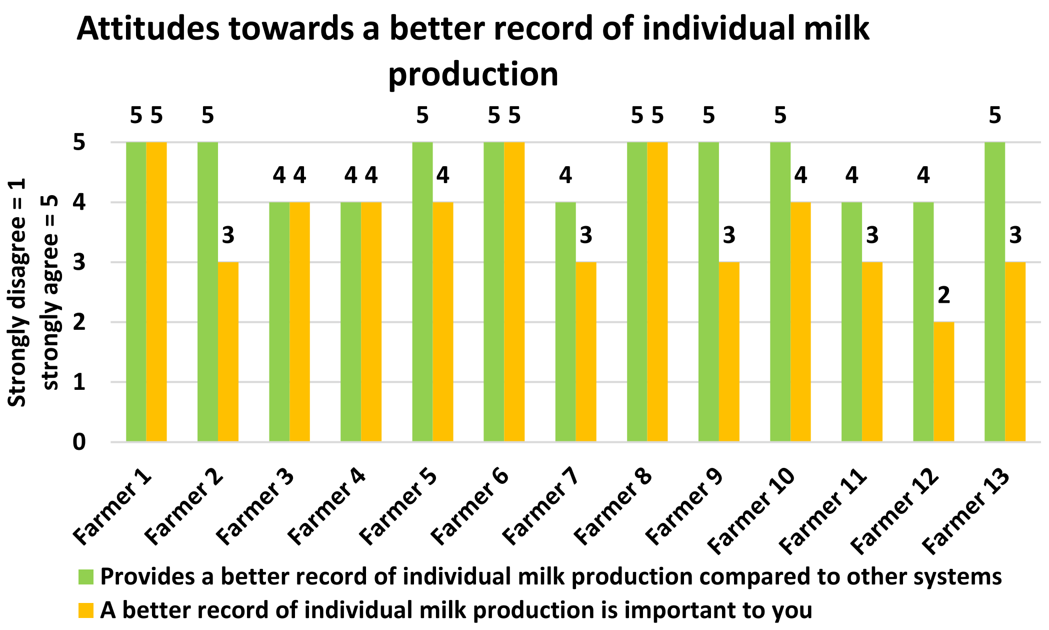

Figure 5.49: Attitudes towards a better record of individual milk production

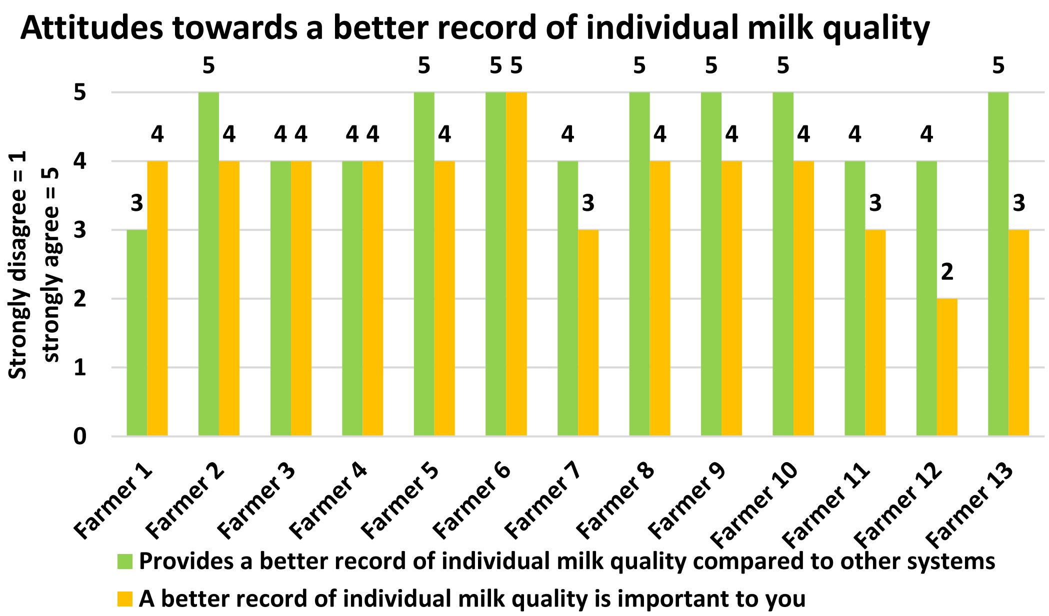

Figure 5.50: Attitudes towards a better record of individual milk quality

A better record of individual cow feed intake was important for eight farmers. Four stated that they were neutral. Eleven of the farmers agreed that AMS would provide this (Figure 5.51).

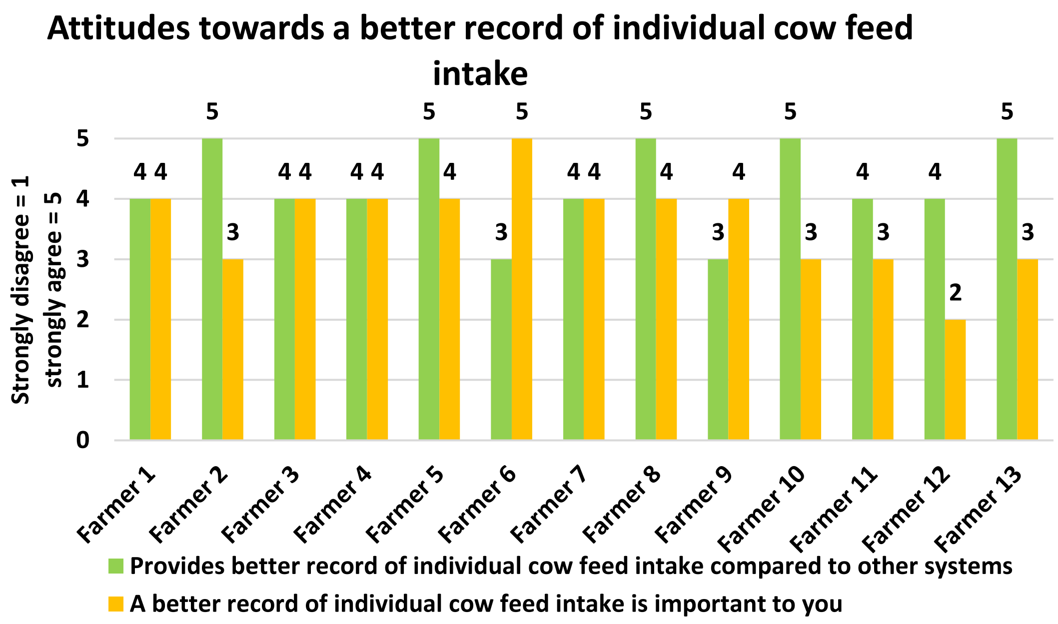

Figure 5.51: Attitudes towards a better record of individual cow feed intake

A better opportunity for individual feeding of cows was important for five. Five farmers were neutral. Eleven farmers agreed AMS would provide this (Figure 5.52).

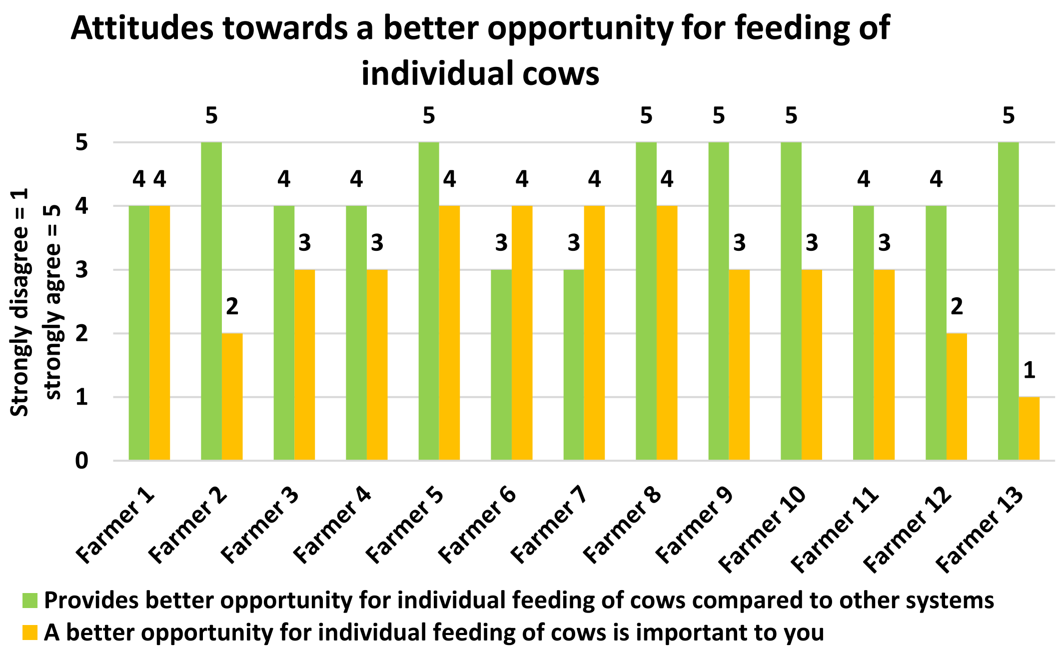

Figure 5.52: Attitudes towards a better opportunity for individual feeding of cows

Better decision making for individual cows was important for seven farmers. Six reported being neutral. Twelve of them agreed that AMS would provide this (Figure 5.53).

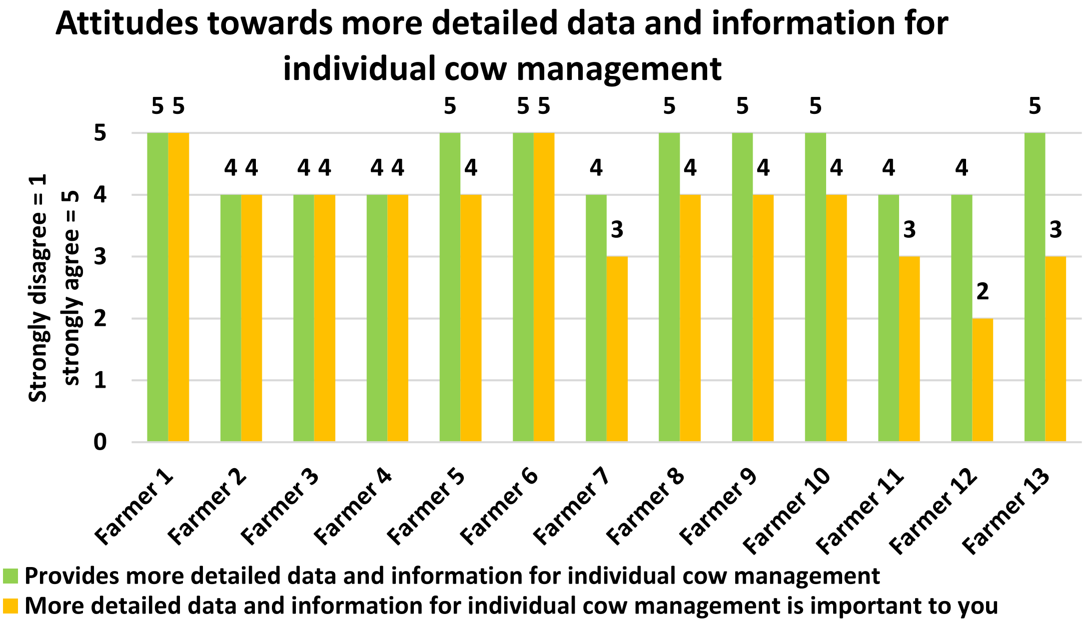

Figure 5.53: Attitudes towards better decision making for individual cow

Better decisions making at the farm level was important for 12 farmers. The rest stated that this was not important. Five farmers agreed that AMS would provide this. Six of them were neutral (Figure 5.54).

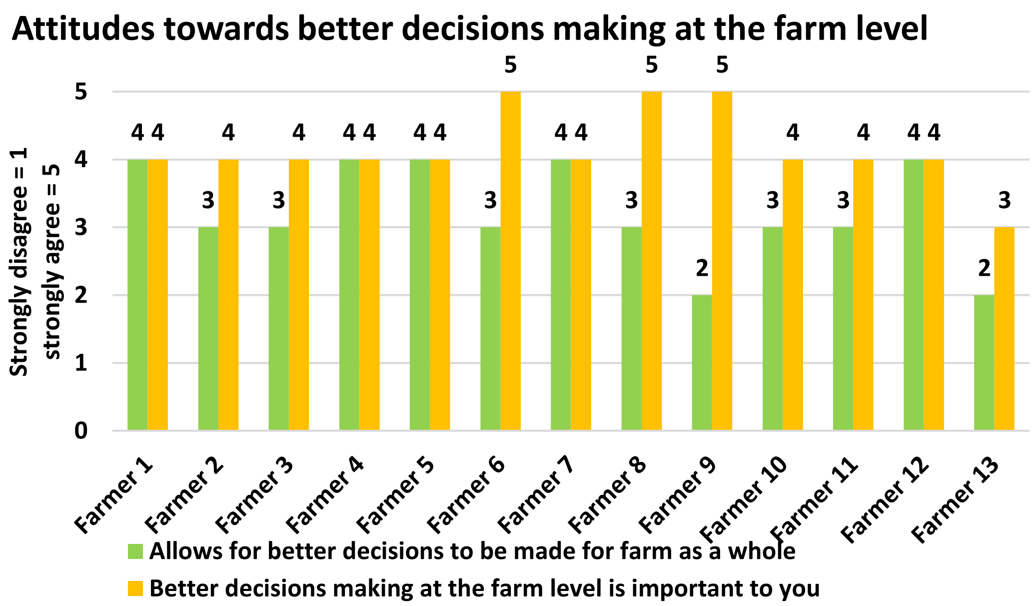

Figure 5.54: Attitudes towards better decisions making at the farm level

Better decision making at the farm level was most important factor for 12 farmers; however, farmers were divided on whether AMS would provide this (Figure 5.55). None of them disagreed that AMS provides farmers with benefits related to herd data management except for better decisions making at the farm level (Table 5.8).

Table 5.8: Total value of herd data management factors

Animal health and welfare factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Provides more detailed data and information for individual cow management	25	16	16	16	20	25	12	20	20	20	12	8	15	225
Provides a better record of individual milk production compared to other systems	25	15	16	16	20	25	12	25	15	20	12	8	15	224
Provides a better record of individual milk quality compared to other systems	12	20	16	16	20	25	12	20	20	20	12	8	15	216
Provides a better record of individual cow feed intake compared to other systems	16	15	16	16	20	15	16	20	12	15	12	8	15	196
Provides a better opportunity for feeding individual cows compared to other systems	16	10	12	12	20	12	12	20	15	15	12	8	5	169
Allows for better decisions to be made for individual cows	16	12	12	16	25	20	16	16	12	15	12	12	12	196
Allowing for better decisions to be made for farm as a whole	16	12	12	16	16	15	16	15	10	12	12	16	6	174

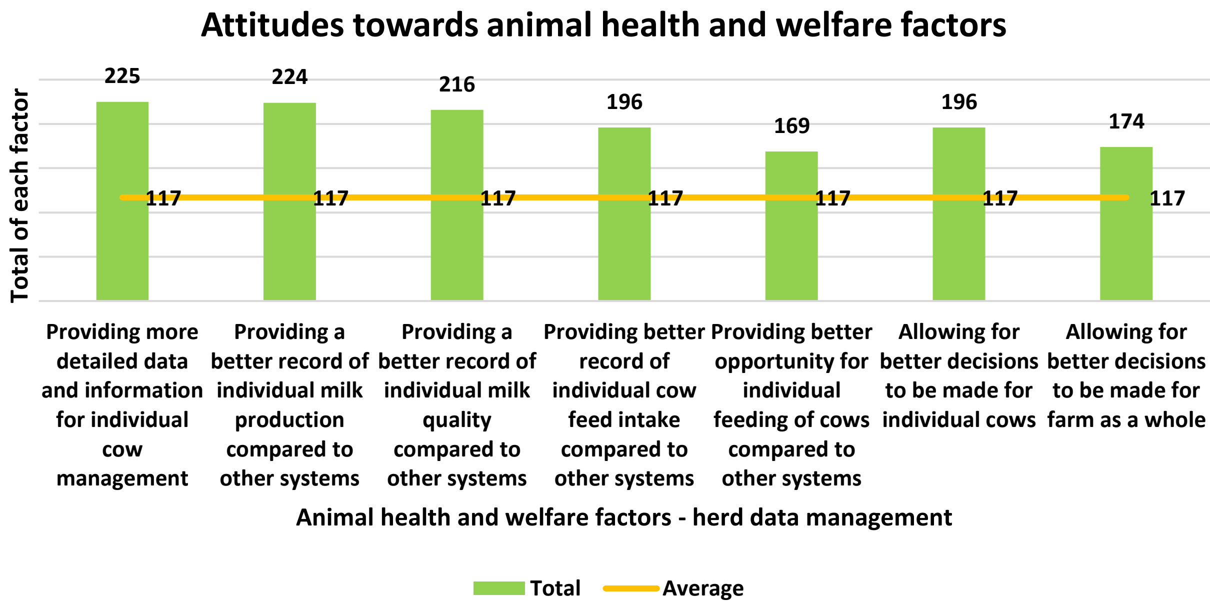

Figure 5.55: Total value of herd data management factors

The technology section focused on social factors: family history, new technologies, automation in farming system, and a new experience and challenges.

One farmer stated that family history was not applicable. Five indicated that it was important. While three farmers stated that it was not important, the rest were neutral. Three of them agreed. The rest of them were equally neutral or disagreed that family had been at the forefront for adoption of new technologies (Figure 5.56).

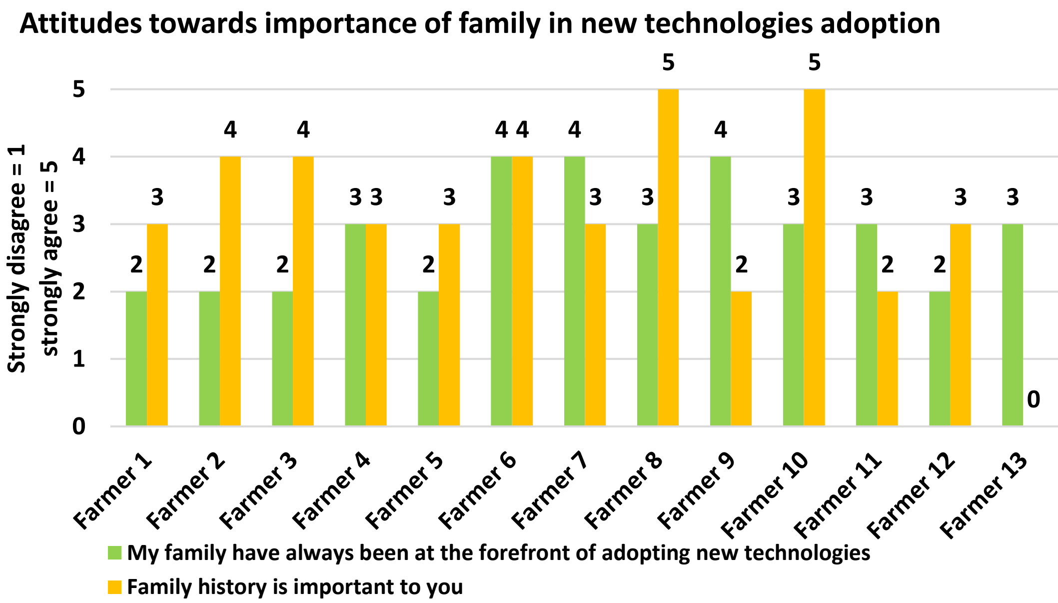

Figure 5.56: Attitudes towards importance of family in adoption of new technologies

While five of the farmers stated that new technology was important to them, five were neutral and three stated that it was unimportant. Ten of them agreed that AMS is a useful new technology (Figure 5.57).

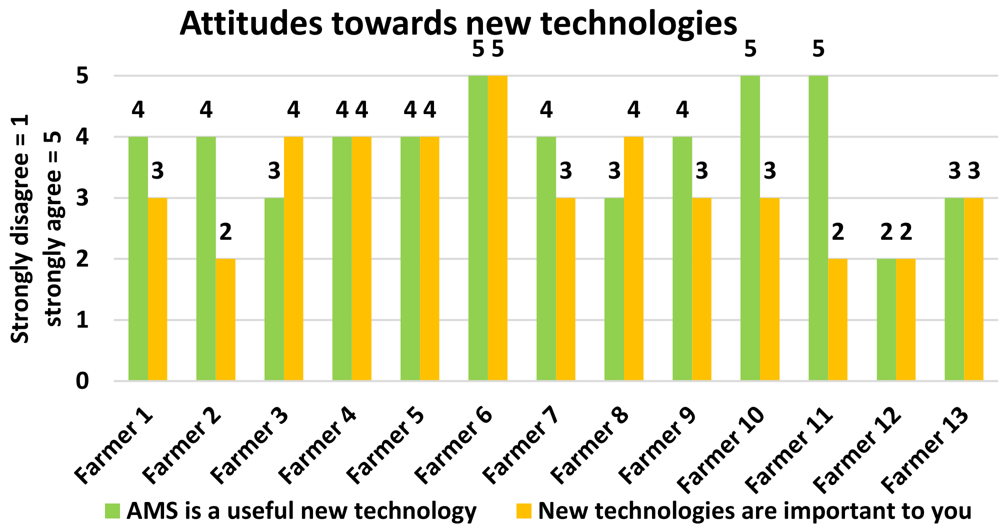

Figure 5.57: Attitudes towards new technologies

Only four farmers thought that automation within the dairy farming system was important. Five were neutral. Four of the farmers indicated that this was unimportant. While nine agreed that AMS would provide this, three were neutral and one disagreed (Figure 5.58).

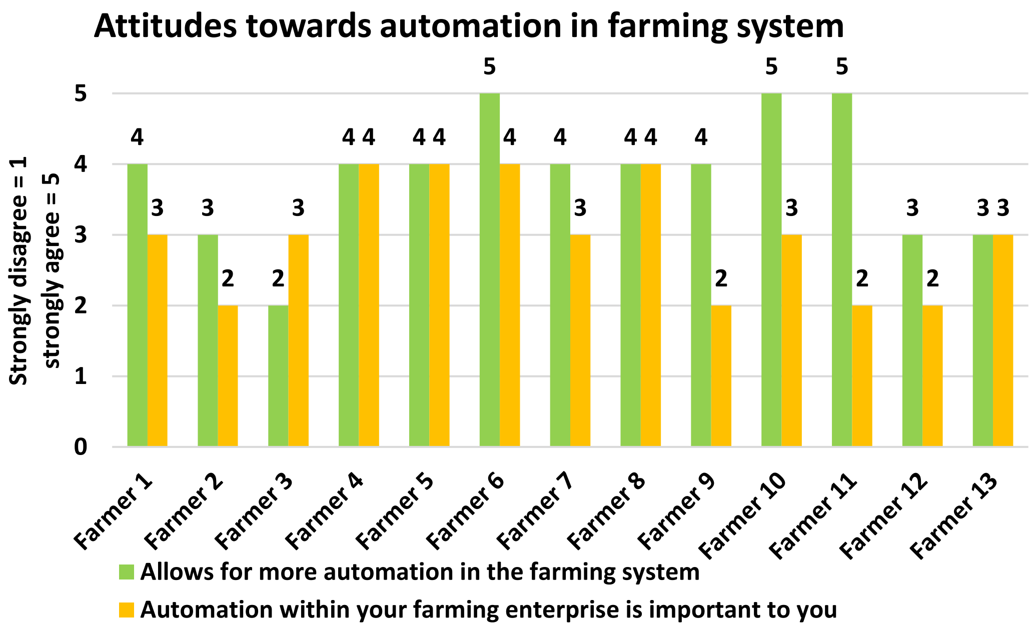

Figure 5.58: Attitudes towards automation in farming system

While a new experience and/or challenges were important for 10 farmers, the rest were neutral. Twelve agreed that AMS would provide a new challenge. The rest were neutral (Figure 5.59).

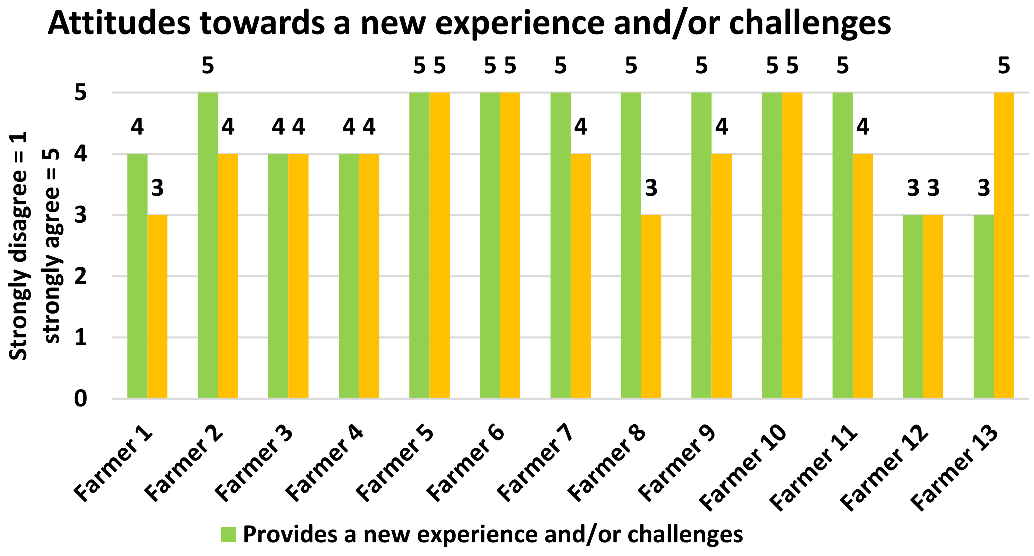

Figure 5.59: Attitudes towards a new experience and challenges

While a new experience and/or challenges was important for most of the farmers, automation in the farming system and new technology were seen as less important (Figure 5.60). Ten farmers agreed that AMS would provide a challenge/new experience, slightly less agreed that AMS is a useful technology which provides automation in the farming system (Table 5.9).

Table 5.9: Total value of technology factors

Animal health and welfare factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Importance of family in technology adoption	6	8	8	9	6	16	12	15	8	15	6	6	0	115
New technologies	12	8	12	16	16	25	12	12	12	15	10	4	9	163
Automation in the farming system	12	6	6	16	16	20	12	16	8	15	10	6	9	152
A new experience and/or challenges	12	20	16	16	25	25	20	15	20	25	20	9	15	238

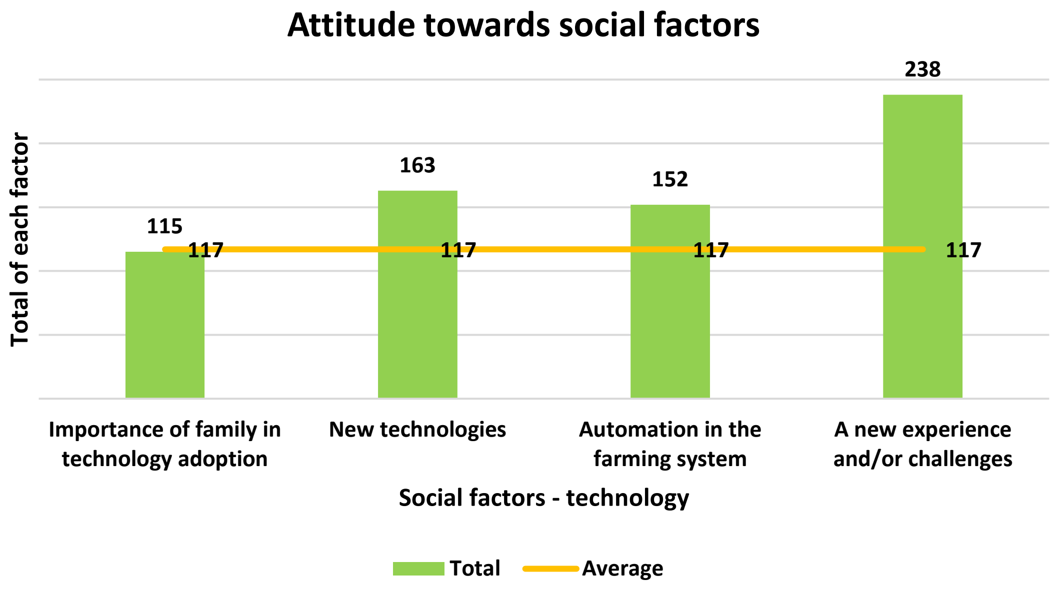

Figure 5.60: Total value of technology factors

5.2.2 Summary of results from attitude section

The factors that were important for all of the farmers came from all three categories: social, economic, and animal health and welfare (Table 5.10). These factors were freeing up time, more flexible working hours and days, improved profit and financial returns, better animal welfare, more relaxed/calm cows, and opportunities to spot problems in cows in a timely fashion. Most of the farmers agreed that AMS provides these benefits, with the exception of freeing up time and reduced opportunities to spot problems in cows in a timely fashion.

The factors which were important for most of the farmers (the rest were neutral or said they were unimportant), were a better lifestyle, better working conditions, decision making at the farm level, reduced rates of mastitis and lameness, a more relaxed operating system, treating cows as individuals, opportunities to observe cows, attractive to future generation, less working hours and days, improvements in milk quality, an increase in the resale value of the farm, reduced labour, milking shed operation and servicing costs, having a new experience, reduced labour requirements, more detailed data for individual cow management, a better record of individual milk quality, production, and feed intake, more up-to-date working conditions, help with labour requirements, less physical work, an increase in milk production, and better decision making for individual cows. Most of the farmers agreed that AMS would provide these benefits, with the exception of improved profits and financial returns, reduced labour, milking shed operation and servicing costs, increased farm resale value, less working days, a better lifestyle and decision making at the farm level, freeing up time, and a more relaxed operating system.

Table 5.10: Social, economic, and animal health and welfare factors

Type of factor	Factor	Score	Description
Social	New experiences/challenges	238	It was important for 10 farmers. Three were neutral. Eleven agreed that AMS would provide this. None disagreed. Two neutral.
Animal health and welfare	Reduced rates of lameness	234	It was important for 12 farmers. One was neutral. Eleven farmers agreed that AMS would provide this. None disagreed. Two were neutral that AMS would provide this.
Animal health and welfare	Treating cows as individuals	233	It was important for 11 farmers. Two were neutral. Twelve farmers agreed that AMS would provide this. None disagreed and one was neutral.
Animal health and welfare	Better animal welfare	229	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed, and three neutral.
Animal health and welfare	More relaxed/calm cows	225	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Animal health and welfare	A better record of individual milk production	224	It was important for seven. Five were neutral and one stated that it was unimportant. All agreed that AMS would provide this.
Social	Attractive to future generations	219	It was important for 10. Three farmers were neutral. Nine agreed that AMS would provide this. None disagreed and four were neutral.
Animal health and welfare	Reduced rates of mastitis	218	It was important for 12 farmers. One farmer was neutral. Seven farmers agreed that AMS would provide this. None disagreed and six were neutral.
Animal health and welfare	A better record of individual milk quality	216	It was important for nine, neutral for three, unimportant for one farmer. 11 agreed, none disagreed, one neutral that AMS would provide this.
Animal health and welfare	Reduced opportunities to spot problems in cows in a timely fashion	210	It was important for all the farmers. Six agreed that AMS would provide this. One disagreed and six were neutral that AMS would provide this.
Economic	Improvements in milk quality	206	It was important for 10. Two were neutral and one farmer reported that it was unimportant. Seven agreed that AMS would provide this. None disagreed. Six were neutral.
Social	More flexible working days	202	It was important for all the farmers. Eight agreed that AMS would provide this. Two disagreed, and three were neutral.
Animal health and welfare	Opportunities to observe cows	202	It was important for 11. Two farmers were neutral. Nine farmers agreed that AMS would provide this. One disagreed and three were neutral.
Social	More flexible working hours	201	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed that AMS would provide this. Three were neutral.

Table 5.11: Social, economic, and animal health and welfare factors (cont.)

Type of factor	Factor	Score	Description
Animal health and welfare	More detailed data and information for individual cow management	196	It was important for nine farmers. Three were neutral and one farmer stated that it was unimportant. All agreed that AMS would provide this.
Animal health and welfare	A better record of individual cow feed intake	196	It was important for eight farmers. Four were neutral and one famer stated that it was unimportant. Eleven farmers agreed that AMS would provide this. None disagreed and two neutral.
Animal health and welfare	Better decision making for individual cows	196	It was important for seven farmers. Six were neutral. Twelve famers agreed that AMS would provide this. None disagreed and one was neutral.
Social	Less working hours	191	It was important for 10 farmers. Three were neutral. Six agreed that AMS would provide this. One disagreed and six were neutral.
Social	Better working conditions	190	It was important for 10 farmers. Three farmers were neutral. Eight agreed that AMS would provide this. One disagreed and four were neutral.
Social	Reduced requirement for labour	190	It was important for nine farmers. Four were neutral. Seven farmers agreed that AMS would provide this. None disagreed and six were neutral.
Social	Better lifestyle	188	It was important for 12 farmers. One farmer was neutral. Four agreed that AMS would provide this. One disagreed and eight were neutral.
Social	Free up time	183	It was important for all the farmers. Five agreed, three disagreed, and five were neutral that AMS would provide this.
Social	Shift in tasks	182	It was important for four farmers. Seven were neutral and two stated that it was unimportant. All agreed that AMS would provide this.
Social	More relaxed operating system	177	It was important for 11 farmers. Two were neutral. Five agreed that AMS would provide this. Three disagreed and five were neutral.
Social	More up-to-date working conditions	175	It was important for eight farmers. Two were neutral and three farmers stated that this was unimportant for three farmers. Ten agreed that AMS would provide this. None of them disagreed and three were neutral.
Animal health and welfare	Better decisions making at the farm level	174	It was important for 12 farmers. One farmer was neutral. Five agreed that AMS would provide this. Two disagreed, and six were neutral.
Animal health and welfare	A better opportunity for individual feeding of cows	169	It was important for five farmers. Five were neutral and three farmers stated that it was unimportant. Eleven agreed that AMS would provide this. None disagreed and two were neutral.

Table 5.12: Social, economic, and animal health and welfare factors (cont.)

Type of factor	Factor	Score	Description
Social	Help with labour requirements	167	It was important for eight farmers. Five farmers were neutral. Six farmers agreed that AMS would provide this. Four disagreed and three were neutral.
Economic	Reduced labour costs	163	It was important for 10 farmers. Two were neutral and one farmer stated that it was unimportant. Five agreed that AMS would provide this. Four disagreed and four were neutral.
Social	Useful new technologies	163	It was important for five farmers. Five were neutral and three stated that it was unimportant. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Social	Less physical work	155	It was important for seven farmers. Four were neutral and two farmers stated that it was unimportant. Seven agreed that AMS would provide this. Three disagreed and three were neutral.
Economic	Increased milk production	155	It was important for seven farmers. Two were neutral and four farmers stated that it was unimportant. Four agreed that AMS would provide this. One disagreed and eight were neutral.
Social	Automation within farming enterprise	152	It was important for four farmers. Five were neutral and four farmers stated that it was unimportant. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Social	Less working days	149	It was important for eight farmers. Five farmers were neutral. Three agreed that AMS would provide this. Three disagreed and seven were neutral.
Economic	Improved profits	144	It was important for all the farmers. None agreed that AMS would provide this. Seven disagreed and six were neutral.
Economic	Improved financial returns	135	It was important for all the farmers. One agreed that AMS would provide this. Nine disagreed and three were neutral.
Social	Help with succession planning	129	It was important for eight farmers. Six were neutral and one farmer stated that it was unimportant. Two agreed that AMS would provide this. Six disagreed and five were neutral.
Economic	Reduced milking shed operation costs	117	It was important for eight farmers. Four were neutral and one farmer stated that it was not important. One agreed that AMS would provide this. Nine disagreed and three were neutral.

Table 5.13: Social, economic, and animal health and welfare factors (cont.)

Type of factor	Factor	Score	Description
Economic	Increase the resale value of the farm	117	It was important for 10 farmers. Two stated that it was unimportant, and it was not applicable for one farmer. Two farmers agreed that AMS would provide this. Seven disagreed and four were neutral.
Social	Family history	115	It was important for five farmers. Four were neutral five and two stated that it was unimportant. One reported that it was not applicable.
Economic	Reduced milking shed servicing/maintenance costs	85	It was important for nine farmers. Two were neutral and two farmers stated that it was unimportant. No farmers agreed that AMS would provide this. Twelve disagreed and one was neutral.

5.2.3 Results from subjective norm

The results from the subjective norm section of the interview helped to identify the individuals who had the most influence on the interviewed farmers in terms of decision making related to technology adoption. This covered the other individuals' beliefs and whether or not they influenced the respondent and the extent of that influence. Individuals were those directly and indirectly related to the farmers and their farm business.

Only one farmer agreed that his spouse/partner thought he should install AMS on the farm, but he was neutral on whether he should install AMS (Figure 5.61).

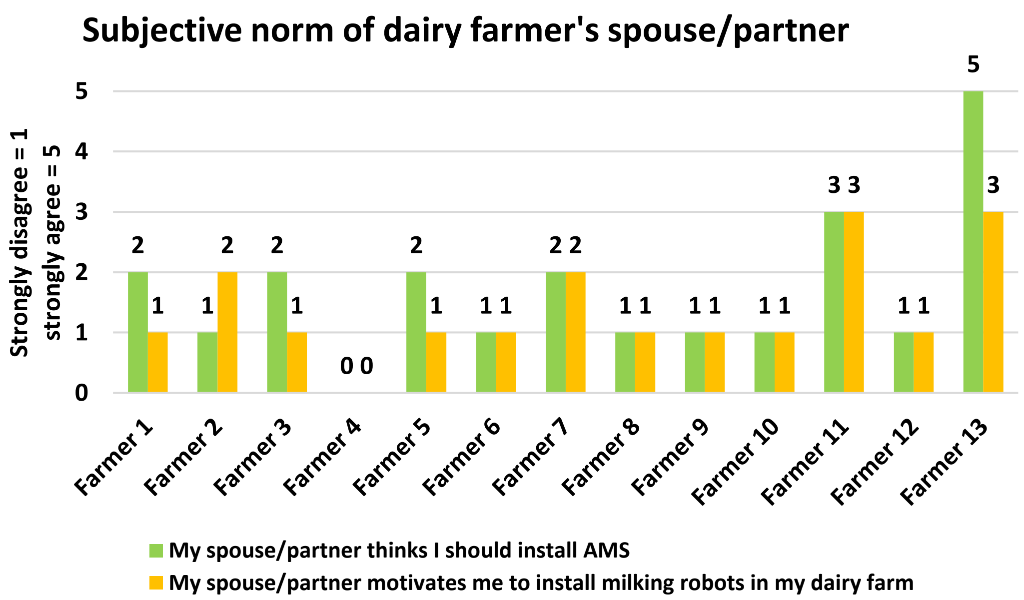

Figure 5.61: Subjective norm of dairy farmer's spouse/partner

None of the farmers agreed that their children thought they should install AMS, nor were they motivated by them to do so (Figure 5.62).

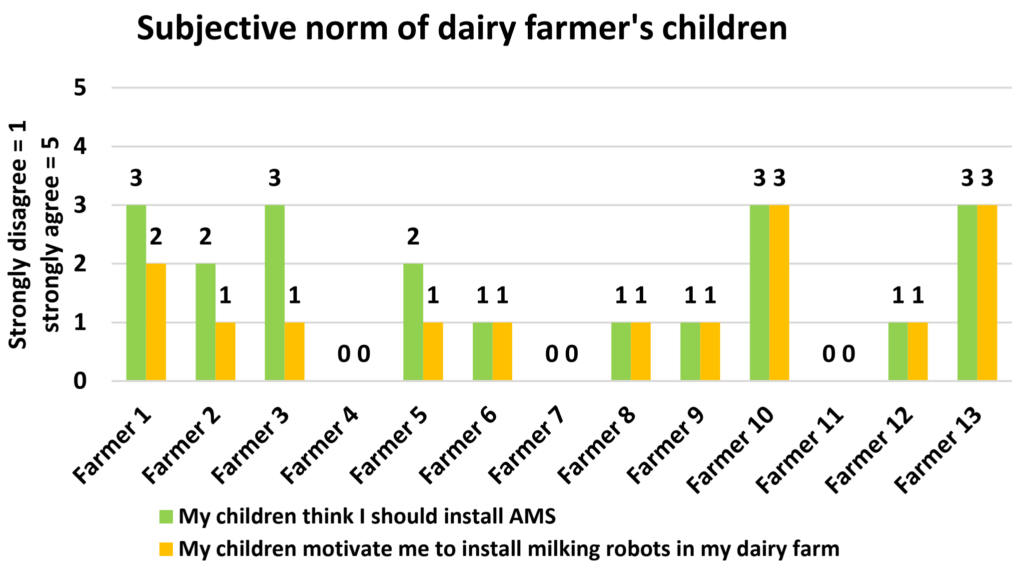

Figure 5.62: Subjective norm of dairy farmer's children

Only one farmer agreed that other family members though he should install AMS. None of the farmers agreed that other family members motivated them to install AMS (Figure 5.63).

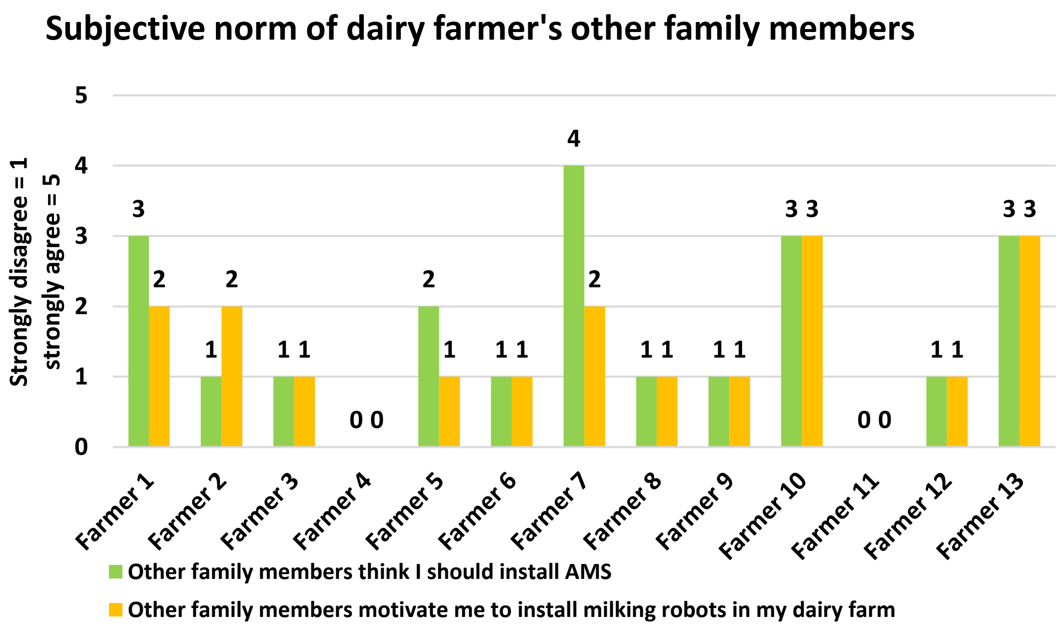

Figure 5.63: Subjective norm of dairy farmer's other family members

Two farmers agreed that their staff thought they should install AMS, but none of them agreed that farm staff motivated them to install AMS (Figure 5.64).

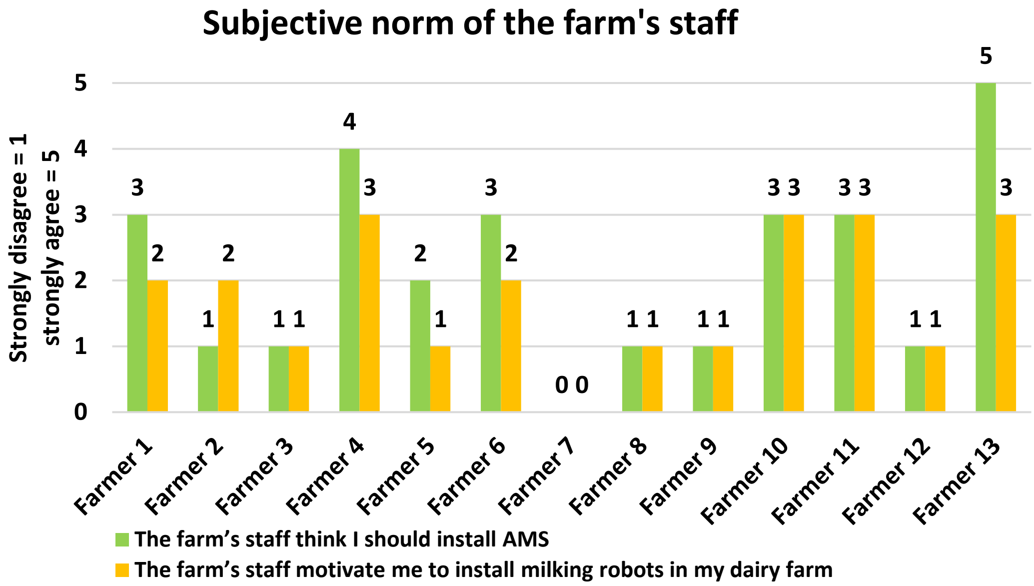

Figure 5.64: Subjective norm of the farm's staff

While three farmers agreed that other dairy farmers with AMS thought they should install AMS, none of them agreed that dairy farmers with AMS motivated them to install AMS (Figure 5.65).

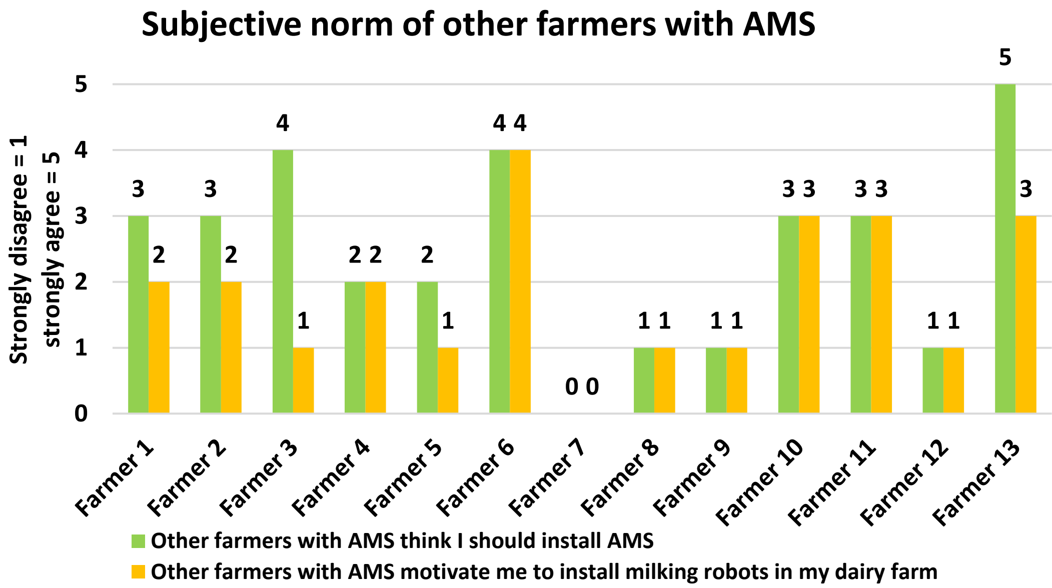

Figure 5.65: Subjective norm of other farmers with AMS

None of the farmers agreed that other dairy farmers without AMS thought they should install AMS, nor did they motivate them to do so (Figure 5.66).

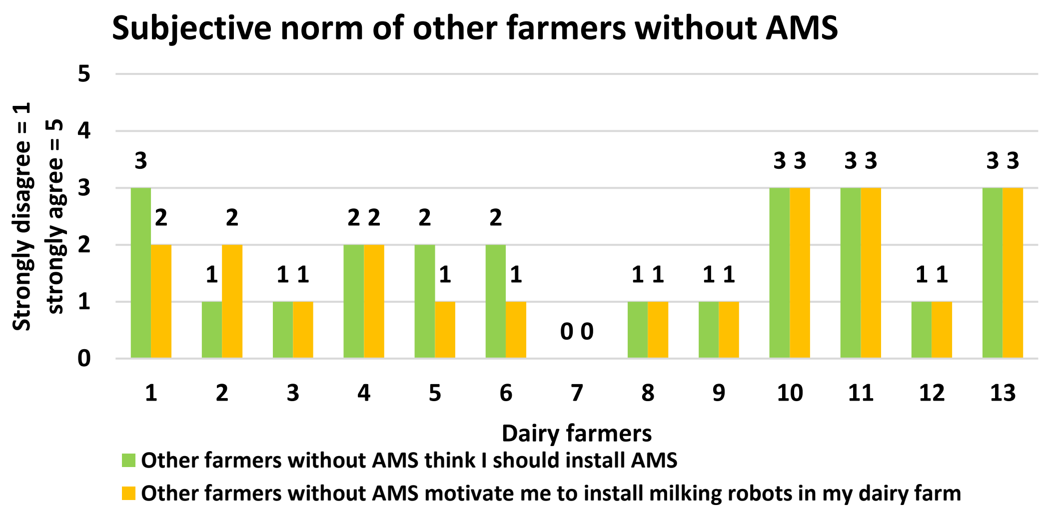

Figure 5.66: Subjective norm of other farmers without AMS

None of the farmer agreed that the milk processor thought they should install AMS, nor did they motivate them to do so (Figure 5.67).

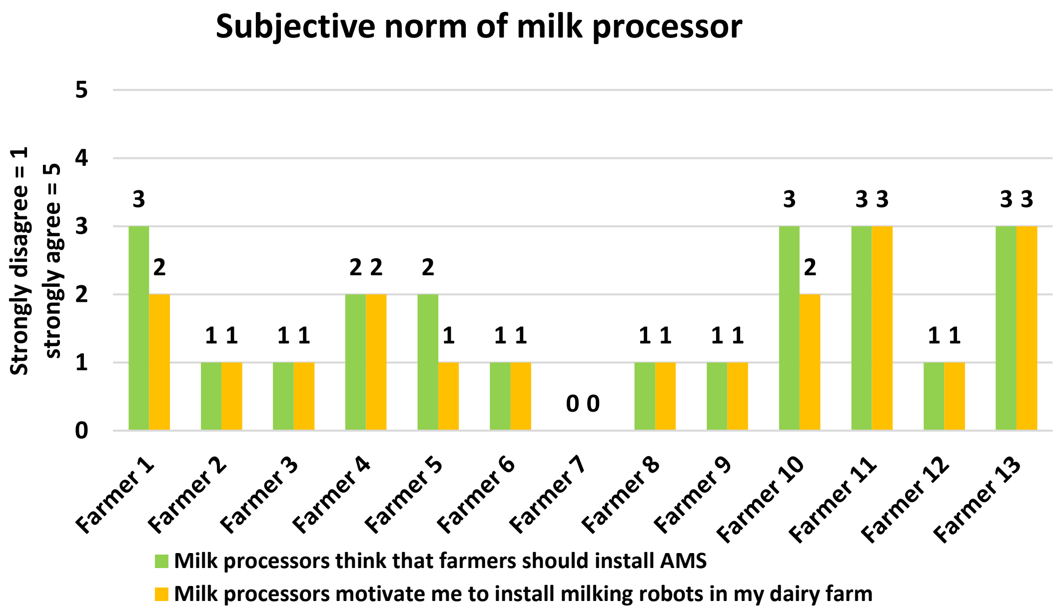

Figure 5.67: Subjective norm of the milk processor

None of the farmers agreed that good industry bodies thought they should install AMS, nor did they motivate them to do so (Figure 5.68).

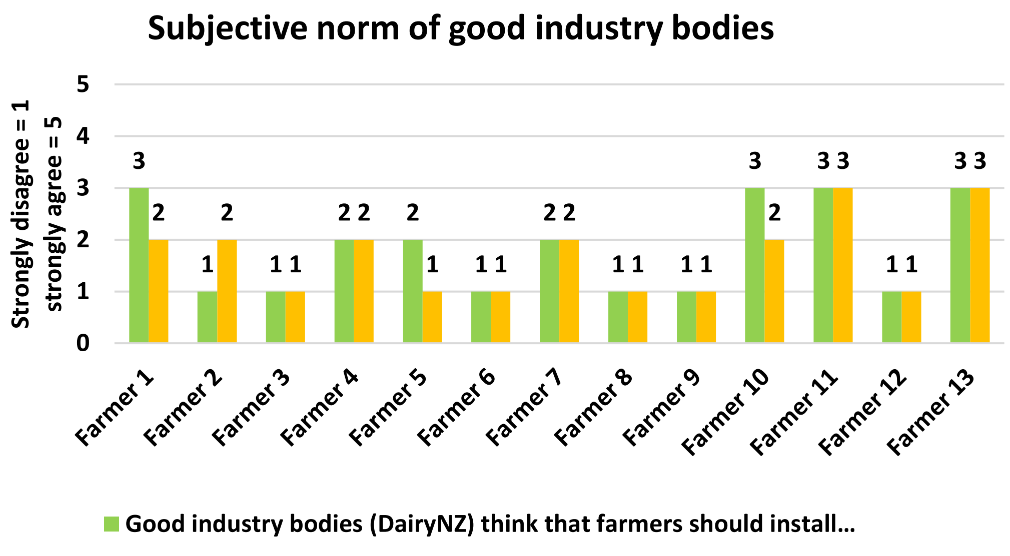

Figure 5.68: Subjective norm of good industry bodies

None of the farmers agreed that private consultants thought they should install AMS, nor did they motivate them to do so (Figure 5.69).

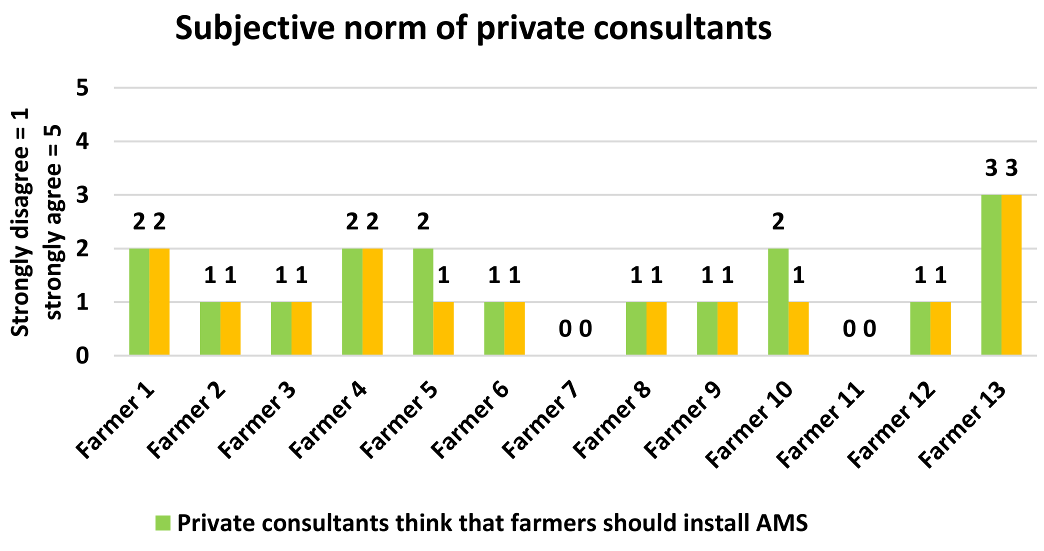

Figure 5.69: Subjective norm of private consultants

One farmer agreed that print media made him think that he should install AMS. Another farmer was motivated by print media to install AMS (Figure 5.70).

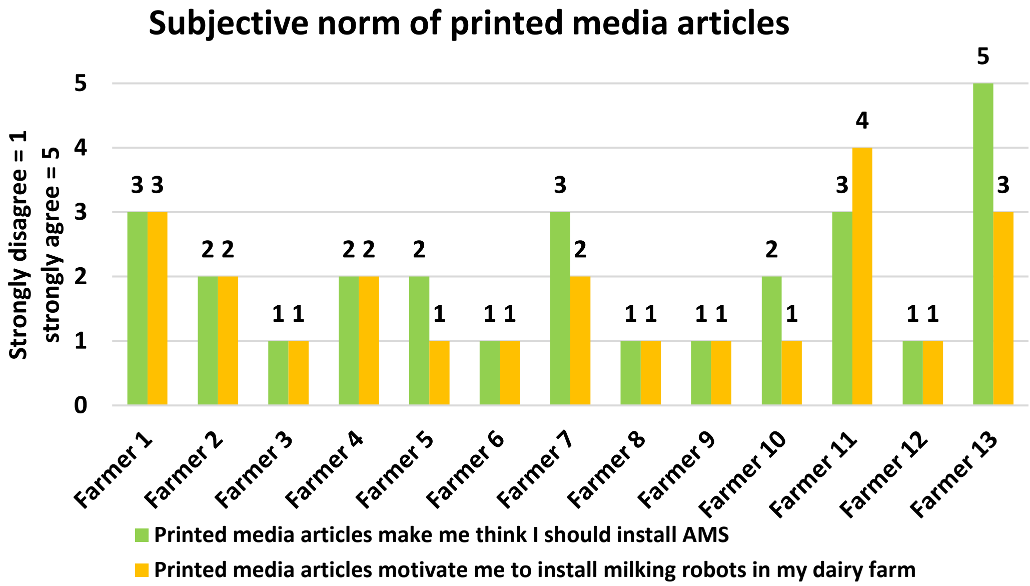

Figure 5.70: Subjective norm of printed media articles

One farmer agreed that online media made him think that he should install AMS. Another farmer was motivated by online material to install AMS (Figure 5.71).

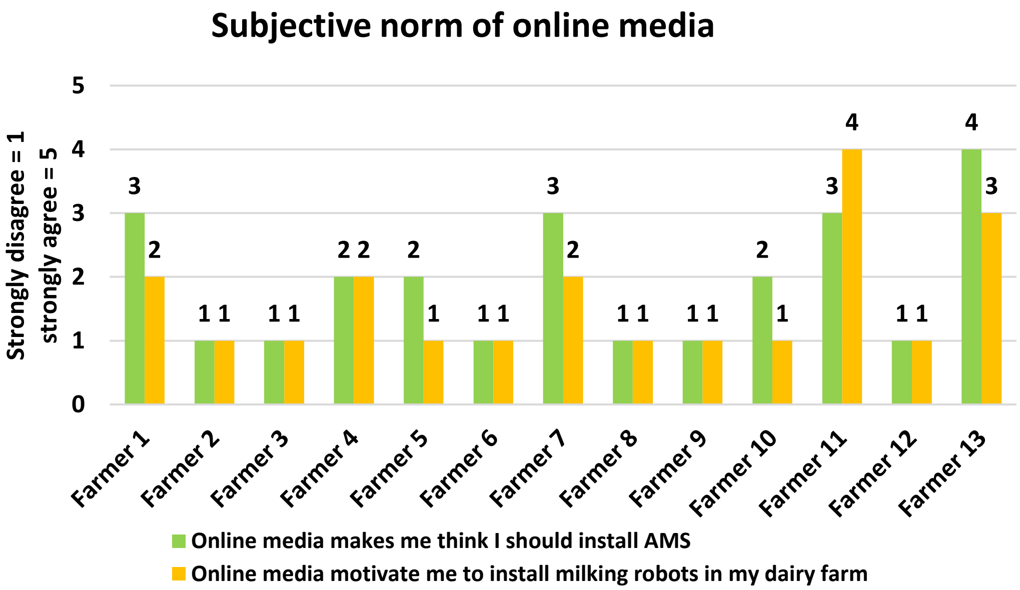

Figure 5.71: Subjective norm of online media

None of the farmers agreed that resources from good industry bodies made them think that they should install AMS. One farmer was motivated by resources from good industry bodies to install AMS (Figure 5.72).

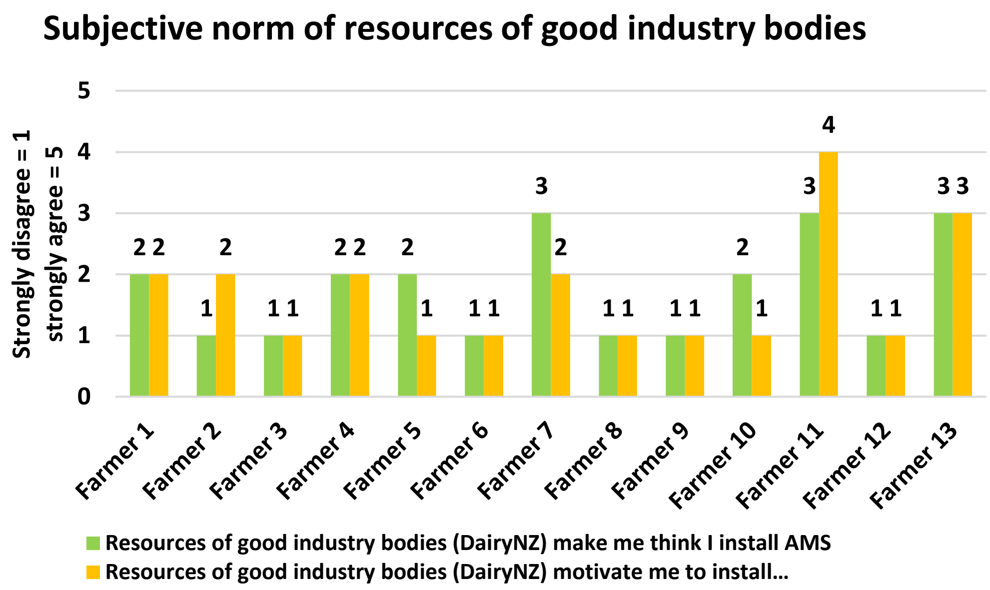

Figure 5.72: Subjective norm of resources of industry good bodies

While two farmers agreed that resources or publicity materials provided by AMS suppliers made them think they should install AMS, only one of them was motivated by them to install AMS (Figure 5.73).

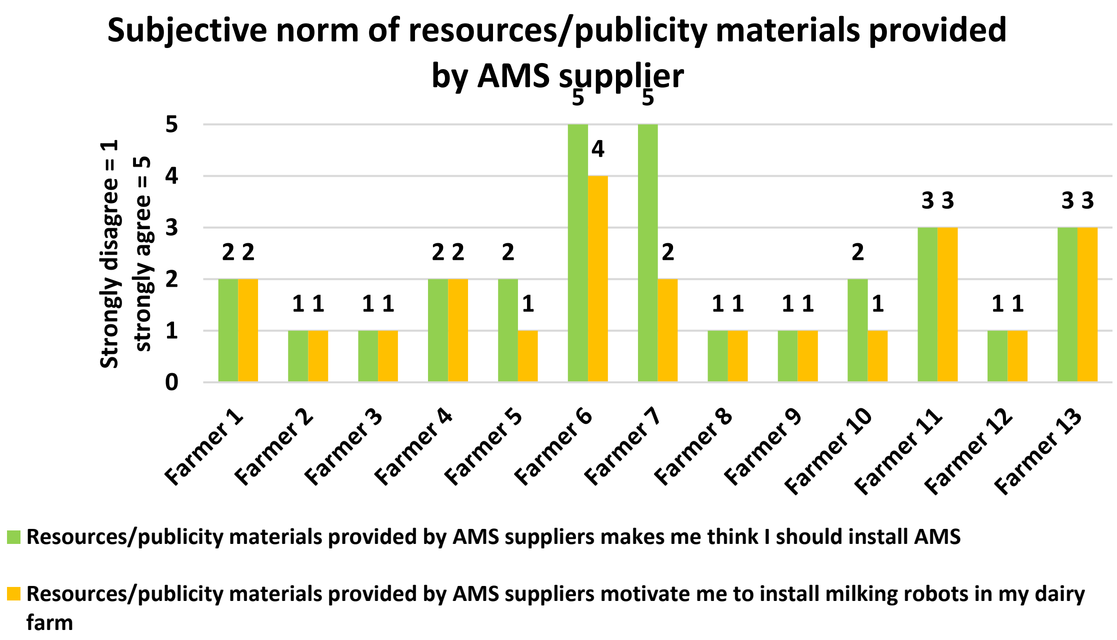

Figure 5.73: Subjective norm of resources/publicity materials provided by AMS suppliers

5.2.4 Summary of subjective norm

The results revealed that individuals, organisations, and resources had little to no influence on farmers' decisions to install AMS, both in terms of the opinions they held and the respondents' desire to be motivated by their opinions (Figure 5.74). While printed and online media sparked an interest for a couple of farmers, they had little influence on most of them in terms of adopting AMS (Table 5.11).

Table 5.14: Individuals influencing farmers' decision making about AMS adoption

Individuals	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Farmer's spouse/partner	2	2	2	0	2	1	4	1	1	1	9	1	15	**41**
Farmer's children	6	2	3	0	2	1	0	1	1	9	0	1	9	**35**
Other family members	6	2	1	0	2	1	8	1	1	9	0	1	9	**41**
Farm's staff	6	2	1	12	2	6	0	1	1	9	9	1	15	**65**
Other farmers with AMS	6	6	4	4	2	16	0	1	1	9	9	1	15	**74**
Other farmers without AMS	6	2	1	4	2	2	0	1	1	9	9	1	9	**47**
Milk processor	6	1	1	4	2	1	0	1	1	6	9	1	9	**42**
Good industry bodies	6	2	1	4	2	1	4	1	1	6	9	1	9	**47**
Private consultants	4	1	1	4	2	1	0	1	1	2	0	1	9	**27**
Printed media articles	9	4	1	4	2	1	6	1	1	2	12	1	15	**59**
Online media	6	1	1	4	2	1	6	1	1	2	12	1	12	**50**
Resources of good industry bodies	4	2	1	4	2	1	6	1	1	2	12	1	9	**46**
Resources from AMS suppliers	4	1	1	4	2	10	10	1	1	2	9	1	9	**65**

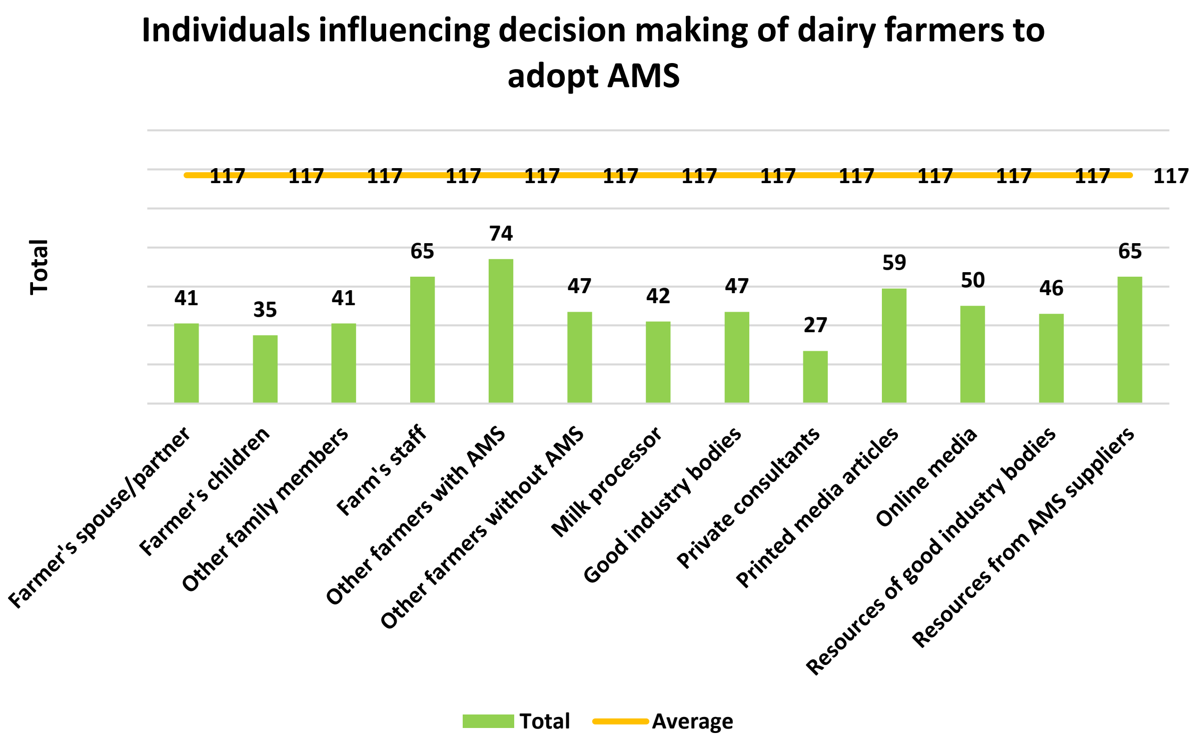

Figure 5.74: Individuals influencing farmers' decision to adopt AMS

5.2.5 Results from perceived behavioural control

This section of the interviews consisted of control beliefs and perceived power. It included the complexity of AMS to install, the capital cost of AMS, the changes required in farm layout, infrastructure, and grazing system, the implications for seasonal calving, the requirement for more skilled labour, the need for labour to be on call 24/7, ongoing support from dealers, and the requirement for more technology.

While ten farmers agreed that AMS is complex to install, two were neutral and one disagreed. Eight suggested it would be complex for them to install, one was neutral, and four disagreed (Figure 5.75).

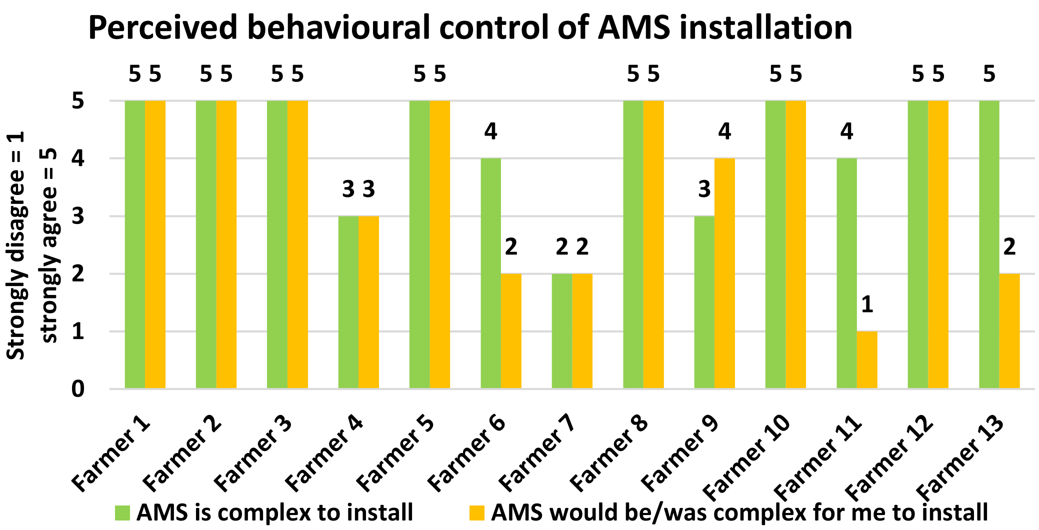

Figure 5.75: Perceived behavioural control of AMS installation

All of the farmers agreed that AMS has a high capital cost, with 11 indicating that this cost would be prohibitive (Figure 5.76).

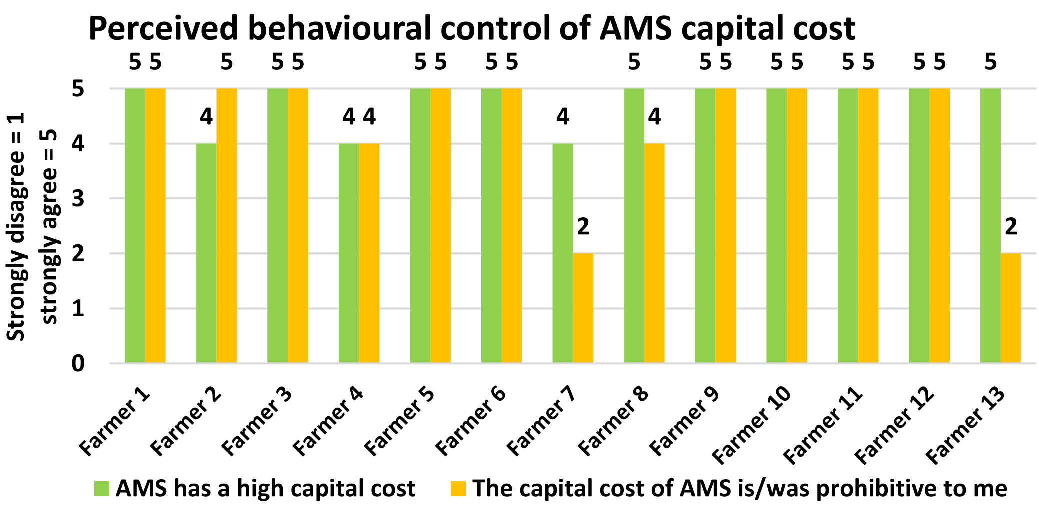

Figure 5.76: Perceived behavioural control of AMS capital cost

For nine farmers, AMS would require a change in farm layout. Two suggested that AMS would not require changes in farm layout. For seven, this was seen as difficult and thus meant that they were unlikely to install AMS (Figure 5.77).

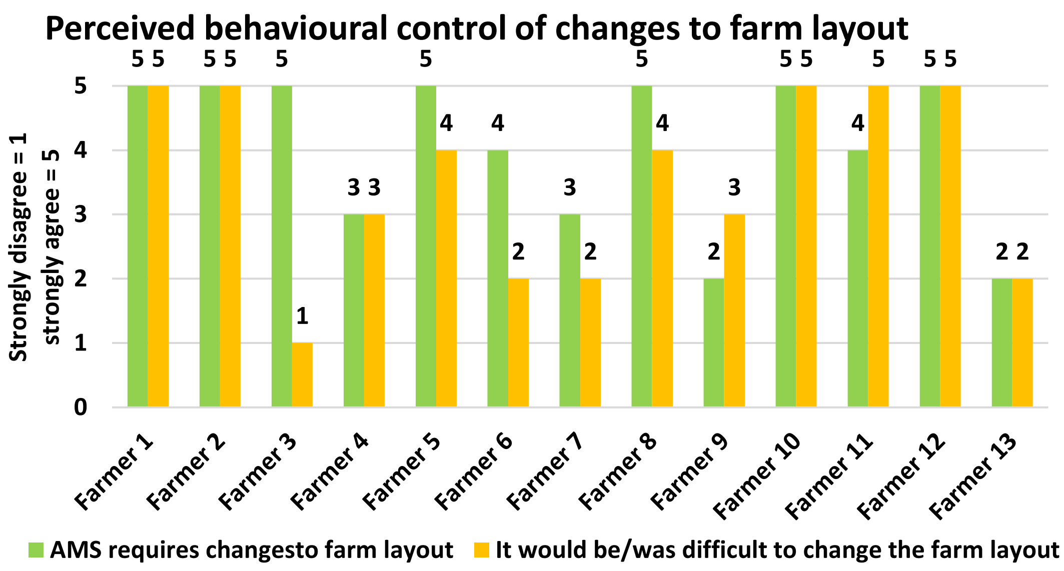

Figure 5.77: Perceived behavioural control of changes in farm layout

For 11 farmers, AMS would require a change in farm infrastructure. Two were neutral. For eight, this was seen as difficult. Four were neutral (Figure 5.78).

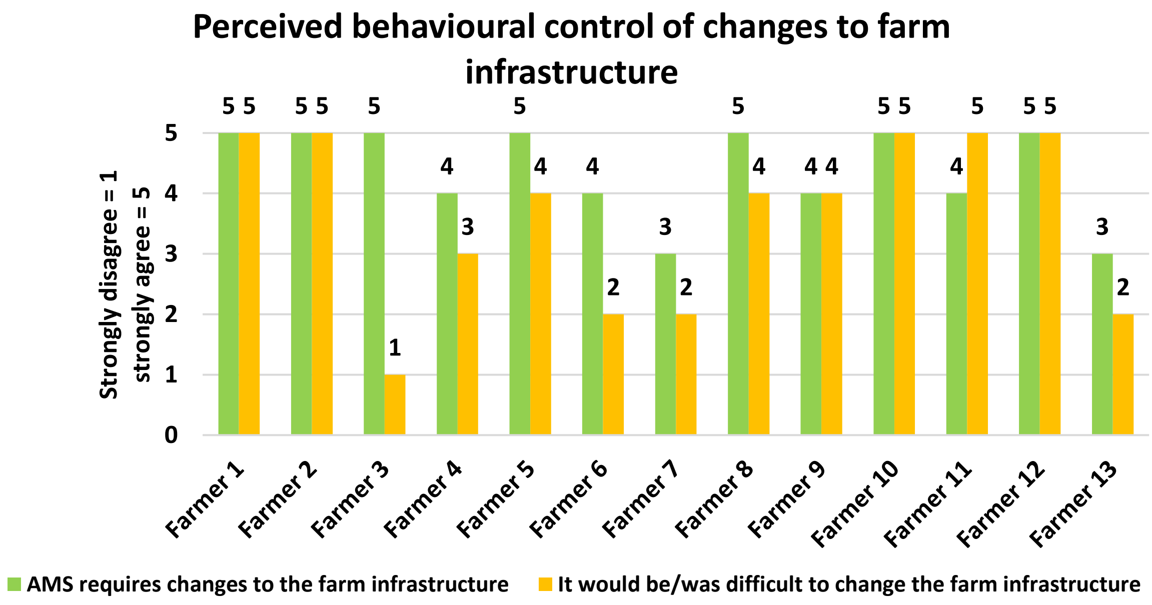

Figure 5.78: Perceived behavioural control of changes in farm infrastructure

For ten farmers, AMS would require a change in grazing system. Two disagreed. For seven, this would be a difficult process. Four disagreed that it would require a lot of work (Figure 5.79).

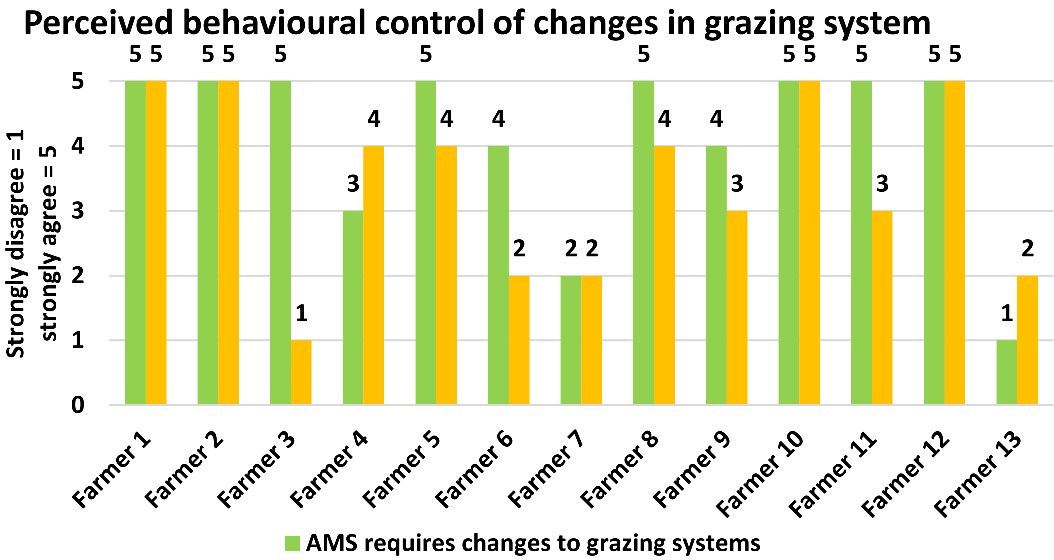

Figure 5.79: Perceived behavioural control of changes to grazing system

Seven farmers agreed and five were neutral that AMS has implications for seasonal calving. While three farmers agreed that it would be difficult to change their calving system, seven were neutral (Figure 5.80).

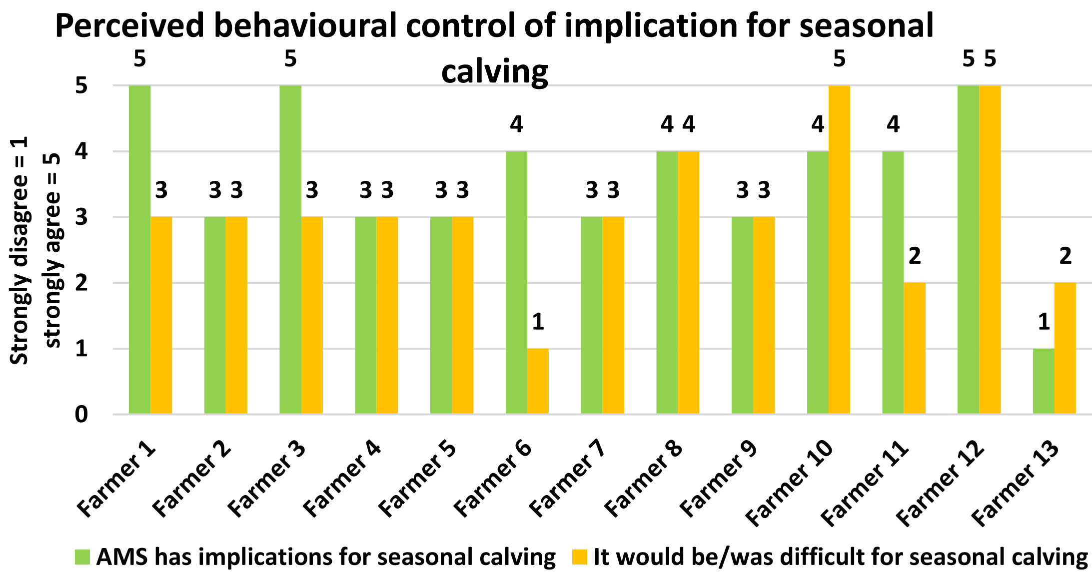

Figure 5.80: Perceived behavioural control of implication for seasonal calving

Nine farmers agreed that AMS requires more skilled labour. Two were neutral. Seven farmers agreed that it would be difficult to find skilled labour (Figure 5.81).

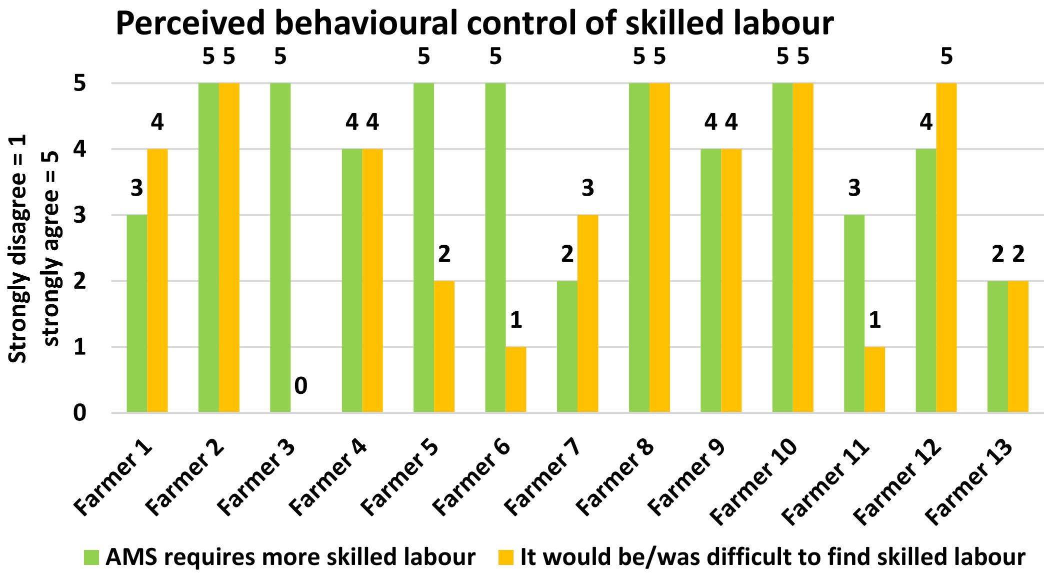

Figure 5.81: Perceived behavioural control of skilled labour

All farmers agreed that AMS requires labour to be on call 24/7. Eight indicated that this would be difficult for them (Figure 5.82).

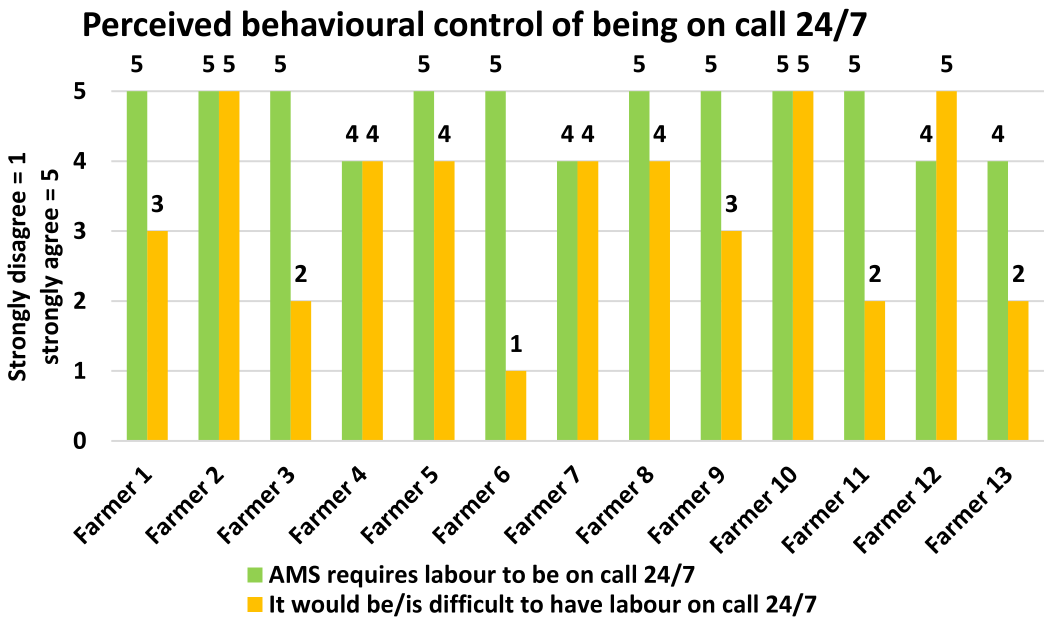

Figure 5.82: Perceived behavioural control of being on call 24/7

Twelve farmers agreed that AMS requires ongoing support from manufacturers and dealers. Three agreed that this would be difficult for them (Figure 5.83).

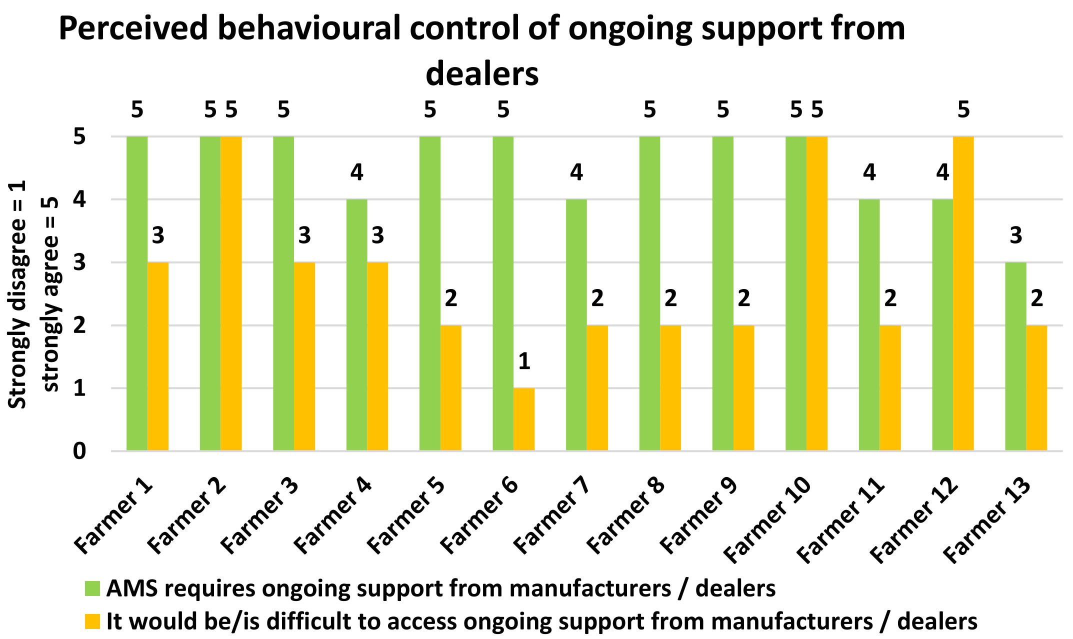

Figure 5.83: Perceived behavioural control of ongoing support from dealers

All farmers agreed that AMS requires additional technology. Four agreed it would be difficult to access technology. Four were neutral and five disagreed (Figure 5.84).

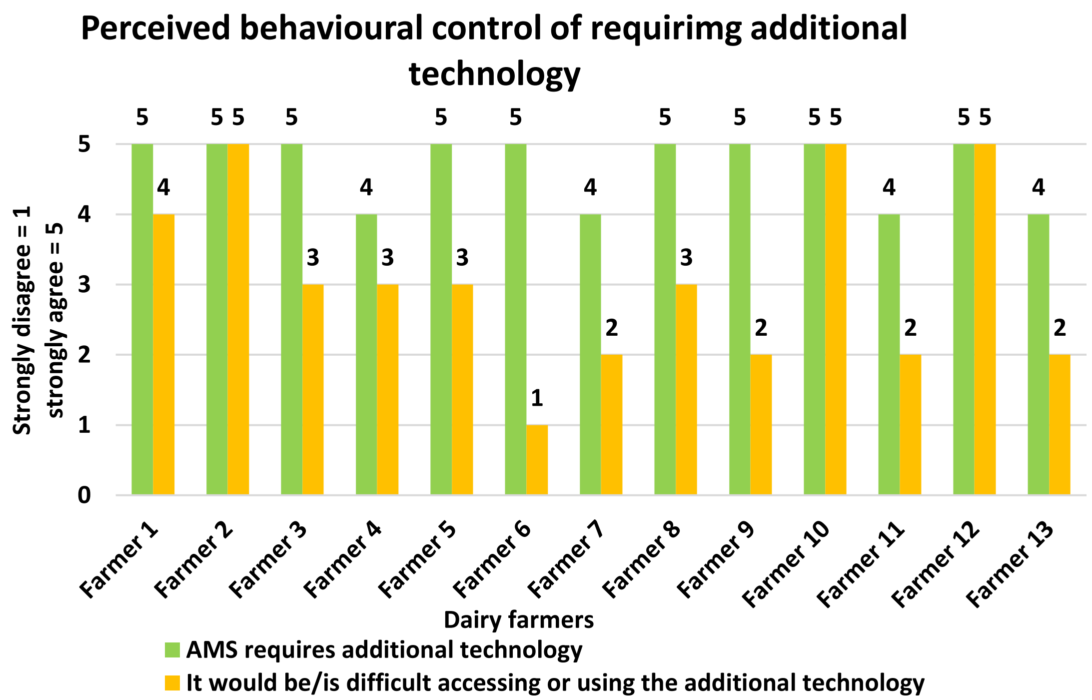

Figure 5.84: Perceived behavioural control of requiring additional technology

5.2.6 Summary of perceived behavioural control

Most of the farmers agreed that AMS is complex to install and that it would be complex for them to install AMS. All of them agreed that AMS has a high capital cost, and this would prohibit them from installing such a system. In terms of changes in the farm layout and infrastructure, and grazing system, most of the farmers agreed that AMS requires these changes. It would be more difficult for most of the farmers to make changes to the farm infrastructure compared to the changes in the farm layout and grazing system (Figure 5.85). More than half of them agreed that AMS has implications for seasonal calving, but only a few of them agreed that it would be difficult for seasonal calving. Additionally, most of them agreed that AMS requires skilled labour and all of them agreed that AMS requires someone to be on call 24/7. More than half of them agreed that it would be difficult to find skilled labour and have them on call 24/7. Furthermore, most of the farmers agreed that AMS requires ongoing support from the manufacturers. More than half of them agreed that it would be difficult to access ongoing support from these organisations. While all of the farmers agreed that AMS requires additional technology, less than one-third of them agreed that it would be difficult to access or use additional technology (Table 5.12).

Table 5.15: Total value of perceived behavioural factors

Factors	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**Total**
Complex to install	25	25	25	9	25	8	4	25	12	25	4	25	10	**222**
High capital cost	25	20	25	16	25	25	8	20	25	25	25	25	10	**274**
Changes to farm layout	25	25	5	9	20	8	6	20	6	25	20	25	4	**198**
Changes to farm infrastructure	25	25	5	12	20	8	4	20	16	25	20	25	6	**213**
Changes to grazing system	25	25	5	12	20	8	4	20	12	25	15	25	2	**198**
Implications for seasonal calving	15	9	15	9	9	4	9	16	9	20	8	25	2	**150**
Requirement for skilled labour	15	25	0	16	10	5	6	25	16	25	3	20	4	**167**
Requirement for labour to be on call 24/7	15	25	10	16	20	5	16	20	15	25	10	20	8	**205**
Requirement for ongoing support from the dealers	15	25	15	12	10	5	8	10	10	25	8	20	6	**169**
Requirement for additional technology	20	25	15	12	15	5	8	15	10	25	8	25	8	**191**

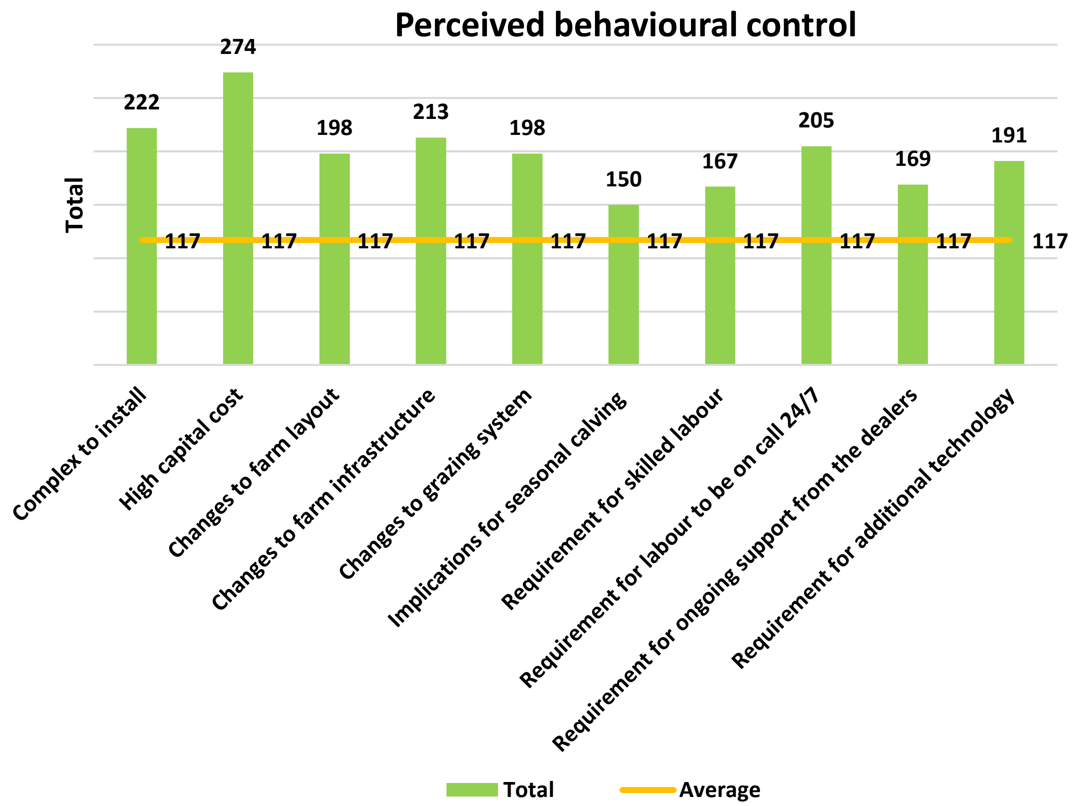

Figure 5.85: Total value of perceived behavioural factors

5.3 Conclusion

The interviewed farmers were located in both the North and South Islands of New Zealand, in the Waikato and Canterbury regions. More than half of them were dairy farm owners who had more than 10 years of farming experience. Farm size ranged from 94 to 1800 ha. The effective hectares ranged from 90 to 560 ha. Herd size ranged from 310 to 1750, with most having cross-bred cows. Farmers employed between two and eight FTE. Milk production ranged from 125 to 780KgMS/cow/year. The farmers practised production systems 2 to 4; no one used systems 1 or 5. Ten farmers had a minimum high school level education. Some had doctoral qualifications in both agriculture and non-agricultural subjects. Three had no formal qualifications. Only a few of the interviewees were over 64 years of age. Five of them were aged between 55 to 64 years old. The rest were younger. The participants were predominantly male; there were only two female participants in the study.

The farmers were concerned with social, economic, and animal health and welfare factors. The factors which were most important were: having a better lifestyle, better working conditions, decision making at the farm level, reduced rates of mastitis and lameness, having a more relaxed operating system, treating cows as individuals rather than as a herd, opportunities to observe the cows, the attractiveness of dairy farming to future generation, less working hours and days, improvements in milk quality, an increase in the farm's resale value, reduced labour, milking shed operation and servicing costs, a new experience, reduced labour requirements, more detailed data for individual cow management, a better record of individual milk quality, production, and feed intake, more up-to-date working conditions, help with labour requirements, less physical work, an increase in milk production, and better decision making for individual cows. Most of the farmers agreed that AMS would provide these benefits, with the exception of improved profits and financial returns, reduced labour costs, milking shed operation and servicing costs, an increase in the farm's resale value, less working days, a better lifestyle and decisions making at the farm level, freeing up time, and a more relaxed operating system.

In terms of subjective norms, other individuals and organisations do not have opinion on AMS or push the farmers to adopt AMS. Resources, including printed articles and online media, may spark an interest in AMS, but, in this case, had little influence on most farmers' decision to install/not install AMS.

Most of the farmers agreed that AMS requires changes in the farm layout, including grazing system and infrastructure, and changes in the operation system, including high capital cost, complexity to install AMS, more skilled labour, and having someone on call 24/7, having access to additional technology and support from AMS suppliers, and changes to the seasonal calving system. Most suggested that these changes would be difficult for them, except for the implications for the seasonal calving system, ongoing support from AMS manufacturers, and accessing additional technology.

In conclusion, dairy farmers who had not adopted AMS appeared to have positive attitudes towards most of the social and animal health and welfare benefits associated with AMS. It appeared that no one had influenced them to adopt AMS other than some printed and online articles and media. Despite believing that AMS has social and animal health and welfare benefits, most of the farmers believe it is complex and has high capital costs. They also stated that it would require changes in the farm layout and operation system which would make it difficult for them to adopt AMS.

Chapter 6
Results discussion

This chapter discusses the results from both the dairy farmers who adopted AMS in a pastoral-based dairy farming system and those who did not. This study included seven dairy farmers who adopted AMS in their pastoral-based dairy farming system. This figure represents 37% of the total dairy farmers who had adopted AMS in New Zealand by 2017. For comparative purposes, the study also included 13 dairy farmers who had not adopted AMS.

This study's aim was to identify the critical factors influencing to the successful adoption of an Automated Milking System (AMS) in New Zealand pastoral-based dairy farms. In addition, it sought to identify the factors preventing dairy farmers from adopting AMS in pastoral-based dairy farming systems.

The objectives of this study were as follows:

1. To determine the characteristics of dairy farms and farmers who adopt and those who do not adopt Automated Milking System (AMS) in New Zealand pastoral-based dairy farms
2. To identify the factors that facilitate or are barriers to Automated Milking System (AMS) adoption in New Zealand pastoral-based dairy farming systems
3. To categorise the perceived impact of Automated Milking System (AMS) on farmer lifestyle and farm operations management
4. To categorise the perceived impact of Automated Milking System (AMS) on animal health and welfare, including cow behaviour
5. To determine the perceived impact on milk production, milk quality, investment, and operating costs of Automated Milking System (AMS) for New Zealand dairy farmers

6.1 Objective 1: Characteristics of farmers and their dairy farms

This objective sought to determine the characteristics of dairy farmers who adopted and those who did not adopting AMS in a pastoral-based dairy farm.

6.1.1 Characteristics of the dairy farmers

The dairy farming sector has witnessed the increasing availability of different precision agriculture technologies, such as electronic animal identification, robotics, and data collection devices (Berckmans & Bocquier, 2008; Bewley, 2010). While there are numerous benefits associated with precision dairy farming, including economic and environmental benefits (Jensen, Jacobsen, Pedersen, & Tavella, 2012; Schlageter-Tello et al., 2015), there have been slow rates of adoption (Borchers & Bewley, 2015; Edwards, Rue, & Jago, 2015). For this reason, it is important to understand the characteristics of the adopters and non-adopters. Previous studies have identified several socio-demographic factors associated with the farms and farmers who adopt technology and the factors that contribute to the successful adoption of technology. These socio-demographic factors are the farmer's age (Boz et al., 2011; Connolly & Woods, 2010; Edwards-Jones, 2006; El-Osta & Morehart, 1999; Gloy & LaDue, 2002; Howley et al., 2012; Shahin, 2004; Solano et al., 2003), years of experience (Paudel et al., 2008; Rezaei & Bagheri, 2011; Shahin, 2004), education level (Edwards-Jones, 2006; El-Osta & Morehart, 1999; Mishra et al., 2009; Paudel et al., 2008; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008; Shahin, 2004), gender (Edwards-Jones, 2006), existence of a successor (Howley et al., 2012; Paudel et al., 2008) family lifecycle, structure of the farm business, social milieu and capital, and trust (Edwards-Jones, 2006), the farm's financial position (Boz et al., 2011; El-Osta & Morehart, 1999; Mishra, El-Osta, & Steele, 1999; Paudel et al., 2008; Prokopy et al., 2008; Shahin, 2004), the farmer's involvement in advisory programmes (Howley et al., 2012), mass media exposure (Shahin, 2004), level of contact with third parties, including veterinarians (Shahin, 2004), access to various sources of information (Prokopy et al., 2008), use of social networks (Prokopy et al., 2008), the technology's ease of use (Douthwaite, Keatinge, & Park, 2001), and environmental awareness (Prokopy et al., 2008).

All of the dairy farmers in this study who adopted AMS were male and over 35 years of age. In other words, AMS adopters were not young. This is in contrast to previous research which has shown that the older a farmer is, the less likely s/he is to adopt technology (Barham, Foltz, Jackson-Smith, & Moon, 2004). The farmers also differed in terms of their level of education: while two had no formal education, rest of them had achieved either a minimum level of education (high school level) or a bachelor's degree (either in an agricultural subject/non-agricultural subject). In contrast to previous studies that have found that young farmers are more innovative, farm at a higher level of intensity, have greater holdings, and have higher levels of education (Prokopy et al., 2008; Wilson, Lewis, & Ackroyd, 2014), in this study, AMS adopters were older and generally had minimal levels of formal education, they had the equivalent of a high school education.

In the group that had not adopted AMS, there was a mix of both men and women. They ranged in age from 25 to more than 65 years old. The non-adopters included both young and older dairy farmers which is in contrast to previous studies (Barham et al., 2004). The farmers differed in terms of their education, from those with no formal education right through to those who had doctoral degrees. There were a number of young dairy farmers who were included in the non-adopter group. Of these younger farmers, ten of them only had the equivalent of a high-school level education which is contrast to previous studies (Prokopy et al., 2008; Wilson, Lewis, & Ackroyd, 2014). These results suggest that being young and well-educated does not necessarily lead to AMS adoption. Instead, this study found that slightly older dairy farmers (35 years old and above) are more likely to adopt AMS.

The adopters included both owners and sharemilkers. For the non-adopters, managers were also included. Business structure did not appear to have any influence on whether farmers adopted AMS or not.

Six of the dairy farmers who adopted AMS had 20 to 40 years of farming experience. The other one had at least 10 years of farming experience. While seven of the non-adopters had none to 20 years of faming experience, the remainder had 21 to 50 years of experience. In short, the results reveal that the dairy farmers who had adopted AMS had more years of farming experience. Rezaei and Bagheri (2011) argued that farmers who have more years of experience are less likely to adopt technology, this is in contrast with the results of AMS adopters that had 20 to 40 years of experience.

While none of the farmers who adopted AMS had definitely identified a successor, three of them had possibly identified a successor. Most of the farmers had young children or their older children were not interested in dairy farming. This result contradicts Howley et al.'s (2012) finding that technology adopters are more likely to have identified a successor to carry on the farm business. In contrast, six of the non-adopters had either possibly or definitely identified a successor. For the remainder, this was either not relevant or they had not identified a successor. This could be due to a variety of reasons, including the farmer’s job role (s/he is a manager), the participants having young children, or the fact that they were leasing the farm. In short, for those who adopted AMS, some did not consider the future generation. For non-adopters, this may be a factor to consider.

6.1.2 Dairy farm characteristics

The majority (five) of farmers who had adopted AMS were located in the North Island, compared to the South Island of New Zealand. This is probably due to the more favourable climate conditions in the Northern regions resulting in a greater number of dairy farms. Only four of the non-adopters were located in the North Island, the remainder (nine) were located in the South Island.

Farm characteristics may contribute to the successful adoption of technology. These factors are the structure of the farm business (Edwards et al., 2015; Rue, Eastwood, Edwards, & Cuthbert, 2020), the type of farm (Edwards et al., 2015; Rue et al., 2020), farm size, (Edwards et al., 2015; El-Osta & Morehart, 1999; Rue et al., 2020; Shahin, 2004), operation size (El-Osta & Morehart, 1999), pasture size (Rezaei & Bagheri, 2011), and herd size (Shahin, 2004).

DairyNZ's published statistics on dairying in the different regions of New Zealand (DairyNZ Limited, 2019b) were crucial for comparing the farm and herd size of AMS adopters with non-adopters, with the farm and herd size averages for the regions they were located in. In terms of farm size, the dairy farms who installed AMS had smaller than the average farm size in those regions (Table 6.1). In Southland, for example, the farm size was more than 50% less than the average farm size of that region. Previous studies also suggest that in both New Zealand pastoral-based dairy farming systems and other parts of the world where barn-based systems are common, AMS appeals more to those with a smaller herd size (Donohue et al., 2010; Hardie, 2015). This includes farmers who do not have a succession plan and those who do not plan to expand their herd size (Harrigan, 2016). This study found similar results. None of the dairy farmers who had adopted AMS had definitely identified a successor. In terms of the farm size, seven of the non-adopters had a smaller farm size than the regional average. The remainder of them had larger than average farms (size) (Table 6.2).

Table 6.1: Farm size of AMS adopters vs. the average regional farm size
Source: (DairyNZ Limited, 2019b)

Farmers	**Regions**	**Farm size**	**Average regional farm size**	**Differences**
Farmer 1	Northland	135	140	-4%
Farmer 2	Waikato	82	127	-35%
Farmer 3	Southland	100	224	-55%
Farmer 4	Canterbury	154	233	-34%
Farmer 5	Manawatu	84	153	-45%
Farmer 6	Waikato	100	127	-21%
Farmer 7	Northland	64	140	-54%

Table 6.2: Farm size of AMS non-adopters vs. average regional farm size
Source: (DairyNZ Limited, 2019b)

Farmers	Regions	Farm size	Average regional farm size	Differences
Farmer 1	Canterbury	200	233	-14%
Farmer 2	Waikato	94	127	-26%
Farmer 3	Canterbury	216	233	-7%
Farmer 4	Canterbury	1800	233	673%
Farmer 5	Canterbury	170	233	-27%
Farmer 6	Canterbury	170	233	-27%
Farmer 7	Canterbury	263	233	13%
Farmer 8	Canterbury	250	233	7%
Farmer 9	Waikato	145	127	14%
Farmer 10	Canterbury	225	233	-3%
Farmer 11	Waikato	110	127	-13%
Farmer 12	Waikato	280	127	120%
Farmer 13	Canterbury	306	233	31%

As with farm size, and to be expected, effective hectares for AMS adopters were below the regional average. For non-adopters, effective hectares mirrored that of actual farm size.

Similar to the farm size, the herd size of the dairy farms with AMS was less than the regional average (Table 6.3). In most of the regions, including Waikato and Southland, the herd size was more than 50% less than the regional average herd size. Studies in Australia and New Zealand, countries which both practice similar dairy farming systems, suggest that herd size has grown significantly. This requires staff with the necessary skillset and knowledge about animal management to avoid restricting growth in milk yields and profitability (Edwards et al., 2015; Rue et al., 2020). Increased farm and herd sizes have resulted in larger dairy farms using more precision technologies (Gargiulo et al., 2018). In contrast to previous research, this study found that dairy farms with smaller herd sizes are more likely adopt AMS. As with the farm size, for the non-adopters some herd sizes were larger and some smaller (Table 6.4).

Table 6.3: Herd size of AMS adopters vs. regional averages
Source: (DairyNZ Limited, 2019b)

Farmers	Regions	Herd size	Average regional herd size	Differences
Farmer 1	Northland	165	318	-48%
Farmer 2	Waikato	300	365	-18%
Farmer 3	Southland	295	601	-51%
Farmer 4	Canterbury	500	799	-37%
Farmer 5	Manawatu	230	408	-44%
Farmer 6	Waikato	160	365	-56%
Farmer 7	Northland	160	318	-50%

Table 6.4: Herd size of non-adopters vs. regional average farm size
Source: (DairyNZ Limited, 2019b)

Farmers	Regions	Herd size	Average regional herd size	Differences
Farmer 1	Canterbury	680	799	-15%
Farmer 2	Waikato	310	365	-15%
Farmer 3	Canterbury	720	799	-10%
Farmer 4	Canterbury	1750	799	119%
Farmer 5	Canterbury	640	799	-20%
Farmer 6	Canterbury	560	799	-30%
Farmer 7	Canterbury	500	799	-37%
Farmer 8	Canterbury	780	799	-2%
Farmer 9	Waikato	390	365	7%
Farmer 10	Canterbury	470	799	-41%
Farmer 11	Waikato	270	365	-26%
Farmer 12	Waikato	480	365	32%
Farmer 13	Canterbury	1090	799	36%

For AMS adopters, milk production ranged from 190 to 480 KgMS/cow/year. Four farmers had higher levels of milk production compared to the regional average milk production. For non-adopters, the milk production ranged from 125 to 780KgMS/cow/year. Seven of the farmers had higher levels of milk production compared to the regional average milk production (LIC & DairyNZ, 2019).
The adopters practised production systems 1, 3, and 4. In other words, the sample included dairy farmers who both imported and did not import feed for their dry cows and the cows' lactation period. AMS non-adopters practiced systems 2, 3, and 4; none practiced systems 1 and 5. Therefore, none of them were feed self-sufficient. They imported feed for the dry cows and the cows' lactation period. In terms of grazing support, three of the AMS adopters were self-sufficient.

The rest of them used maize silage, palm kernel, Nutri-Liq, and molasses. Those who had not adopted AMS used different grazing support including, maize silage.

Overall, dairy farmers who had adopted AMS had smaller farms and smaller herds. Some non-adopters had smaller or larger farms and herd sizes. Generally, both of them had higher milk production compared to the regional average milk production where they were located. There was a full spread of production systems, with farmers using every system except for system 5. Some used a mixture of grazing support. Others were self-sufficient. Milk production was not a primary reason for AMS adoption.

In terms of FTE, and as with farm and herd size, the AMS adopters hired fewer staff members ranging from no hired staff to three staff members. Non-adopters hired between two to eight FTE. The results from AMS adopters are in line with the previous studies which have argued that AMS adoption results in reduced labour requirements, with figures ranging from 19% to 30% (Bijl et al., 2007; Mathijs, 2004; Sonck, 1995).

Five of the AMS adopters had a mix of Friesian and Holstein breeds, or a mix of Friesian, Jersey, and cross-bred. The remainder had either Friesian or Holstein cows. Eleven of the non-adopters had crossbreeds. The remainder had Ayrshire. Both those who had adopted and those who had not adopted AMS had cross-bred dairy cows.

The seasonal calving system is the most common system practised by New Zealand dairy farmers (Haile-Mariam & Goddard, 2008). In this system, dairy cows are milked almost 300 days of the year. They are typically dried off for two months. Ten of the non-adopters practised this system. In contrast, the AMS adopters had a greater range of calving systems; while most practice split calving, some used seasonal and all year-round methods.

In New Zealand, dairy farmers can be divided into two groups in terms of technology adoption, fast and slow technology adopters. The slow adopters are conservative; they wait for other dairy farmers to adopt and experience new technologies. For this reason, they are more likely to adopt simple types of technology such as automatic yard washing machines. These adopters also believe that one should not fix things that are not broken. Fast technology adopters are generally younger, have worked in bigger dairy farms with bigger herds, and have newer milking sheds, often rotary. (Edwards et al., 2015; Rue et al., 2020). They favour more complex types of technology since they have already adopted simpler forms of technology (Edwards et al., 2015; Rue et al., 2020). In this study, AMS adopters share some similarities with the fast technology adopters. The interviewed farmers were enthusiastic to experience new technology and challenges; therefore, they did not wait for other dairy farmers to try them first. AMS is considered a complex type of technology since the system automates the milking task and captures data at the individual cow level. Therefore, it appeals to AMS adopters and fast technology adopters. Unlike the fast technology adopters who tend to be young (Edwards et al., 2015; Rue et al., 2020), the AMS adopters were mainly middle aged, from 35 to 64 years old. While fast technology adopters have bigger herds and larger farms, the AMS adopters in this study work on a smaller scale when compared to the regional average. It is difficult to categorise the non-adopters. This group included young farmers. They also had larger herds compared to the AMS adopters. However, 10 of them agreed that AMS is a complex technology and eight of them agreed that it would be difficult for them to install AMS. Consequently, these farmers cannot be categorised as fast technology adopters in this case.

6.2 Objective 2: Factors facilitating and hindering AMS adoption

This objective sought to identify the factors that facilitate or hinder the adoption of AMS in a pastoral-based dairy farming system. For this purpose, the study included different social, economic, and animal health and welfare factors.

6.2.1 Attitudes towards AMS adoption

The factors with the highest influence for AMS adoption were important to all or most of the dairy farmers who adopted AMS. The majority of them agreed that AMS provides these benefits; the remaining farmers were neutral on this. These factors spanned all three categories. The factors are better animal welfare, having more relaxed and calmer dairy cows, the ability to treat cows as individuals, having a new experience and a challenge, providing a more relaxed operating system, making better decisions for individual cows, and reducing the rates of lameness, having a better lifestyle and better working conditions, increased milk production, and flexible working hours (Table 6.5).

Table 6.5: Factors with the highest influence on AMS adopters for AMS adoption

Type of factors	Factors with highest influence	Score	Descriptions
Animal health and welfare	Better animal welfare	165	It was important for all the farmers. All of them strongly agreed that AMS is better for animal welfare.
Animal health and welfare	More relaxed/calmer cows	160	It was important for all of the farmers. All of them strongly agreed that AMS makes the dairy cows more relaxed.
Animal health and welfare	Treating cows as individuals	156	It was important for six of the farmers. All of them agreed that AMS treats cows as individuals rather than as a herd.
Social	New experience and challenges	156	It was important for all of the farmers to experience new technology and/or challenges. All of them agreed that AMS provides this.
Social	Providing a more relaxed operating system	143	It was important for six of the farmers. All of them agreed that AMS provides a more relaxed operating system.
Animal health and welfare	Better decisions to be made for individual cows	143	It was important for all the farmers. Six of them agreed that AMS allows for better decision making for individual cow, whilst none of them disagreed.
Animal health and welfare	Reduced rates of lameness	140	It was important for all the farmers. Five of them agreed that AMS reduces the rates of lameness.
Social	Better lifestyle	132	It was important for six of the farmers. Six of them agreed that AMS improves lifestyle.
Social	Better working conditions	130	It was important for five of the farmers. All of them agreed that AMS provides better working conditions.
Economic	Increased milk production	126	It was important for six of the farmers. Only four of them agreed that AMS increases milk production, none of them disagreed that AMS provides this.
Social	Flexible working hours	125	It was important for four of the farmers. Six of them agreed that AMS provides more flexible working hours. Only one disagreed.

The factors which were important to all or most of the non-adopters are: flexible working hours and days, improved animal welfare, having more relaxed/calm cows, reduced rates of mastitis and lameness, the ability to treat cows as individuals, reduced opportunities to observe cows, better working condition, attractive to future generations, having new experience or challenges, more detailed data and information for individual cow management, and better records of individual milk quality and feed intake (Table 6.6). Most of the farmers agreed that AMS provides these benefits. The remaining minority were neutral and/or disagreed. These factors are from the social and animal health and welfare categories and may influence dairy farmers to adopt AMS in a pastoral-based dairy farming system.

Table 6.6: Factors which potentially influence non-adopters to adopt AMS

Type of factors	Factors with the highest influence	Score	Descriptions
Social	New experiences/challenges	238	It was important for 10 of the farmers. Three were neutral. Eleven agreed that AMS would provide this. None disagreed. Two were neutral.
Animal health and welfare	Reduced rates of lameness	234	It was important for 12 farmers. One was neutral. Eleven of the farmers agreed that AMS would provide this. None disagreed. Two were neutral that AMS would provide this.
Animal health and welfare	Treating cows as individuals	233	It was important for 11 farmers. Two were neutral. Twelve farmers agreed that AMS would provide this. None disagreed and one was neutral.
Animal health and welfare	Better animal welfare	229	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed, and three neutral.
Animal health and welfare	More relaxed/calmer cows	225	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Social	Attractive to future generation	219	It was important for 10 farmers. Three farmers were neutral. Nine agreed that AMS would provide this. None disagreed and four were neutral.
Animal health and welfare	Reduced rates of mastitis	218	It was important for 12 farmers. One farmer was neutral. Seven farmers agreed that AMS would provide this. None disagreed and six were neutral.
Animal health and welfare	A better record of individual milk quality	216	It was important for nine farmers. Three were neutral. One farmer stated that it was unimportant. Eleven agreed that AMS would provide this. None disagreed and one was neutral that AMS would provide this.
Social	More flexible working days	202	This was important for all the farmers. Eight agreed that AMS would provide this. Two disagreed and three were neutral.
Animal health and welfare	Opportunities to observe cows	202	It was important for 11 farmers. Two farmers were neutral. Nine farmers agreed that AMS would provide this. One disagreed and three were neutral.
Social	More flexible working hours	201	It was important for all the farmers. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Animal health and welfare	More detailed data and information for individual cow management	196	It was important for nine farmers. Three were neutral and one farmer stated that it was unimportant. All agreed that AMS would provide this.
Social	Better working conditions	190	It was important for 10 farmers. Three farmers were neutral. Eight agreed that AMS would provide this. One disagreed and four were neutral.
Animal health and welfare	A better record of individual cow feed intake	196	It was important for eight farmers. Four were neutral and one famer stated that it was unimportant. Eleven farmers agreed that AMS would provide this. None disagreed and two neutral.
Social	More up-to-date working conditions	175	It was important for eight farmers. Two were neutral and three farmers stated that this was unimportant for three farmers. Ten agreed that AMS would provide this. None of them disagreed and three were neutral.

The common factors with the highest influence for AMS adopters and non-adopters are social and animal health and welfare factors: flexible working hours, better animal welfare and working conditions, having more relaxed/calm cows, reduced rates of lameness, the ability to treat cows as individuals, and having a new experience or challenges. The other remaining factors with the highest influence on AMS adopters are providing a more relaxed operating system, making better decisions for individual cows, having a better lifestyle, and increased milk production. These factors were important for more than half of the dairy farmers who had not adopted AMS. The farmers were mostly neutral about whether AMS would provide these benefits.

The other remaining factors with the highest potential influence on non-adopters are more flexible working days, reduced rates of mastitis, reduced opportunities to observe cows, being attractive to future generation, more detailed data and information for individual cow management, and better records of individual milk quality and feed intake. Flexible working days, reduced rates of mastitis, opportunities to observe the cows, and better records of individual milk quality were important to most of the farmers who had adopted AMS. About three of them were neutral that AMS would provide these benefits. Other factors, including being attractive to future generations and a better record of individual cow feed intake did not influence farmers to adopt AMS. These factors were important to only a small minority of the farmers who had adopted AMS. A small number of them agreed that AMS provides these benefits. More detailed data for individual cow management was important to four of the farmers who had adopted AMS. All of them agreed that AMS provides this benefit.

This study's findings related to animal health and welfare factors for AMS adopters and non-adopters were similar to those of prior research. The factors are better animal welfare, having more relaxed and calmer dairy cows, the ability to treat cows as individuals, making better decisions for individual dairy cows, reduced rates of mastitis and lameness, reduced opportunities to observe cows, more detailed data and information for individual cow management, better records of individual milk quality and feed intake. Previous studies have shown that AMS enables dairy cows to voluntarily and freely to move from the pasture to the milking robots which is better for animal welfare (Deavoll, 2015; Haldane, 2018). Farmers who installed AMS noted that their cows were calmer. They also experienced reduced rates of mastitis and lameness and their cows had a longer lifespan (Molfino, Kerrisk, & Monks, 2014b, 2014c, & 2014e). The AMS database includes detailed information about each cow including information about each milking event, their level of activity, their feed intake, milk yield and body composition. If there are any changes in the cow's details, the AMS has the ability to inform the farmer straight away so that s/he can make a quick decision (Brown, 2014; Pickett, 2017). AMS is able to detect whether there is blood or colostrum in the milk. Therefore, the farmer/staff are able to make sure that the milk does not reach the main vat (Pickett, 2017) which helps with milk quality. By virtue of the conductivity sensors, dairy farmers using AMS experienced less clinical cases of lameness (Deavoll, 2015). AMS provides a voluntary milking system for the cows. The cows have unlimited and unrestricted access to the milking shed resulting in less pressure on their udders; this in turn, has a positive effect on the cows' health (Agriland Team, 2017; Brown, 2014). After installing AMS, farmers have found that their cows are heavier, healthier, and more visibly content (Haldane, 2018). Based on the collected and generated data of individual cows, AMS helped a dairy farmer to better manage the feed in the milking stalls based on the individual cow's body condition, milk yield, and place in the gestational cycle. Consequently, the dairy cows receive the right portion of concentrated feed in the milking stalls (Griekspoor, 2018).

The social factor results obtained from AMS adopters and non-adopters were similar to the findings of previous studies, except for being attractive to future generation. There are no previous studies to examine this factor. The factors included having a new experience and challenge, a more relaxed operating system, having a better lifestyle, better working conditions, and flexible working hours and days. Previous studies have shown that an interest in technology and automation systems are key factors in some farmers' decisions to adopt AMS. One farmer stated that money is not the only matter, sometimes you want to do something simply because you are interested in it (Brown, 2014). A more relaxed operating system is associated with more relaxed and calmer dairy cows (Molfino et al., 2014b, 2014c, & 2014e) and a reduction in the labour associated with conventional forms of milking, a time-consuming and labour-intensive activity (Allen, 2017). Young dairy farmers noted that they want to spend more quality time with their family and children (Molfino et al., 2014e). Moreover, dairy farmers also prefer to have an improved lifestyle in old age, whilst running their farms with family labour (Molfino, Kerrisk, & Monks, 2014f). In the previous studies, farmers believed that AMS provides them with a better lifestyle. AMS provides a good solution for the dairy farmers seeking to have more flexibility at work, meaning they could do other farm tasks, spend more time with their family members, and plan for family trips (Milkproduction, 2014; Rodenburg & House, 2007). It is also helpful for dairy farmers who are tied to the daily routine of milking three times a day (Common, 2014).

The economic factors, including increased milk production, was similar to the results of previous studies. AMS installation makes it possible to have higher levels of milk production (Deavoll, 2015). One study found an increase from 450 kg Milk Solids (MS) to 505 kg MS per cow in the initial year of operating AMS (Brown, 2014). In another study, a farmer produced 20% more milk despite having less 40 cows (Haldane, 2018). In this study, for four of the farmers milk production was above the regional average, but it is difficult to conclude that this is as a result of AMS adoption. Just over half of the non-adopters also had above average milk production when compared to the regional average.

The use of precision agriculture technologies has enabled dairy farmers to decrease their required labour force and better manage larger herds (Bewley, 2010; Eastwood, Chapman, & Paine, 2012; Eastwood, Jago, Edwards, & Burke, 2016). In the conventional milking parlour, milking requires two labour units to work 12 hours per day, including the weekends. Most famers cannot afford to employ extra staff and thus rely on family members to help out (Griekspoor, 2018). A primary reason for AMS adoption is to reduce the labour units and cost of labour (Griekspoor, 2018; Rodenburg & House, 2007; Rushen, 2017). Similarly, in this study, the farmers stated that reducing the number of FTE was important factor in their decision to install AMS. Most of them agreed that AMS reduces labour requirements. While this factor was not as important for non-adopters, more than half of them agreed that AMS would provide this.

The factors that had the least influence on AMS adopters and non-adopters were those which were important to most of them but disagreed that AMS would provide these benefits. These factors represent potential barriers for AMS adoption. The factors which were important to most of the farmers, but which they disagreed AMS would provide them with, are economic ones, including an increase in the dairy farm's resale value, and reduced milking shed servicing and operation costs (Table 6.7, Table 6.8). For non-adopters there were another three factors: help with succession planning, improved profit and financial return. AMS adopters and non-adopters had different perceptions on a number of factors which were important to the minority of them, but all agreed that AMS provides these benefits. For AMS adopters, these factors are less working hours, help with succession planning, and providing a better record of individual cow feed intake. For non-adopters, these factors had the potential to influence them to adopt AMS: useful new technologies, a shift in tasks, and automation within a farming enterprise. These factors are also important to AMS adopters, with more stating that AMS provides these benefits. Both AMS adopters and non-adopters agreed that AMS provides a better opportunity for individual feeding of cows (see Tables 6.7 and 6.8).

Table 6.7: Factors with the least influence on AMS adopters for AMS adoption

Type of factors	Factors with least influence	Score	Descriptions
Economic	Reduced milking shed operating costs	47	It was important for six of the farmers. Six of them disagreed that AMS reduces milking shed operating costs. None of them agreed.
Economic	Reduced milking shed servicing and maintenance costs	50	It was important for six of the farmers. Six of them disagreed that AMS reduces milking shed servicing and maintenance costs. None of them agreed.
Economic	Increase in resale value of the dairy farm	55	It was important for four of the farmers. Three of them disagreed that AMS increases the farm’s resale value. None of them agreed.
Social	Less working days	55	It was important for two of the farmers. Three of them disagreed that AMS provides this. Only one agreed.
Animal health and welfare	Providing better opportunity for individual feeding of cows compared to other systems	64	It was important for one farmer. Four of them agreed that AMS provides better opportunities for individual feeding of cows. None of them disagreed.
Animal health and welfare	Providing a better record for individual cow feed intake compared to other systems	68	It was important for one farmer. Four farmers strongly agreed that AMS provides a better record of individual cows’ feed intake. One disagreed.
Social	Less working hours	73	It was important for one farmer. Three of them agreed that AMS provides less working hours. Three disagreed and one was neutral.
Social	Help with succession planning	73	It was important for two of the farmers. Only three of them agreed that AMS helps with succession planning. One strongly disagreed.
Social	Help with labour recruitment	74	It was important for three of the farmers. Two agreed that AMS helps with labour recruitment. One strongly disagreed.

Table 6.8: Factors with the least influence on non-adopters for AMS adoption

Type of factors	Factors with least influence	Score	Descriptions
Social	Shift in tasks	182	It was important for four farmers. Seven were neutral and two stated that it was unimportant. All agreed that AMS would provide this.
Animal health and welfare	A better opportunity for individual feeding of cows	169	It was important for five farmers. Five were neutral and three farmers stated that it was unimportant. Eleven agreed that AMS would provide this. None disagreed and two were neutral.
Social	Useful new technologies	163	It was important for five farmers. Five were neutral and three stated that it was unimportant. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Social	Automation within farming enterprise	152	It was important for four farmers. Five were neutral and four farmers stated that it was unimportant. Nine agreed that AMS would provide this. One disagreed and three were neutral.
Economic	Improved profit	144	It was important for all the farmers. None agreed that AMS would provide this. Seven disagreed and six were neutral.
Economic	Improved financial returns	135	It was important for all the farmers. One agreed that AMS would provide this. Nine disagreed and three were neutral.
	Help with succession planning	129	It was important for eight farmers. Six were neutral and one farmer stated that it was unimportant. Two agreed that AMS would provide this. Six disagreed and five were neutral.
Social	Increase the resale value of the farm	117	It was important for 10 farmers. Two stated that it was unimportant, and it was not applicable for one farmer. Two farmers agreed that AMS would provide this. Seven disagreed and four were neutral.
Economic	Reduced milking shed operation costs	117	It was important for eight farmers. Four were neutral and one farmer stated that it was not important. One agreed that AMS would provide this. Nine disagreed and three were neutral.
Economic	Reduced milking shed servicing/maintenance costs	85	It was important for nine farmers. Two were neutral and two farmers stated that it was unimportant. No farmers agreed that AMS would provide this. Twelve disagreed and one was neutral.

6.2.2 Social norms of individuals interacting with farmers

Advisors from both public and private sectors, consultants, farm equipment technicians, veterinarians, agronomists, and nutritionists are all part of dairy farmers' networks, and they can play an important role in decision making processes (Eastwood et al., 2012; Klerkx & Jansen, 2010; Murphy et al., 2013). These advisors have the opportunity to introduce precision technologies and use these technologies to generate detailed data. For instance, service providers could provide computer generated reports for animal health and feed (Eastwood et al., 2016a; Eastwood et al., 2016). This study asked farmers about these and other individuals/organisations' influence on them. The study also considered other possible influences. The full list included the farmer's spouse/partner, farmer's children, other family members, farm staff, other farmers with AMS, other farmers without AMS, milk processors, good industry bodies, private consultants, printed media articles, online media, resources from good industry bodies, and resources from AMS suppliers. The results revealed that what had the most influence on those who had adopted AMS were the resources and publicity materials provided by AMS suppliers and dairy farmers who had already adopted AMS. Milk processors, private consultants, the farmers' children, and farm staff had the least influence. In contrast to AMS adopters, individuals, organisations, and resources had no influence on non-adopters in terms of the opinions they held and the respondent's desire to be motivated by their opinions. While farmers stated that printed and online media might spark an interest, they had little influence on most of the farmers in terms of AMS adoption.

6.2.3 Farmers' ability to adopt AMS

There are a number of factors that influence a dairy farmer's ability to adopt AMS in their farming system. Factors contributing to the low rate of technology adoption include complications and possible unintended effects related to the usage of such technology (Kutter, Tiemann, Siebert, & Fountas, 2011; Schewe & Stuart, 2015). Amongst all of the factors, five of the adopters noted the complexity of AMS installation. This was similar for non-adopters. Previous studies have indicated that the capital costs associated with AMS are too high for most dairy farmers to consider installing it. (Common, 2014; Geleynse, 2003). Even though four of the adopters agreed that AMS is costly to install, they had the finances required to do so. In other words, high capital cost was not prohibitive to them to adopt AMS. All non-adopters agreed that AMS has a high capital cost. Eleven of them indicated that the cost was prohibitive to them, a finding which is in line with previous studies.

Changes in farm layout are required for AMS installation (Jacobs, Ananyeva, & Siegford, 2012). Three of the adopters in this study agreed that AMS requires changes in the farm layout, but none of them agreed that it was difficult to make these changes. Likewise, none of them agreed it was difficult to change the farm infrastructure. In contrast, the non-adopters stated that they would need to make changes to their farm layout and infrastructure, nine non-adopters and 11 non-adopters respectively. Most indicated that these changes would be difficult for them to make.

AMS requires farmers to divide the pasture into three sections every day (Kerrisk & Ravenhill, 2010). This results in an increase in cow traffic, milking frequency, and milk production during early lactation and late lactation when it is more difficult to motivate the cows (Lyons et al., 2013). Four of the adopters in this study agreed that AMS requires changes in the grazing system but stated that these changes were easy to make. Ten non-adopters reported that they would need to make changes to their grazing systems; most stating that it would be difficult for them to make these changes.

New Zealand dairy farmers typically use seasonal calving patterns (Haile-Mariam & Goddard, 2008). While five of the adopters and seven of the non-adopters in this study agreed that AMS has implication for seasonal calving, six of the adopters and three of the non-adopters disagreed that this made AMS difficult to implement. Seven of the non-adopters were neutral.

Operating the AMS also requires users to have a specific level of computer skills. The dairy farmers must monitor the AMS reports and manage the cows appropriately (Dairy Australia Limited, 2014; Kerrisk, 2008a & 2008c). Farmers must therefore employ staff members with the necessary skills. In this study, four adopters and nine non-adopters agreed that AMS requires more skilled labour. Two of the adopters and seven of the non-adopters suggested that it would be difficult to find qualified labour.

AMS can be programmed to work 24 hours a day, seven days a week. If farmers choose this option, then alarms may sound at any time of the day or night. Depending on the severity of issue, it might be possible for the staff or the dairy farmer to solve the issue remotely. However, more severe cases, may require help from a properly trained technicians, either on the phone or physically (Dairy Australia Limited, 2014; Kerrisk, 2008a & 2008c). Even though six of the adopters agreed that AMS requires labour to be on call 24/7, only one agreed that it would be difficult to be on call 24/7. In contrast, all of non-adopters agreed on this being a factor and eight of them suggested that it would be difficult to be on call all the time.

All of the adopters agreed that AMS requires ongoing support from the manufacturers. All of them stated that it would not be difficult to access ongoing support from the AMS manufacturers and dealers. Twelve of the non-adopters agreed with this need for ongoing support. Three suggested that it would be difficult for them to access ongoing support from the dealers.

Embodied knowledge technologies and information intensive technologies are two types of precision agriculture technologies (Fernandez-Cornejo et al., 2001; Lambert et al., 2004). Embodied knowledge technologies are those which do not require the farmers to have a particular skillset in order to use them. Information intensive technologies provide a considerable amount of data and information which can be used to make decisions (Fernandez-Cornejo et al., 2001; Winstead et al., 2010). Historically, farmers have been more willing to adopt embodied knowledge technologies and automatic guidance in comparison to other types of technologies (Miller et al., 2019). AMS is an information intensive technology. It requires farmers to use computers (Driessen & Heutinck, 2015) and a smartphone to keep an eye on the farm's operation (Hardie, 2015) and interpret individual cow data. Thus, farmers must gain extra skills or attend training so that they know how to interpret the data. This fact may explain the lower AMS adoption rates. In this study, four of the adopters agreed that AMS requires additional technology, but none of them agreed that it was difficult to use or access additional technology. Innovations which are simpler for potential adopters to understand compared to those which require the adopters to learn new knowledge and/or a new skillset have higher rates of adoption (Rogers, 2003). In this study, the non-adopters agreed that AMS requires additional technology and that it would be difficult for them to access or use that additional technology.

Overall, the dairy farmers in this study who had adopted AMS were more likely to be older and educated with more years of experience. Most had not definitely identified a successor. Dairy farmers who had not adopted AMS were more likely to be younger and educated with fewer years of experience. However, in contrast to the previous group, most had identified a successor. Similar to previous studies, the common social and animal health and welfare factors which influenced AMS adopters and could potentially influence non-adopters were having more flexible working hours, better animal welfare and working conditions, having more relaxed/calm cows, reduced rates of lameness, the ability to treat cows as individuals, and having a new experience or challenges. The remaining factors with the highest influence on AMS adopters were providing a more relaxed operating system, making better decisions for individual cows, having a better lifestyle, and increased milk production. While non-adopters stated that these factors were important, they were mostly neutral that AMS would provide these benefits. The other factors with the highest potential influence on non-adopters were more flexible working days, reduced rates of mastitis, reduced opportunities to observe cows, being attractive to future generation, more detailed data and information for individual cow management, and better records of individual milk quality and feed intake. These factors were either less important to AMS adopters or they were neutral that AMS would provide these benefits. The factors which had least influence and may hinder AMS adoption were an increase in the dairy farm's resale value, and reduced milking shed servicing and operation costs. For non-adopters, additional factors were including help with succession planning, and improved profit and financial return.

In this study, it appears that individuals and organisations have no influence on non-adopters. For adopters, resources and publicity materials provided by AMS suppliers and dairy farmers who had previously adopted AMS had a little influence.

Despite the fact that AMS requires high capital costs and changes to the farm layout and structure, the adopters found these easy and said they were not prohibitive to them to install AMS. This was not the case for the non-adopters.

6.3 Objective 3: Impact of AMS on farm operation management and dairy farmer lifestyle

In terms of farm operations, the study's aim was to understand the changes associated with AMS installation. Unlike conventional milking systems where staff manually perform the milking task, in AMS the cows have the freedom to voluntarily visit the milking stalls where they are milked by a robotic arm (Driessen & Heutinck, 2015; Jacobs & Siegford, 2012; King & DeVries, 2018; Varinsky, 2017). Due to the automated nature of the system, there can be problems with AMS, such as incomplete milking events and other issues related to the milking robot. In most cases, the farmer is able to solve these problems relatively quickly. However, more serious problems may require an AMS technician and may take longer to solve. Interruptions in milking may result in lower milk production. In other words, less milking events are performed which results in reduced milk production. For this reason, dairy farmers who use AMS need to be available, or have a staff member, 24/7 to ensure any problems are identified and solved immediately. Six of the dairy farmers stated that this was not difficult for them.

The main reasons that the dairy farmers in this study experienced incomplete milking events were related either to problems with the milking robot or the cows were inexperienced with using the system. It was their first season using AMS. Common issues related to the milking robot include an inability to detect the teat, loose rubber causing the milk cups to come off, power cuts, dirty sensors, low air pressure, poor maintenance of the robotic arm, and tangled up cups caused by nervous cows, when the cow keeps kicking or are new to AMS.

The success of AMS relies strongly on the voluntarily and individual movements of the dairy cow entering and exiting the milking stall without the intervention or assistance from the farm staff. Consequently, it is crucial to understand the interactions between the dairy cows and their surrounding environment as these affect the cows' movements through the AMS (Calcante, Tangorra, & Oberti, 2016). Moreover, if the dairy cow fails to take itself to the AMS within the milking interval, then farm staff must fetch it (Driessen & Heutinck, 2015). Farmers must train the dairy cows to voluntarily use AMS to benefit from reducing the labour units and to diminish the effects on milk yield during the transition period. In the training process, dairy cows have to learn to walk to the AMS milking stalls either from the pasture or barn area, get into the milking stall, wait for the milking to be completed, and leave the milking stall (Jago & Kerrisk, 2011). There is no specific procedure to train the dairy cows to use AMS. The training process varies in terms of duration and approaches (Tse et al., 2017). Inexperienced dairy cows often take a longer time to learn the system and become familiar with the milking process (Donohue et al., 2010). Some approaches involve providing grain-based concentrates as a reward (Calcante et al., 2016), exposing the dairy cows to the process and sound of AMS before attending the first milking event (Jago & Kerrisk, 2011), and making heifers familiar with the AMS before calving to ensure a positive result in terms of milking intervals, milk yields, and feed frequency (Kashiwamura et al., 2001; Widegren, 2014).

In this study, the interviewed farmers used different approaches to facilitate the transition to AMS. This included providing feed as a reward and taking the cows through the system before using it for the first time. Other approaches included grazing heifers with the dry cows and putting cups on by hand or manually for the first two to three days. The farmers stated that the process was labour intensive and that they needed to have a good understanding of the technology, the interaction between the cows and AMS, in terms of cups and noise, nervous cows, flies in autumn time biting the cows, which means that the cows are not calm, and getting the cows to go through the gates. The training process typically took between a few days up to two weeks.

In order to install AMS in a pastoral-based dairy farming system, a farmer must divide the pasture into three sections (Kerrisk & Ravenhill, 2010) to increase the cow traffic, milking frequency, and milk production during early and late lactation when it if difficult to motivate the cows (Lyons et al., 2013). In this study, the dairy farmers also practiced the 3-way grazing system. This mainly required new races to be added or extending the existing ones using new fences. This did not require significant changes to the farm layout.

AMS can require more precise pasture allocation and management. If the dairy cows have excessive daily access to the pasture, they will not leave the pasture to move to the milking stalls to attend the milking events (Kerrisk, 2008d). In order to allocate and manage the pasture, the dairy farmers in this study practiced different approaches, including the use of a plate meter and accurate Kg/DM allocation, receiving advice from AMS suppliers, and cleaning the paddock before cows move.

There are two main traffic systems: free and guided. Both have similar rates of milking frequency success (Hermans et al., 2003; Munksgaard et al., 2011). All of the dairy farmers in this study had guided traffic systems which pre-select cows. A gate guides the dairy cows with milking permission to go to the milking stalls and those without milking permission are returned to the pasture. The gates to the milking shed and the pasture need to be changed three times a day, approximately every eight hours. This was an easy task for the dairy farmers since they could do this using an AMS application on their phone. In addition, farm layout changes primarily involved adding new and extra races and installing gates. None of the farmers had to make significant changes to their farm layouts. The only other change farmers spoke of was upgrading the old milking shed to a new one.

It is important for farmers to have realistic expectations about what they wish to achieve through installing milking robots. The benefits associated with AMS vary from one farmer to the another based on their objectives (Dairy Australia Limited, 2014; Kerrisk, 2008a & 2008c). In this study, farmers' primary expectation was that AMS would improve the work environment, by making the milking process easier for staff and the animal. They noted that these benefits resulted in social and animal welfare benefits. The factors that the farmers expected the most and most of them got were increased milk production, an improved milking process, improved cow welfare, a reduced workload, changes in their daily tasks, adaption in the milking shed infrastructure, adaptions to the farm's traffic system, data provision, and reduced rates of mastitis and lameness (Table 6.8). In previous studies, dairy farmers reported similar benefits, including increased milk production (Bijl et al., 2007; Deavoll, 2015; Wade et al., 2004), data provision, animal welfare benefits (Common, 2014; Rushen, 2017; Tse et al., 2017; Tse et al., 2018), a reduced workload (Hardie, 2015), changes in tasks (Jago & Kerrisk, 2011; Kerrisk, 2008d), reduced rates of mastitis and lameness (Deavoll, 2015; Pickett, 2017), an improved milking process, and adaption in milking shed infrastructure and traffic system.

The factors that the dairy farmers expected the least from AMS included reduced labour, operation, and maintenance costs. While these factors were important to most of the farmers, they agreed that AMS does not provide economic benefits, with the exception of four farmers who stated that AMS did reduce their labour costs. Almost all of the dairy farmers achieved their goals and planned to continue dairy farming.

Table 6.9: Factors dairy farmers expected and got

Type of factor	**Factors**	**No. of farmers (Expected)**	**No. of farmers (got)**
Economic	Increased milk production	Six	Five
Economic	Improved milking process	Six	Four
Animal health and welfare	Beneficial in terms of cow welfare	Six	Six
Social	Reduced workload	Five	Four
Social	Changes in tasks	Five	Four
Social	Adaption of the milking shed infrastructure	Five	Four
Social	Adaption of the traffic system	Five	Four
Social	Additional features/functions provided by the robotic milking system, e.g., the provision of data	Four	Seven
Animal health and welfare	Reduced rates of mastitis	Four	Five
Animal health and welfare	Reduced rates of lameness	Four	Five

The process of milking is time-consuming. It also increases an individual's physical workload, and requires skilled labour (Morrison, 2016; Pirlo, Abeni, Capelletti, Migliorati, & Speroni, 2005). Dairy farmers struggle to find and maintain both skilled and unskilled labour (Shortall et al., 2016). In AMS, milking is performed without human assistance; as a consequence, there is a decrease in the demand for labour (Jacobs et al., 2012; King & DeVries, 2018; Pirlo et al., 2005; Shortall et al., 2016). Previous studies have found that AMS adoption results in a reduction of labour units, within figures ranging from 19% to 30% (Bijl et al., 2007; Mathijs, 2004; Sonck, 1995). The reduction in labour varies from one country to another (Mathijs, 2004). For instance, Belgian dairy farmers managed to reduce their labour requirements by 28%. In contrast, Danish farmers only reduced their labour unit requirements by 11%. In this study, the figures ranged between 20% and 50%.

Land et al. (2000) have argued that reductions in labour unit requirements and costs depend on an individual dairy farmer's management capacity. They also depend on the dairy farm's staffing situation. It is true that AMS reduces the necessary labour units and physical workload for the milking task, including fetching the cows, the attachment and detachment of milking cups, and the actual milking of the cows. AMS eliminates tasks such as milking at specific times (Hogeveen, Heemskerk, & Mathijs, 2004). However, installing AMS also means that a farmer will have new tasks, including training the cows, making changes to the farm's traffic system and farm layout, and responding to AMS alarms (Jago & Kerrisk, 2011; Kerrisk, 2008d). AMS also requires someone to be available 24/7 (Crowell, 2012).

Like previous research, in this study, the labour unit dropped from 20% to 50%. After AMS installation, dairy farmers were able to spend less time standing on concrete and had greater flexibility in what tasks they performed as a result of not having to fetch the cows and attach the cups. After installing AMS, farmers were no longer required to fetch the cows from the pasture and attach the cups to the cows for the purpose of milking them. The job of milking the cows was replaced with the other tasks such as checking the computer, training the cows, entering data, setting up fences, changing the gates, and cleaning the robotic arm. While farmers also had to ensure that someone was available 24/7 in case of any AMS issues, they were not bothered by this. The dairy farmers made the following statements:

"The number of labourers has been reduced by half a labour unit but not eliminated."

"Still there is a need for a labour to be available 24/7 in case of facing issues with AMS."

Of all farmers, dairy farmers work the most hours: on average, they spend 48 hours on the farm per week (Morrison, 2016). They work shorter hours on the weekend. On farms where there are no workers, farmers fetch and milk the cows almost seven days a week, early in the morning and late in the afternoon (Driessen & Heutinck, 2015). In other words, farmers/workers perform a repetitive task for long hours every day. The hard physical and repetitive nature of this job may result in a high turnover rate or a labour shortage within the dairy farming sector. This study found that working days and hours before and after AMS adoption remained almost the same for all the dairy farmers; however, they had more flexibility in terms of their working days and hours. However, one of the dairy farmers running the farm on his own managed to significantly reduce his working hours, from 70 hour/week to 40 hour/week, after installing AMS. This new flexibility means that dairy farmers are not obligated to attend the milking shift early in the morning and spend long hours milking the cows. The farmers are able to spend more time on other tasks, the farm business, and his/her social life. Increased flexibility in working hours and days can improve a dairy farmer's lifestyle and business management. In doing so, this system may alleviate the negative perception of dairy farming as an occupation which requires long working hours and other labour-related issues.

This study found that while AMS can reduce labour requirements, and particularly in relation to milking, there is still a need for workers to help with other tasks around the farm. It found that AMS allows for more flexibility. Some farmers reduced their excessive hours, some experienced a reduction in the need for FTE staff. Most just reallocated the extra time they had to other tasks, like setting up the system, training the cows, ensuring the computer is running properly, entering data, setting up new fences, changing the gates and cleaning the robotic arm.

6.4 Objective 4 – Perceived impact of AMS on animal health and welfare, including cow behaviour

Previous studies suggest that cows' unrestricted access to the milking shed results in less pressure on their udders which has positive effect on their health (Agriland Team, 2017; Brown, 2014). Likewise, other research has indicated that the dairy cows are calmer and more relaxed compared to the cows who are milked using a conventional system (Hopster et al., 2002). As a result, they show much less step and kicking movements during the milking event (Driessen & Heutinck, 2015). The cows also do not react badly to the behaviour of the other cows (Crowell, 2012). After AMS installation, farmers noted that the cows are heavier, healthier, and visibly more contented (Haldane, 2018). Likewise, in this study, once training was complete, the farmers stated that the cows were calmer, more relaxed, quiet, contented, chilled, and independent, compared to when they were milked using a conventional system.

In AMS, the cows have the freedom to follow their natural routine in terms of feed, movement, and milking events. In other words, the cows are not forced to follow the dairy farmers' schedules. Subsequently, dairy cows are relaxed and comfortable (Common, 2014; Geleynse, 2003; Pengelly,

2017) which results in improved animal welfare. In this study, all of the farmers stated that better animal welfare was important to them. All of them agreed that AMS provides better animal welfare. The farmers all wanted more relaxed cows and believed that it was important to treat cows as individuals. All of them agreed that AMS provide these benefits.

In a conventional parlour milking system, the farmer or the farm staff bring the cows to the waiting area where they are forced to enter the milking parlour (Halachmi et al., 2003). As a result of this process, farmers have the opportunity to observe and spot any health problems in a timely fashion. But in AMS, cows voluntarily bring themselves from the pasture or barn to the AMS (Halachmi et al., 2003). This may mean that farmers/staff have less opportunities to spot problems (Huhtala et al., 2007). However, AMS provides health monitoring technology which generates daily data and information about individual cow health, behaviour, and production level reports. A farmer can use this data for managing his/her herd's health and spot illness earlier (Jacobs & Siegford, 2012; Tse et al., 2017). This means that the dairy farmers have more detailed data relating to each individual cow; in short, AMS does not reduces the opportunity to observe and spot the problems in the dairy cows. In this study, observing the cows was important for most of the farmers. Two of them disagreed and three were neutral that AMS reduces the opportunity to observe the cows. All of the farmers stated that spotting problems were important. Three of them disagreed and three were neutral that AMS reduces the opportunity to spot problems, whilst one agreed that this statement was true.

In previous studies, dairy farmers experienced less clinical cases of mastitis (Pickett, 2017) and lameness (Deavoll, 2015) by virtue of the conductivity sensors. Another dairy farmer reported that his cows were calmer, and that he had experienced significant declines in rates of mastitis and lame cows. He also noted that his cows lived longer (Molfino et al., 2014b, 2014c, 2014e). All of the farmers in this study reported that these two factors were important for them. Four agreed that AMS reduces the rates of lameness and five agreed that AMS reduces the rates of mastitis.

AMS features a herd management programme which stores information collected automatically or manually entered by the dairy farmers to generate reports and charts. Farmers can use this data to make better management decisions, control and monitor an individual cow's performance and the system. The reports and figures assist the dairy farmers to detect diseases at an earlier stage and make practical decisions to increase the entire farm's productivity (Kerrisk, 2008a). Moreover, in AMS each individual milking event generates a wide range of information: more than 100 pieces on a daily basis. The information consists of milk quality, temperature, body weight, cow health, and the speed of milk. Dairy farmers can also access information related to milk quantity and yield, the level of protein and an individual cow's body fat levels (Cummins, 2018; Jacobs & Siegford, 2012). In this study, dairy farmers had similar attitudes to AMS systems. Most of them agreed that AMS provides more detailed and better records, data, and information for individual cow management, milk production and quality, and individual cow feeding and feed intake. While they agreed that AMS enabled them to make better decisions for individual cows, most stated this was not true for the farm as a whole.

6.5 Objective 5: Perceived impact on milk production, milk quality, investment and operating costs of AMS

In this study, more than half of the dairy farmers agreed that AMS has high capital costs; the rest were neutral. The adopters stated that the economic cost was not prohibitive to them. In other words, even though the dairy farmers agreed that AMS has a high capital cost, they believed that the other social and animal health and welfare benefits of AMS outweighed this. The previous studies find that AMS is considered a more capital-intensive system compared to conventional milking systems (Driessen & Heutinck, 2015; A. Rotz et al., 2003). When a farmer installs AMS, the cows are no longer the main capital expense (Driessen & Heutinck, 2015). The high capital cost of AMS, in addition to maintenance and running costs, have made farmers and scholars more interested in evaluating the economics of AMS. Various studies have concluded that AMS is not cost effective when determined using a financial return basis (Jago, 2006; Rotz, Coiner, & Soder, 2003; Shortall et al., 2016). Farmers consider profitability and cash flow when switching from conventional milking systems to AMS (Moyes, Ma, McCoy, & Peters, 2014). Consequently, the high capital cost of AMS is considered one of the factors which hinders AMS adoption (Common, 2014; Geleynse, 2003).

In this study, increased milk production and improved milk quality were important for six and all of the farmers respectively. Four farmers agreed that AMS increases the milk production and three of them agreed AMS improves milk quality. The previous studies indicate that AMS enables dairy farmers to control the frequency of the milking events of individual dairy cows and to alter the milk yield level or for certain periods of lactation without incurring additional labour costs (Hogeveen, Ouweltjes, De Koning, & Stelwagen, 2001; Svennersten-Sjaunja & Pettersson, 2008). Dairy cows can be milked more frequently during lactation as they produce more milk; in short, milk production increases (Svennersten-Sjaunja & Pettersson, 2008). As AMS increases the frequency of the milking event it reduces the stress on the cow’s udder and thus milk production increases (Halachmi, Adan, Van Der Wal, Van Beek, & Heesterbeek, 2003). In addition, cows are milked based on their milk yield, so cows with higher milk production can be milked more than twice a day. As a result, the average milk production can be increased. In some studies, AMS helped dairy farmers to increase their milk production by between 2% and 20% (Bijl et al., 2007; Wade et al., 2004).

The relative advantage is the degree to which a new innovation is perceived as better than existing innovations or a competing one (Rogers, 2003). As Batz, Peters, and Janssen (1999), argue if the farmers believe that the new innovation outperforms the existing one, as found in this study and others in terms of social, animal health and welfare, and milk production and quality benefits, they will adopt that innovation. A further relevant factor is in terms of increasing the farm's resale value. In this study, dairy farmers showed a negative attitude towards increase an increased resale value. While this economic factor was important for four of them, none agreed that AMS would increase the farm's resale value. One farmer purchased a dairy farm which already had AMS installed; significantly, the dairy farmer did not pay a higher price for the farm because it had AMS installed. According to the dairy farmers, there are other factors like the location, the fertility of the soil, and the climate that can potentially increase the farm's resale value. Some of the dairy farmers stated that it might be challenging to find a new farm owner interested in AMS. As discussed under the characteristics of dairy farmers who adopted AMS, the farm's resale value was only important to those who owned their own farm; significantly, it was found that AMS fails to increase the farm's resale value.

In this study, most of the farmers stated that they were interested in generating more profit and financial return, which comes from either increasing sales or reducing costs; however, most were neutral that AMS would provide these benefits. As discussed earlier, more than half of the dairy farmers believed that AMS would increase milk production. Increased milk production results in greater sales. In contrast, the dairy farmers had a more negative attitude towards AMS in terms of reducing their milking shed operation and maintenance costs. Six of the dairy farmers disagreed that AMS reduces the milking shed costs. However, four of the farmers agreed that AMS reduces the cost of labour. As opposed to the previous study stating technology can decrease the production costs and more effectively manage finance within pastoral-based systems (Shalloo, Dillon, Rath, & Wallace, 2004). But the shift from experimental decision-making to a data-driven process leads to uncertainty about the possible expenses and benefits of the technology (Kutter et al., 2011). In addition, when the innovation is first, less compatible with the existing system, in this case, the compatibility of AMS with traditional milking systems including rotary and herringbone systems, and second, offers less relative advantage, in this case, the costs associated with operating and maintaining AMS compared to the traditional milking systems including rotary and herringbone, then the innovation adoption rate is slow.

This study found that while AMS fails to reduce the milking shed operation and maintenance costs, it helps farmers to reduce the labour costs since milking is conducted by the robot. AMS also helps to increase and improve milk production and quality, to a certain extent, which ultimately generates higher sales.

6.6 Summary

This chapter has reviewed the results obtained from the interviews with both farmers who have and have not adopted AMS in a pastoral-based dairy farming system. These results have been discussed in light of this study’s objectives and literature review. It was found that demographic factors do not necessarily influence the farmers to adopt AMS in pastoral-based dairy farming systems. Farmers who had adopted AMS were more interested in the values of social and animal health and welfare benefits associated with AMS compared to the economic benefits. Therefore, it can be argued that they believed these benefits outweighed the high capital, operation, and maintenance costs associated with AMS installation. The farmers who had not adopted AMS were also interested in the social, economic, and animal health and welfare benefits of AMS; however, they did not believe that AMS would provide the economic benefits; for them, the cost of AMS was prohibitive. The final chapter revisits the study’s objectives to explore the key conclusions of the study.

Chapter 7
Conclusion

This chapter revisits each of the research objectives to outline the study's key conclusions. This study's primary aim was to identify the critical factors influencing to the successful adoption of Automated Milking Systems (AMS) in New Zealand pastoral-based dairy farms. It also sought to identify the factors preventing dairy farmers from adopting AMS in pastoral-based dairy farming. The objectives of this study were as follows:

1. To determine the characteristics of dairy farms and farmers who adopt and those who do not adopt Automated Milking System (AMS) in New Zealand pastoral-based dairy farms

2. To identify the factors that facilitate or are barriers to Automated Milking System (AMS) adoption in New Zealand pastoral-based dairy farming systems

3. To categorise the perceived impact of Automated Milking System (AMS) on farmer lifestyle and farm operations management

4. To categorise the perceived impact of Automated Milking System (AMS) on animal health and welfare, including cow behaviour

5. To determine the perceived impact on milk production, milk quality, investment, and operating costs of Automated Milking System (AMS) for New Zealand dairy farmers

7.1 Objective 1: Characteristics of the dairy farms and farmers

This study's findings on the dairy farms and farmers' characteristics were contrary to the research identified in the literature review. The demographic factors did not necessarily influence the farmers to adopt AMS. To a certain extent, the characteristics of the dairy farmers who had adopted and had not adopted AMS were similar. AMS adopters and non-adopters were spread across the North and South Island. Both adopters and non-adopters used a range of productions systems. None of the farmers used system 5. AMS adopters had smaller farms and herds than the regional averages, where they are located. This was almost the same for the non-adopters. In short, farm and herd size are not necessarily drivers for AMS adoption given that some non-adopters also had smaller farms and herds, but a smaller farm and herd size is more likely to lead to adoption. Most of the interviewed farmers were owners. The remainder of them were sharemilkers. In the case of non-adopters, there were a few farm managers. Most of the AMS adopters and non-adopters had a minimum level of education. However, some had doctoral degrees, in both agriculture and non-agricultural subject. AMS adopters were 35 years old and above, with 20 to 60 years of farming experience. Non-adopters were younger, with more than 10 years of farming experience. While this study found that AMS adopters are older and have more years of farming experience, this is an indicative rather than conclusive finding. None of the dairy farmers who had adopted AMS had definitely identified a successor; in other words, the farmers did not necessarily consider the future generation in their adoption of AMS. Six non-adopters had definitely and possibly identified a successor.

7.2 Objective 2: Factors that facilitate or hinder AMS adoption

The factors that had the greatest influence on AMS adopters and the highest potential for non-adopters are listed below. Most of the farmers agreed that AMS provides these benefits, with the remaining few being neutral or disagreeing with this statement.

Social factors:

- Flexible working hours
- Having a new experience and/or challenges
- Better working conditions
- Animal health and welfare:
- Better animal welfare
- Have more relaxed or calmer cows
- The ability to treat cows as individuals
- Reduced rates of lameness

The other factors that had the greatest influence on AMS adopters were, providing a more relaxed operating system, making better decisions for individual cows, having a better lifestyle, and increased milk production. While these factors were important for non-adopters, they were mostly neutral on whether AMS would actually provide these benefits.

The other remaining factors with the highest potential influence on non-adopters were, more flexible working days, reduced rates of mastitis, reduced opportunities to observe the cows, being attractive to future generations, providing more detailed data and information for individual cow management, and better records of individual milk quality and feed intake. These factors were either less important to AMS adopters or they were neutral that AMS would provide these benefits.

The factors which were important to most of the farmers, but they disagreed that AMS would provide these benefits, are listed below. These factors may be potential barriers for AMS adoption.

Economic factors:

- ➢ An increase in the farm's resale value
- ➢ Reduced milking shed operation, servicing, and maintenance costs

Non-adopters were also concerned about an additional three factors: help with succession planning, and improved profits and financial return. While AMS adopters and non-adopters had different perceptions on which factors were the most important, there were factors which were least important to them, but they agreed that AMS provides these benefits. Both groups stated that AMS provides a better opportunity for individual feeding of cows. AMS adopters noted that the least important factors were less working hours, help with succession planning, and providing a better record of individual cow feed intake. These factors have the potential to influence non-adopters to install AMS. For non-adopters the least important factors were, useful new technologies, a shift in tasks, and automation within a farming enterprise. In contrast, these factors were important to AMS adopters, with many agreeing that AMS provides these benefits.

For AMS adopters, the value of social and animal health and welfare factors were more important than the economic benefits; these resulted in the successful adoption of AMS. However, for non-adopters the opposite was true. They believed that AMS provides social and animal health and welfare benefits, but they stated that the high capital cost of AMS was prohibitive to them.

In terms of individuals or organisations influencing farmers to adopt AMS adoption, the results revealed that what had the most influence on AMS adopters were the resources and publicity materials provided by AMS suppliers and dairy farmers who had already adopted AMS. The milk processors, private consultants, the farmers' children, and farm staff had the least influence. In contrast to AMS adopters, individuals, organisations, and resources had no influence on non-adopters, both in terms of the opinions they held and the respondent's desire to be motivated by their opinions. While printed and online media might spark an interest, they had little influence on most of the farmers' decisions to adopt AMS.

The factors that influence the farmer's ability to adopt AMS in their farming system were the high capital cost of AMS, the implications for traditional calving systems, having skilled labour, available 24/7, receiving ongoing support from AMS dealers, and having the necessary computer skills. AMS installation also requires changes to the traditional farm layout, infrastructure, and grazing system. The adopters noted that most of the requirements and changes were easy to be make, with the exception of the AMS itself which was seen as complex. While the adopters did not find the high capital cost of AMS prohibitive, the opposite was true for non-adopters. Conversely, the non-adopters stated that they would find the requirements and changes difficult, they would have trouble making changes to the seasonal calving system, obtaining ongoing support from AMS manufacturers/dealers and accessing additional technology.

The characteristic of AMS is similar to information-intensive technologies which provide a considerable amount of data and information, and farmers must have a particular skillset in order to interpret the data correctly. It is necessary for the farmers to gain extra skills or attend trainings to leverage the generated data completely. In this study AMS farmers found AMS complex to install. It took one of them almost two years to learn the system. The information-intensive technologies have a lower adoption rate as compared to embodied technologies. Similar to this study, non-AMS farmers found that it is complex to install AMS and this was one of the barriers to AMS non-adopters.

7.3 Objective 3: The perceived impact of AMS on farmer lifestyle and farm operations

Farmers stated that while AMS can reduce labour requirements and the time allocated for milking, they still need workers to perform new tasks, such as training the cows during the initial set-up, checking the computer, entering data, fencing, changing the gates, and cleaning the robots. The farmers noted that they would simply spend the time previously spent on milking performing new tasks and that AMS would provide them with more flexibility in terms of their working day and the hours that they work.

The farmers used different approaches to facilitate the transition from the traditional milking system to AMS. In terms of training the cows, some provided feed and put the cows through the system beforehand. They also had to add new races or extend the existing ones with new fences. They divided the pasture into three and installed new gates to establish 3-way grazing and guided traffic systems. Farmers who had adopted AMS stated that these changes were not difficult to make. In contrast, the farmers who had not adopted AMS reported that these changes would be difficult to make.

7.4 Objective 4: The perceived impact of AMS on animal health and welfare, including cow behaviour

Farmers stated that it was important for them to be able to observe the cows and spot problems in them. They disagreed with the statement that AMS reduces the opportunity to do this. All of the farmers stated that better animal welfare was important for them. All of them agreed that AMS provides this, a perception that is probably linked to their observation of calmer and happier cows and treating them as individuals. All of the farmers stated that reducing rates of lameness and mastitis were important for them and most of them agreed that AMS provides these benefits. Most of the farmers agreed that AMS provides more detailed and better records, data, and information for individual cow management, milk production and quality, and individual cow feeding and feed intake. While they agreed that AMS enabled them to make better decisions for individual cows, they did not believe the same was true for the farm as a whole. After AMS adoption, the farmers found that their cows were calmer, more relaxed, quiet, content, and more independent compared to when they were milked using conventional milking systems.

7.5 Objective 5: The perceived impact on milk production, milk quality, investment and operating costs of AMS

AMS adopters did not see investment in AMS as a financial decision. They were more interested in having a better lifestyle and improved animal health and welfare. Although the farmers reported that increased milk production and improvements in milk quality were important to them, these economic factors did not outweigh the costs of AMS. Significantly, while a few of the farmers found that their milk production increased and milk quality improved, this was not the case for all of them. This was the same for other economic factors, such as improved profits and financial returns, and reduced labour, milking shed operation and maintenance costs. For AMS adopters, the economic factors did not stop them from installing this technology. The economic factors were important for non-adopters, but they did not believe AMS would provide these benefits. The social and animal health and welfare benefits did not outweigh the economic benefits. Therefore, the economic factors were the barriers towards AMS adoption.

7.6 Limitations and future study

While this research has several limitations, it does indicate opportunities for future research.

The first limitation is related to the lack of secondary data about AMS adoption in New Zealand. Most of the published studies took place in the early and late 2000s. This made it difficult to make comparisons between the dairy farmers in terms of their characteristics, initial reasons for AMS adoption, their experience, and achievements.

The second limitation relates to the small number of New Zealand dairy farmers who have adopted AMS in a pastoral-based dairy farming system. This means that the study had a small sample size. At the start of this study, there were only 19 New Zealand dairy farmers who had adopted AMS in a pastoral-based dairy farming system; with seven (37%) agreeing to participate in this study.

The third limitation relates to the nature of dairy farming. Due to their busy schedules, it was challenging to find time to interview the participants, particularly given the in-depth nature of the interview process. This was definitely the case for the AMS adopters who had a greater number of questions. For non-adopters, who may have had limited interest in the subject matter, the in-depth nature of the questions may also have been a barrier to participation.

The fourth limitation was the Covid-19 pandemic which resulted in travel restrictions. This meant that the researcher was not able to travel to interview non-adopters. This study recommends that future research includes a greater number of non-adopters to enable greater quantitative analysis. This study also recommends interviewing key stakeholders in the industry and rural professionals, including AMS suppliers, to ascertain their perceptions of the technology. It would also be useful to widen the study to include other relevant technologies linked to the automation of the management of pastoral systems.

Despite these limitations, this study has provided the following insights. AMS adoption is not necessarily influenced by the socio-demographic factors traditionally associated with technology adoption. This study found that AMS adopters tend to be older, educated, more years of farming experience, and no definite succession plans. Their herds and farms are smaller than the regional averages, where they are located. They want a better lifestyle and are interested in improving animal health and welfare. They see AMS as a way to spend less time in the milking shed. After installation, they confirmed that AMS improves animal health and welfare and does not prevent them from observing the cows or spotting problems. They also noted that the improved profits and financial returns and reduced milking shed and operation costs do not necessarily outweigh AMS' high capital costs. While these economic factors, including the high capital cost, were not prohibitive for AMS adopters, the social and animal health and welfare aspects being more important, this was not the case for the non-adopters.

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Appendix A

First stage of interview survey with AMS adopters

Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

Farmer information

Name	
Contact details	
Email address	
Farm address	

What were the main reasons for AMS adoption?

What are the main advantages of AMS?

What are the main disadvantages of AMS?

Appendix B

Second stage of Interview survey with AMS adopters

Information Sheet

Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

My name is Naz (Nazanin), I am a postgraduate student at Lincoln University, undertaking a PhD. The project presented here is part of my PhD study at Lincoln University.

The purpose of my project entitled "Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)" is to identify the critical factors leading to the successful adoption of automated milking systems (AMS) in New Zealand and barriers towards adoption.

I want to determine the characteristics of dairy farmers who have adopted or have not adopted AMS - exploring the impact of the use (or not) of AMS on: farmer lifestyles and farm operations management, the impact on animal health and welfare, milk production, milk quality, investment and operating costs of AMS for pastoral-based dairy farmers. This is of importance because the uptake of AMS by New Zealand farmers has been relatively limited and you have some understanding of and expertise in this area. The outcome of the project is to provide recommendations and guidance to farmers regarding farmer motivations for adopting the system.

I would like your participation in this project. It involves you participating in an interview involving your answering a set of questions at your farm that include details about your farm business, your adoption reasons, attitudes to/experience of AMS, and if you have adopted AMS on your farm, your achievements and future plans after AMS adoption, and changes as a result of AMS. I can assure you, that the data you provide is confidential and you cannot be identified as you will be anonymous. The data will be held electronically on password protected computers accessible by me, and my Lincoln University supervisors, Professor Alison Bailey and Dr Majeed Safa. Once the raw data has been analysed, it will be disposed of securely to ensure your confidentiality is maintained.

Your participation is entirely voluntary and even if you initially agree to participate, you can withdraw from participation at any time. For this purpose, please do not hesitate to content me by email or phone call to remove your information from my database.

This project has been approved by Lincoln University Human Ethics Committee.

If you have any questions about the project or your involvement in it, please contact me or my supervisor, whose details are at the bottom of this page.

In appreciation of your time, I would like to give you a small thank you gift.

Thank you very much for your help in conducting this research.

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Consent Form

Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

I have read and understood the description of the above-named project. On this basis, I agree to participate as a subject in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved. I understand also that I may at any time withdraw from the project, including withdrawal of any information I have provided, up to April 2020 when Nazanin Mansouri will be nearing completion of her studies.

I consent to having an audio recording made of my interview.

Name: ________________________

Signed: ________________________ Date: ___________________

Section 1: General Information

1. Farmer information

Name	
Contact details	
Email address	
Farm address	
Job role, please state (e.g. owner, manager, share-milker)	
Years in farming	
Years on this farm	

2. Have you identified a successor?

   ☐ Definitely ☐ Possibly ☐ Definitely not ☐ Not relevant

3. Do you operate or work on more than one farm?

   ☐ No (this survey will relate to your only farm or the only farm you work on)

   ☐ Yes (this survey should relate to just one of your farms or just the farm that you predominantly work on)

Section 2: Details of Farm Business

1. Farm information

<table>
<tr><td colspan="5">Farm location (region)</td><td colspan="5"></td></tr>
<tr><td colspan="5">Farm size (hectares)</td><td colspan="5"></td></tr>
<tr><td colspan="5">Effective hectares</td><td colspan="5"></td></tr>
<tr><td colspan="5">Amount of milk produced (kgMS/cow/day)</td><td colspan="5"></td></tr>
<tr><td colspan="5">Who is the milk sold to? (e.g. Fonterra, Synlait)</td><td colspan="5"></td></tr>
<tr><td colspan="5">Dairy: grazing support</td><td colspan="5"></td></tr>
<tr><td colspan="10">Dairy NZ has defined five production systems, depending on the amount of feed imported. Are you aware of this? Which system best defines your farming? (Please indicate the one that best defines your farming system)</td></tr>
<tr><td>System 1</td><td></td><td>System 2</td><td></td><td>System 3</td><td></td><td>System 4</td><td></td><td>System 5</td><td></td></tr>
</table>

*kgMS/cow/day is kg of milk solids per cow per day.

*Effective hectares: Effective Milking Hectares is the true area over which the milking cows graze. When young stock graze even briefly on farm, this grass they consume is no longer available for milking cows, hence the milking platform is effectively reduced. This makes the KPIs comparable between farms that graze heifers on farm and those who graze off.

System 1 - All grass self-contained, all stock on the dairy platform. No feed is imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows are not grazed off the effective milking area.

System 2 - Feed imported, either supplement or grazing off, fed to dry cows. Approx. 4 - 14% of total feed is imported. Large variation in % as in high rainfall areas and cold climates such as Southland, most of the cows are wintered off.

System 3 - Feed imported to extend lactation (typically autumn feed) and for dry cows. Approx. 10 - 20% of total feed is imported. Westland - feed to extend lactation may be imported in spring rather than autumn.

System 4 - Feed imported and used at both ends of lactation and for dry cows. Approx. 20 - 30% of total feed is imported onto the farm.

System 5 - Imported feed used all year, throughout lactation & for dry cows. Approx. 25 - 40% (but can be up to 55%) of total feed is imported.

*Note: Farms feeding 1-2 kg of meal or grain per cow per day for most of the season will best fit in System 3.

2. What is number of Full-time Equivalent (FTE) staff?
3. Herd information

Livestock	**Details**
Herd size	
Herd's breed	☐ Friesian ☐ Jersey ☐ Cross bred ☐ Holstein ☐ Ayrshire ☐ Other:
Dairy: mixed age cows, peak milking	
Dairy: young stock Rising 1-year old (R1) Rising 2-year-old (R2)	
Other:	

4. What is your calving system?
   - ☐ Seasonal calving: where cows calve in one distinct group, spread over 5 months or less; autumn or spring calving
   - ☐ Split or batch calving: where cows calve in two or three distinct groups
   - ☐ Year-round calving: where cows calve over 10 months or more

Section 3: Details of Automated Milking System (AMS)

1. Do you have milking robots? ☐ Yes ☐ No

   * If yes, please answer questions 2 – 4.

   * If no, please move to Section 4
2. Who is your milking robot supplier?
   - ☐ DeLaval ☐ Lely ☐ Other: _______________
3. What year did you install milking robots?

4. Over what time period did you consider AMS before adoption?

    - Less than 1 month   - 1 to 3 month(s)   - 3 to 6 months
    - 6 to 9 months   - 9 to 12 months   - 1 to 2 year(s)
    - More than 2 years

5. How many milking robots do you have?

    - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - Others:

6. What type of traffic system have you got?

    - Free traffic system - Forced traffic system - Others:

Section 4: Questions on your attitudes towards AMS (TPB)

1. **Attitude toward the behaviour**

    i. Behavioural belief strength

How do you think AMS influences the overall farm working environment?

Table 1a: Farm Working Environment

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Better lifestyle						
Frees up time						
Less physical work						
Provides better working conditions						
Provides more up-to-date working conditions						
Provides a more relaxed operating system						

How do you think AMS influences the labour requirement?

Table 2a: Labour Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Less working days						
More flexible working days						
Less working hours						
More flexible working hours						
Leads to a shift in tasks						
Reduces requirement for labour units						
More attractive to future generations						
Helps with succession planning						
Helps with labour recruitment						

How do you think AMS influences milk production?

Table 3a: Milk Production

Strongly Disagree	1	2	3	4	5	Strongly Agree
Increases milk production						
Improves milk quality						

How do you think AMS influences cost of production?

Table 4a: Cost of AMS

Strongly Disagree	1	2	3	4	5	Strongly Agree
Improves profit						
Improves financial returns						
Reduces milking shed operating costs						
Reduces milking shed servicing/maintenance costs						
Reduces labour costs						
Increases the resale value of the farm						

How do you think AMS influences herd health and animal welfare?

Table 5a: Herd's Health and Animal Welfare

Strongly Disagree	1	2	3	4	5	Strongly Agree
Is better for animal welfare						
Cows are more relaxed/calm						
Treats cows as an individual						
Reduces opportunities to observe cows						
Reduces opportunities to spot problems in cows in a timely fashion						
Reduces rates of mastitis						
Reduces rates of lameness						

How do you think AMS influences herd data management?

Table 6a: Herd Data Management

Strongly Disagree	1	2	3	4	5	Strongly Agree
Provides more detailed data and information for individual cow management						
Provides a better record of individual milk production compared to other systems						
Provides a better record of individual milk quality compared to other systems						
Provides better record of individual cow feed intake compared to other systems						
Provides better opportunity for individual feeding of cows compared to other systems						
Allows for better decisions to be made for individual cows						
Allows for better decisions to be made for farm as a whole						

What is it about AMS as a different technology that influences adoption?

Table 7a: Technology

Strongly Disagree	1	2	3	4	5	Strongly Agree
My family have always been at the forefront of adopting new technologies						
AMS is a useful new technology						
Allows for more automation in the farming system						
Provides a new experience and/or challenge						

ii. Outcome evaluation

To what extent do you agree or disagree with the statements below?

Table 1b: Farm Working Environment

Strongly Disagree	1	2	3	4	5	Strongly Agree
Better lifestyle is important to you						
Frees up time is important to you						
Less physical work is important to you						
Better working conditions is important to you						
More up-to-date working conditions is important to you						
A more relaxed operating system is important to you						

Table 2b: Labour Management

Strongly Disagree	1	2	3	4	5	Strongly Agree
Less working days is important to you						
More flexible working days is important to you						
Less working hours is important to you						
More flexible working hours is important to you						
A shift in tasks is important to you						
Reduced requirement for labour units is important to you						
More attractive to future generations is important to you						
Helps with succession planning is important to you						
Helps with labour recruitment is important to you						

Table 3b: Milk Production

Strongly Disagree	1	2	3	4	5	Strongly Agree
Increased milk production is important to you						
Improved milk quality is important to you						

Table 4b: Cost of AMS

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Improved profit is important to you						
Improved financial returns is important to you						
Reduced milking shed operating costs is important to you						
Reduced milking shed servicing/maintenance costs is important to you						
Reduced labour costs is important to you						
Increased the resale value of the farm is important to you						

Table 5b: Herd's Health and Animal Welfare

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Better animal welfare is important to you						
Having more relaxed/calm cows is important to you						
Treating cows as an individual is important to you						
Opportunities to observe cows is important to you						
Opportunities to spot problems in cows in a timely fashion is important to you						
Reduced rates of mastitis is important to you						
Reduced rates of lameness is important to you						

Table 6b: Herd Data Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
More detailed data and information for individual cow management is important to you						
A better record of individual milk production is important to you						
A better record of individual milk quality is important to you						
A better record of individual cow feed intake is important to you						
A better opportunity for individual feeding of cows is important to you						
Better decision making for individual cows is important to you						
Better decisions making at the farm level is important to you						

Table 7b: Technology

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Family history is important to you						
New technologies are important to you						
Automation within your farming enterprise is important to you						
New experiences/challenges are important to you						

2. Subjective Norm

i. Normative belief strength

Who has the most influence in terms of the adoption of AMS on farm?

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
My spouse/partner thinks I should install AMS						
My children think I should install AMS						
Other family members think I should install AMS						
The farm's staff think I should install AMS						
Other farmers with AMS think I should install AMS						
Other farmers without AMS think I should install AMS						
Milk processors think that farmers should install AMS						
Good industry bodies (DairyNZ and Dairy Australia) think that farmers should install AMS						
Private consultants think that farmers should install AMS						
Printed media articles make me think I should install AMS						
Online media makes me think I should install AMS						
Resources of good industry bodies (DairyNZ and Dairy Australia) make me think I install AMS						
Resources/publicity materials provided by AMS suppliers makes me think I should install AMS Please state the name of influencing company:						

ii. Motivation to comply

To what extent do you agree or disagree with the statements below?

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
My spouse/partner motivates me to install milking robots in my dairy farm						
My children motivate me to install milking robots in my dairy farm						
Other family members motivate me to install milking robots in my dairy farm						
The farm's staff motivate me to install milking robots in my dairy farm						
Other farmers with AMS motivate me to install milking robots in my dairy farm						
Other farmers without AMS motivate me to install milking robots in my dairy farm						
Milk processors motivate me to install milking robots in my dairy farm						
Good industry bodies (DairyNZ and Dairy Australia) motivate me to install milking robots in my dairy farm						
Private consultants motivate me to install milking robots in my dairy farm						
Printed media articles motivate me to install milking robots in my dairy farm						
Online media motivate me to install milking robots in my dairy farm						
Resources of good industry bodies (DairyNZ and Dairy Australia) motivate me to install milking robots in my dairy farm						
Resources/publicity materials provided by AMS suppliers motivate me to install milking robots in my dairy farm Please state the name of influencing company:						

3. **Perceived Behavioural Control**
    i. Control belief strength

To what extent do you agree or disagree with the statements below?

To what extent do the following factors influence the ability of an individual farmer to adopt AMS in their farming system? (*3 is neutral/don't know)

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
AMS is complex to install						
AMS has a high capital cost						
AMS requires changes in farm layout						
AMS requires changes to the farm infrastructure						
AMS requires changes in grazing systems						
AMS has implications for seasonal calving						
AMS requires more skilled labour						
AMS requires labour to be on call 24/7						
AMS requires ongoing support from manufacturers / dealers						
AMS requires additional technology						

    ii. Control belief power

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
AMS would be/was complex for me to install						
The capital cost of AMS is/was prohibitive to me						
It would be/was difficult to change the farm layout						
It would be/was difficult to change the farm infrastructure						
It would be/was difficult to change the grazing system						
It would be/was difficult for seasonal calving						
It would be/was difficult to find skilled labour						
It would be/is difficult to have labour on call 24/7						
It would be/is difficult to access ongoing support from manufacturers / dealers						
It would be/is difficult accessing or using the additional technology						

Section 5: Operation and Labour Before and After AMS Adoption

1. What were the main problems before AMS adoption?
2. What are the main reasons for incomplete milking events in your AMS?
3. How often do you face problem with AMS (i.e. receive an alarm)?
   ☐ Daily ☐ Weekly ☐ Monthly ☐ If more than a month, please state ………..
4. What are the main reasons for problems that arise?
5. How long does it take to fix the problem? State
   ☐ Minimum time: ☐ Maximum time: ☐ on average:

6. How do you solve the problem?

   ☐ Yourself ☐ Manufacturer technician ☐ Both ☐ Others:

Cows Training

7. How long did it take to train the cows to adopt AMS?
8. What kind of activities made your training process easier?
9. What kind of activities made your training process difficult?

Voluntary milking

10. How do you manage to deal with the cows hesitating to use AMS?

Number of labour units

11. What was your labour unit before and after AMS adoption?

    ☐ Before: ☐ After:

Working days

12. What was your working days before and after AMS adoption?

    Before:

    After:

Working hours

13. What was your working hours before and after AMS adoption?

    Before:

    After:

Workload

14. What kind of changes have you faced in terms of workload before and after AMS adoption?

    Before:
    After:

Shift in the tasks

15. What tasks are no longer required?
16. What tasks were changed after AMS installation?
17. What new tasks were added after AMS installation?

Grazing system

18. What is your grazing system?
19. What kind of changes did you have to make in the farm's layout to have your new grazing system?

20. How did you manage to adopt your new grazing system?

Traffic system

21. What is your traffic system?
22. What kind of changes did you have to make in the farm's layout to have your new traffic system?
23. How did you manage to adopt your new traffic system?

Gate time changes

24. How many times do you change the gates per day?
25. What time do you change the gates?

Milking shed system/design

26. What kind of changes did you have to make in the farm's layout to have your new barn system?
27. How did you manage to adopt your new barn system?

Welfare

28. Have you seen any changes in cow's behaviour after AMS adoption?

Section 6: Changes as a result of AMS

1. What Changes as a result of AMS did you expect, need, got, not got, like, dislike, or are indifferent to?

Factors	**Expect**	**Need**	**Got**	**Not Got**	**Like**	**Dislike**	**Indifferent**
Additional features/functions provided by the robotic milking system, e.g. data provision							
Milk quality improvement							
Milk production increased							
Milking process improved							
Beneficial in terms of cow's welfare							
Mastitis reduced							
Lameness reduced							
Costs:							
Investment required							
Operational costs reduced							
Labour costs reduced							
Maintenance costs reduced							
Labour:							
Working hour reduced							
Workload reduced							
Tasks changed							
Software and mobile application adopted							
Changes in the farm's layout							
Milking shed infrastructure adapted							
Grazing system adapted							
Traffic system adapted							

1. What did you hope to achieve when you adopted AMS?
2. Did you achieve your goals?
3. Is there anything you would like to see in the future of AMS which is not currently available in terms of technology, farm system adoption, or support?
4. What are your future plans/goals?

Section 7: Personal Information

1. What is the highest level of education you have attained? Please tick the appropriate box.
   - ☐ No formal education
   - ☐ Certificate (level 1 to 4) ☐ Diploma (level 5 to 6)
   - ☐ Bachelor's degree in agriculture ☐ Bachelor's degree in non-agriculture
   - ☐ Postgraduate diploma in agriculture ☐ Postgraduate diploma in non-agriculture
   - ☐ Postgraduate certificate in agriculture ☐ Postgraduate certificate in non-agriculture
   - ☐ Master's degree in agriculture ☐ Master's degree in non-agriculture)
   - ☐ Doctoral degree in agriculture ☐ Doctoral degree in non-agriculture
2. Age group:
   - ☐ Less than 18 years old ☐ 18 - 24 years old ☐ 25 - 34 years old
   - ☐ 35 - 44 years old ☐ 45 - 54 years old ☐ 55 - 64 years old
   - ☐ More than 64 years old
3. Gender: ☐ Female ☐Male

Do you wish to receive the outcomes of the project? ☐ Yes ☐ No

Thank you for your time.

Appendix C

Second stage of interview survey with AMS non-adopters

Information Sheet

Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

My name is Naz (Nazanin), I am a postgraduate student at Lincoln University, undertaking a PhD. The project presented here is part of my PhD study at Lincoln University.

The purpose of my project entitled "Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)" is to identify the critical factors leading to the successful adoption of automated milking systems (AMS) in New Zealand and barriers towards adoption.

I want to determine the characteristics of dairy farmers who have adopted or have not adopted AMS - exploring the impact of the use (or not) of AMS on: farmer lifestyles and farm operations management, the impact on animal health and welfare, milk production, milk quality, investment and operating costs of AMS for pastoral-based dairy farmers. This is of importance because the uptake of AMS by New Zealand farmers has been relatively limited and you have some understanding of and expertise in this area. The outcome of the project is to provide recommendations and guidance to farmers regarding farmer motivations for adopting the system.

I would like your participation in this project. It involves you participating in an interview involving your answering a set of questions at your farm that include details about your farm business, your adoption reasons, attitudes to/experience of AMS, and if you have adopted AMS on your farm, your achievements and future plans after AMS adoption, and changes as a result of AMS. I can assure you, that the data you provide is confidential and you cannot be identified as you will be anonymous. The data will be held electronically on password protected computers accessible by me, and my Lincoln University supervisors, Professor Alison Bailey and Dr Majeed Safa. Once the raw data has been analysed, it will be disposed of securely to ensure your confidentiality is maintained.

Your participation is entirely voluntary and even if you initially agree to participate, you can withdraw from participation at any time. For this purpose, please do not hesitate to content me by email or phone call to remove your information from my database.

This project has been approved by Lincoln University Human Ethics Committee.

If you have any questions about the project or your involvement in it, please contact me or my supervisor, whose details are at the bottom of this page.

In appreciation of your time, I would like to give you a small thank you gift.

Thank you very much for your help in conducting this research.

Project Investigator: Naz (Nazanin) Mansouri
Email: nazanin.mansouri@lincolnuni.ac.nz
Phone: 022 3812267

Project Supervisor: Professor Alison Bailey
Email: alison.bailey@lincoln.ac.nz
Phone: 03 4230226

Consent Form

Technology Adoption in New Zealand pastoral-based system: A study of Automatic Milking System (AMS)

I have read and understood the description of the above-named project. On this basis, I agree to participate as a subject in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved. I understand also that I may at any time withdraw from the project, including withdrawal of any information I have provided, up to April 2020 when Nazanin Mansouri will be nearing completion of her studies.

I consent to having an audio recording made of my interview.

Name: _______________________

Signed: _______________________ Date: ___________________

Section 1: General Information

4. Farmer information

Name	
Contact details	
Email address	
Farm address	
Job role, please state (e.g. owner, manager, share-milker)	
Years in farming	
Years on this farm	

5. Have you identified a successor?

   ☐ Definitely ☐ Possibly ☐ Definitely not ☐ Not relevant

6. Do you operate or work on more than one farm?

   ☐ No (this survey will relate to your only farm or the only farm you work on)

   ☐ Yes (this survey should relate to just one of your farms or just the farm that you predominantly work on)

Section 2: Details of Farm Business

5. Farm information

<table>
<tr><td colspan="4">Farm location (region)</td><td colspan="6"></td></tr>
<tr><td colspan="4">Farm size (hectares)</td><td colspan="6"></td></tr>
<tr><td colspan="4">Effective hectares</td><td colspan="6"></td></tr>
<tr><td colspan="4">Amount of milk produced (kgMS/cow/day)</td><td colspan="6"></td></tr>
<tr><td colspan="4">Who is the milk sold to? (e.g. Fonterra, Synlait)</td><td colspan="6"></td></tr>
<tr><td colspan="4">Dairy: grazing support</td><td colspan="6"></td></tr>
<tr><td colspan="10">Dairy NZ has defined five production systems, depending on the amount of feed imported. Are you aware of this? Which system best defines your farming? (Please indicate the one that best defines your farming system)</td></tr>
<tr><td>System 1</td><td></td><td>System 2</td><td></td><td>System 3</td><td></td><td>System 4</td><td></td><td>System 5</td><td></td></tr>
</table>

*kgMS/cow/day is kg of milk solids per cow per day.

*Effective hectares: Effective Milking Hectares is the true area over which the milking cows graze. When young stock graze even briefly on farm, this grass they consume is no longer available for milking cows, hence the milking platform is effectively reduced. This makes the KPIs comparable between farms that graze heifers on farm and those who graze off.

System 1 - All grass self-contained, all stock on the dairy platform. No feed is imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows are not grazed off the effective milking area.

System 2 - Feed imported, either supplement or grazing off, fed to dry cows. Approx. 4 - 14% of total feed is imported. Large variation in % as in high rainfall areas and cold climates such as Southland, most of the cows are wintered off.

System 3 - Feed imported to extend lactation (typically autumn feed) and for dry cows. Approx. 10 - 20% of total feed is imported. Westland - feed to extend lactation may be imported in spring rather than autumn.

System 4 - Feed imported and used at both ends of lactation and for dry cows. Approx. 20 - 30% of total feed is imported onto the farm.

System 5 - Imported feed used all year, throughout lactation & for dry cows. Approx. 25 - 40% (but can be up to 55%) of total feed is imported.

*Note: Farms feeding 1-2 kg of meal or grain per cow per day for most of the season will best fit in System 3.

6. What is number of Full-time Equivalent (FTE) staff?
7. Herd information

Livestock	**Details**
Herd size	
Herd's breed	□ Friesian □ Jersey □ Cross bred □ Holstein □ Ayrshire □ Other:
Dairy: mixed age cows, peak milking	
Dairy: young stock Rising 1-year old (R1) Rising 2-year-old (R2)	
Other:	

8. What is your calving system?
   - □ Seasonal calving: where cows calve in one distinct group, spread over 5 months or less; autumn or spring calving
   - □ Split or batch calving: where cows calve in two or three distinct groups
   - □ Year-round calving: where cows calve over 10 months or more

Section 4: Questions on your attitudes towards AMS (TPB)

4. **Attitude toward the behaviour**

   iii. Behavioural belief strength

How do you think AMS influences the overall farm working environment?

Table 1a: Farm Working Environment

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Better lifestyle						
Frees up time						
Less physical work						
Provides better working conditions						
Provides more up-to-date working conditions						
Provides a more relaxed operating system						

How do you think AMS influences the labour requirement?

Table 2a: Labour Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Less working days						
More flexible working days						
Less working hours						
More flexible working hours						
Leads to a shift in tasks						
Reduces requirement for labour units						
More attractive to future generations						
Helps with succession planning						
Helps with labour recruitment						

How do you think AMS influences milk production?

Table 3a: Milk Production

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Increases milk production						
Improves milk quality						

How do you think AMS influences cost of production?

Table 4a: Cost of AMS

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Improves profit						
Improves financial returns						
Reduces milking shed operating costs						
Reduces milking shed servicing/maintenance costs						
Reduces labour costs						
Increases the resale value of the farm						

How do you think AMS influences herd health and animal welfare?

Table 5a: Herd's Health and Animal Welfare

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Is better for animal welfare						
Cows are more relaxed/calm						
Treats cows as an individual						
Reduces opportunities to observe cows						
Reduces opportunities to spot problems in cows in a timely fashion						
Reduces rates of mastitis						
Reduces rates of lameness						

How do you think AMS influences herd data management?

Table 6a: Herd Data Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Provides more detailed data and information for individual cow management						
Provides a better record of individual milk production compared to other systems						
Provides a better record of individual milk quality compared to other systems						
Provides better record of individual cow feed intake compared to other systems						
Provides better opportunity for individual feeding of cows compared to other systems						
Allows for better decisions to be made for individual cows						
Allows for better decisions to be made for farm as a whole						

What is it about AMS as a different technology that influences adoption?

Table 7a: Technology

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
My family have always been at the forefront of adopting new technologies						
AMS is a useful new technology						
Allows for more automation in the farming system						
Provides a new experience and/or challenge						

iv. Outcome evaluation

To what extent do you agree or disagree with the statements below?

Table 1b: Farm Working Environment

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Better lifestyle is important to you						
Frees up time is important to you						
Less physical work is important to you						
Better working conditions is important to you						
More up-to-date working conditions is important to you						
A more relaxed operating system is important to you						

Table 2b: Labour Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Less working days is important to you						
More flexible working days is important to you						
Less working hours is important to you						
More flexible working hours is important to you						
A shift in tasks is important to you						
Reduced requirement for labour units is important to you						
More attractive to future generations is important to you						
Helps with succession planning is important to you						
Helps with labour recruitment is important to you						

Table 3b: Milk Production

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Increased milk production is important to you						
Improved milk quality is important to you						

Table 4b: Cost of AMS

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Improved profit is important to you						
Improved financial returns is important to you						
Reduced milking shed operating costs is important to you						
Reduced milking shed servicing/maintenance costs is important to you						
Reduced labour costs is important to you						
Increased the resale value of the farm is important to you						

Table 5b: Herd's Health and Animal Welfare

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Better animal welfare is important to you						
Having more relaxed/calm cows is important to you						
Treating cows as an individual is important to you						
Opportunities to observe cows is important to you						
Opportunities to spot problems in cows in a timely fashion is important to you						
Reduced rates of mastitis is important to you						
Reduced rates of lameness is important to you						

Table 6b: Herd Data Management

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
More detailed data and information for individual cow management is important to you						
A better record of individual milk production is important to you						
A better record of individual milk quality is important to you						
A better record of individual cow feed intake is important to you						
A better opportunity for individual feeding of cows is important to you						
Better decision making for individual cows is important to you						
Better decisions making at the farm level is important to you						

Table 7b: Technology

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
Family history is important to you						
New technologies are important to you						
Automation within your farming enterprise is important to you						
New experiences/challenges are important to you						

5. **Subjective Norm**

    iii. Normative belief strength

Who has the most influence in terms of the adoption of AMS on farm?

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
My spouse/partner thinks I should install AMS						
My children think I should install AMS						
Other family members think I should install AMS						
The farm's staff think I should install AMS						
Other farmers with AMS think I should install AMS						
Other farmers without AMS think I should install AMS						
Milk processors think that farmers should install AMS						
Good industry bodies (DairyNZ and Dairy Australia) think that farmers should install AMS						
Private consultants think that farmers should install AMS						
Printed media articles make me think I should install AMS						
Online media makes me think I should install AMS						
Resources of good industry bodies (DairyNZ and Dairy Australia) make me think I install AMS						
Resources/publicity materials provided by AMS suppliers makes me think I should install AMS Please state the name of influencing company:						

iv. Motivation to comply

To what extent do you agree or disagree with the statements below?

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
My spouse/partner motivates me to install milking robots in my dairy farm						
My children motivate me to install milking robots in my dairy farm						
Other family members motivate me to install milking robots in my dairy farm						
The farm's staff motivate me to install milking robots in my dairy farm						
Other farmers with AMS motivate me to install milking robots in my dairy farm						
Other farmers without AMS motivate me to install milking robots in my dairy farm						
Milk processors motivate me to install milking robots in my dairy farm						
Good industry bodies (DairyNZ and Dairy Australia) motivate me to install milking robots in my dairy farm						
Private consultants motivate me to install milking robots in my dairy farm						
Printed media articles motivate me to install milking robots in my dairy farm						
Online media motivate me to install milking robots in my dairy farm						
Resources of good industry bodies (DairyNZ and Dairy Australia) motivate me to install milking robots in my dairy farm						
Resources/publicity materials provided by AMS suppliers motivate me to install milking robots in my dairy farm Please state the name of influencing company:						

6. **Perceived Behavioural Control**

iii. Control belief strength

To what extent do you agree or disagree with the statements below?

To what extent do the following factors influence the ability of an individual farmer to adopt AMS in their farming system? (*3 is neutral/don't know)

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
AMS is complex to install						
AMS has a high capital cost						
AMS requires changes in farm layout						
AMS requires changes to the farm infrastructure						
AMS requires changes in grazing systems						
AMS has implications for seasonal calving						
AMS requires more skilled labour						
AMS requires labour to be on call 24/7						
AMS requires ongoing support from manufacturers / dealers						
AMS requires additional technology						

iv. Control belief power

Strongly Disagree	**1**	**2**	**3**	**4**	**5**	**Strongly Agree**
AMS would be/was complex for me to install						
The capital cost of AMS is/was prohibitive to me						
It would be/was difficult to change the farm layout						
It would be/was difficult to change the farm infrastructure						
It would be/was difficult to change the grazing system						
It would be/was difficult for seasonal calving						
It would be/was difficult to find skilled labour						
It would be/is difficult to have labour on call 24/7						
It would be/is difficult to access ongoing support from manufacturers / dealers						
It would be/is difficult accessing or using the additional technology						

Section 7: Personal Information

4. What is the highest level of education you have attained? Please tick the appropriate box.
    - ☐ No formal education
    - ☐ Certificate (level 1 to 4) ☐ Diploma (level 5 to 6)
    - ☐ Bachelor's degree in agriculture ☐ Bachelor's degree in non-agriculture
    - ☐ Postgraduate diploma in agriculture ☐ Postgraduate diploma in non-agriculture
    - ☐ Postgraduate certificate in agriculture ☐ Postgraduate certificate in non-agriculture
    - ☐ Master's degree in agriculture ☐ Master's degree in non-agriculture)
    - ☐ Doctoral degree in agriculture ☐ Doctoral degree in non-agriculture
5. Age group:
    - ☐ Less than 18 years old ☐ 18 - 24 years old ☐ 25 - 34 years old
    - ☐ 35 - 44 years old ☐ 45 - 54 years old ☐ 55 - 64 years old
    - ☐ More than 64 years old
6. Gender: ☐ Female ☐Male

Do you wish to receive the outcomes of the project? ☐ Yes ☐ No

Thank you for your time.