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Investigating crop and dairy complementarities within a Canterbury farming system

*Case Studies from the Mid-Canterbury region, New Zealand.*

A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Commerce (Agriculture)

at

Lincoln University
Canterbury
New Zealand

by
Sally Peel

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By Sally Peel

In Canterbury, the majority of dairy farmers use their land as an intensive milking platform and rely on feed and grazing from other sources for dry cows and young stock. As a result, the Canterbury cropping sector is closely linked to the dairy sector. This thesis investigates the integration and complementarities that can occur when arable farmers take a further step and convert part of their land to an intensive milking platform. In the seven case studies analysed, the drivers of land-use change were a combination of profitability, personal lifestyle needs and risk management through diversification of income. Dairy farming was attractive because it was a simple system with a reduced workload compared to their current crop systems. Lower order sharemilkers and/or managers responsible for dairy staff were crucial to meet the lifestyle needs of the farmer. In all cases the farmers had the desire to continue cropping as it was the farming system they enjoyed.

There was evidence that diversification did reduce volatility of income. The other benefits achieved through the synergies resulting from vertical integration were reduced transaction costs through reliable crop markets and access to dairy feed. The case study farmers had a higher stocking rate and per cow production than industry averages.

Some of the case study farms had adjoining or overlapping crop and dairy land, whereas others had separate land parcels. The case studies were categorised by land sharing and levels of complementarity. While adjoining land may increase some synergistic benefits the level of interaction can vary. A framework was developed for the case studies allowing them to be categorized into three groups: complementary due to spatial separation, integration through amalgamation and in-transition where the case study farm was transitioning away from diversification and into full dairy farming.
The case study farmers saw mixed farming as a success, six of the seven case study farmers aimed to continue both crop and dairy farming. All the case study farmers were intensive crop farmers before conversion and therefore had a specialised skill-set related to cropping. These existing skills allow the case study farmers to maintain cropping within their operations. There are implications as to whether the complementarities will pass through to the next generation if the skill-set in crop is not passed on.
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# TABLE OF CONTENTS

Abstract ...................................................................................................................................... i
Acknowledgements ................................................................................................................... iii
Table of Contents ....................................................................................................................... v
Table of Figures ......................................................................................................................... xi
Table of Tables ......................................................................................................................... xii
Glossary ................................................................................................................................... xiii

## CHAPTER 1 INTRODUCTION ............................................................................................. 1

1.1 Overview .......................................................................................................................... 1
1.2 Background and research opportunity ............................................................................ 2
1.3 Aim ................................................................................................................................... 4
1.4 Research Questions ......................................................................................................... 5

## CHAPTER 2 REVIEW OF LITERATURE ......................................................................... 6

2.1 Introduction ..................................................................................................................... 6
2.2 Overview of changing land use and farm development in Canterbury ......................... 6

2.2.1 Dairy Industry ............................................................................................................ 6
2.2.2 Arable Industry ........................................................................................................ 10
2.2.3 Comparing crop and dairy profitability ................................................................... 13

2.3 Mixed farming systems .................................................................................................. 15

2.3.1 International mixed farming systems ...................................................................... 15
2.3.2 The problem with farmer decision making in a mixed system. .............................. 17

2.4 The Interaction between crop and livestock ................................................................. 19

2.4.1 Description of farms systems .................................................................................. 19
2.4.2 Defining complementarities in the farm system ..................................................... 21
2.4.3 Proposed framework to find synergies in Canterbury mixed systems ................. 23
2.4.4 Differentiating between diversification and vertical integration .......................... 26
2.4.5 Mixed farming approaches: Within-farm and among-farm integration ............... 26
2.4.6 Further categorisation to describe practices involving integration ..................... 29
2.5 Agricultural sustainability and the role of ‘synergy’ in mixed farming .................... 32
2.6 Current crop-dairy research in New Zealand ......................................................... 34
2.7 Areas of deficiency and summary of chapter 2 ...................................................... 35

CHAPTER 3 METHODOLOGY ....................................................................................... 37
3.1 Introduction ............................................................................................................. 37
  3.1.1 Hypothesis ......................................................................................................... 37
3.2 Type of research ..................................................................................................... 38
3.3 Selection of the sample .......................................................................................... 39
3.4 Data Collection ...................................................................................................... 39
3.5 Confidentiality Issues ............................................................................................ 40

CHAPTER 4 CASE STUDY PROFILES ......................................................................... 41
4.1 Introduction ............................................................................................................ 41
4.2 FARMER A ........................................................................................................... 41
  4.2.1 Introduction ....................................................................................................... 41
  4.2.2 Reasons for conversion and the chosen farm system ....................................... 42
  4.2.3 How the systems run and how they are integrated ......................................... 43
  4.2.4 Profitability (and justification of the farm system) ........................................... 46
4.3 FARMER B ........................................................................................................... 49
  4.3.1 Introduction ....................................................................................................... 49
  4.3.2 Reasons for the conversions ............................................................................. 49
  4.3.3 The farm systems ............................................................................................. 50
    4.3.3.1 Crop farm ...................................................................................................... 50
5.5.2 Sharing of machinery resources ................................................................. 83
5.5.3 Land use synergies .................................................................................. 83
5.5.4 Supplementary feed ............................................................................... 84
5.5.5 Information sharing and farmer knowledge ............................................. 85
5.5.6 Environmental synergies ....................................................................... 85
5.5.7 Summary ............................................................................................... 85

5.6 What was the process of adoption and development? How did the physical attributes of the properties influence farm development and the available synergies? .......... 86
5.6.1 The process of dairy adoption ................................................................. 86
5.6.2 Farm physical attributes influencing synergies and development ............. 87
5.6.3 Summary ............................................................................................... 87

5.7 What were the challenges and successes of partial conversion? What are the future plans and proposed developments? ............................................................... 87
5.7.1 Summary ............................................................................................... 88

5.8 How do the identified complementarities fit relative to prior theoretical frameworks on farm system complementarities? ......................................................... 88
5.8.1 Villano’s synergistic relationships applied to the case studies .................. 89
5.8.2 Classification of system complementarities .............................................. 90
5.8.2.1 Organisation: Applying system complementarities ............................. 90
5.8.2.2 Space: Types of system complementarities ........................................ 93
5.8.2.3 Time: Type of synergies ................................................................. 93
5.8.3 Creating an applicable framework .......................................................... 94
5.8.4 Summary ............................................................................................... 96

5.9 Conclusion ............................................................................................... 98
5.10 Limitations of research ........................................................................... 99
5.11 Future research ....................................................................................... 100

REFERENCES ................................................................................................. 101
# TABLE OF FIGURES

**Figure 1:** Canterbury Region: Land area under dairy (milking platforms) 2001-2011. ............7

**Figure 2:** Trend overtime for New Zealand dairy farms in the 5 production systems (Sinclair, 2011). ........................................................................................................................................ 9

**Figure 3:** Total imports of palm kernel extract (PKE) 2004-2010. ..........................................10

**Figure 4:** Inflation-adjusted indices of agricultural commodity prices (1980-81 to 2007-08) (Pangborn & Woodford, 2011). ................................................................................................ 12

**Figure 5:** Cash operating surplus/ha for arable and dairy in Canterbury (2000-12). ..........14

**Figure 6:** Farm profit before tax/ha for arable and dairy in Canterbury (2002-12). ............14

**Figure 7:** Dairy farm income and arable farm income (per effective area in crop), in Canterbury (2001-12.). .............................................................................................................. 15

**Figure 8:** The many layers of factors that farmers take into account in their decision making. Adapted from McGackian & Rickards (2011). ................................................................. 17

**Figure 9:** An overview of the five central factors landholders take into account when assessing any new innovation or technology. Adapted from Pannell et al. (2006). ..........18

**Figure 10:** Proposed synergies between crop and dairy based on the framework from Villano et al. (2010). .................................................................................................................. 24

**Figure 11:** A nested categorisation to describe practices that involve interaction of crop and livestock enterprises on large-sized commercial farms. Adapted from: Bell and Moore (2012) ........................................................................................................................................ 31

**Figure 12:** A nested categorisation to describe practices that involve interaction of crop and dairy enterprises ................................................................. 92

**Figure 13:** Case Study farms development since 1980 and the systems adaption to complementary approaches ................................................................. 97

**Figure 14:** Conclusion of Theory ....................................................................... 98
TABLE OF TABLES

Table 1: Information required for decision making for integrated crop-livestock systems. (Russelle et al. 2007, p.g 329 )........................................................................................................................27

Table 2: Farmer A, current estimated Crop income and EBIT Aim (2011/12). ..................45

Table 3: Farmer A, Comparison of crop and dairy profitability .............................................47

Table 4: Farmer A, dairy EBIT at $7.90 and $5.50 per kilogram of milk solids. .................48

Table 5: Summary of the seven case studies (1) .................................................................76

Table 6: Summary of the seven case studies (2)..................................................................77

Table 7: A comparison between the averages for the Ashburton District and the case study averages.........................................................................................................................79

Table 8: Application of two integration categorisation models to the case studies ..........94
**Dairy Support (DSL):** Land that provides support to the milking platform by wintering cows, grazing replacements and growing supplements. The word ‘runoff’ is a common term referring to DSL which is owned by the dairy farmer.

**EBIT:** Earnings before interest and tax.

**NCI:** Net Cash Income is earnings before interest and tax. NCI can differ from EBIT as it only includes the farm’s actual cash receipts and expenses in a given year regardless of the year goods were sold or produced. NCI serves as a good indicator of the short-term financial condition of agricultural producers.

**Lower order sharemilking:** Sharemilking is an arrangement where the farm owner and the sharemilker enter into a contract. The sharemilker gets a percentage of the milk solid income (commonly between 15-35%) in return for providing limited capital assets, the labour required and its management.

**Milking Platform (MP):** A milking platform is a parcel of land used exclusively for feeding lactating cows.

**Supplementary feed:** Feed supplied to stock in addition to pasture.

**KPI:** Key Performance Indicator.
CHAPTER 1
INTRODUCTION

1.1 Overview
The majority of cropping farms on the Mid-Canterbury plains are operated as mixed systems, growing crops integrated with livestock. Historically, sheep breeding and/or finishing has been the livestock component of these systems. The relative profitability of dairy support and the demand from the dairy industry for supplements has resulted in a decrease in mixed crop systems with sheep enterprises and a rise in dairy support. This progression into the dairy feed market has increased farm diversification and is an example of horizontal integration.

Dairy support land is an integral component of the Canterbury dairy industry as most farms operate with a ‘milking platform’ structure. A milking platform can be defined as a parcel of land used exclusively for feeding lactating cows. Consequently, a dairy farm is reliant on supplementary feed, heifer grazing and wintering support. This support role is increasingly replacing other crop markets or is being integrated into crop rotations, either as a replacement for sheep or for lower returning crops. Further, as dairy farms aim to increase their production, both per ha and per cow, the reliance and demand for dairy support services is becoming greater.

The purpose of this thesis was to investigate a further level of integration between cash cropping, dairy support and the milking platform. Primarily, the focus was on cropping farmers who had diversified or integrated (if crop used for dairy feed) their farms to include a milking platform within their farm system. Industry informants had observed the development of a complementary relationship between crop and dairy enterprises owned or managed by the same farmer or farming families. This thesis confirms and defines the existence of these observed systems by investigating the synergies which exist between crop and dairy. Further, this thesis has aimed to understand the drivers behind the development of complementary and integrated systems and thus understand the efficiencies of these systems.
1.2 Background and research opportunity

Dairy farming has expanded in Canterbury with an increase in dairy land from less than 20,000 hectares in the early 1980s to nearly 200,000 hectares in 2009-10 (Pangborn & Woodford, 2011). Pangborn (2012) theorised that this increase in dairy land occurred in three waves (or periods) of development.

The first wave of dairy development was in the early 1980s. These farms were generally established by farmers who were from the historical dairy areas in the North Island. The drivers of this ‘dairy movement’ to Canterbury included lower land prices in Canterbury relative to elsewhere in New Zealand, the development of irrigation, new technology and the reduced profitability of traditional sheep and beef farming systems.

The second wave of development was in the 1990s. This wave of conversion was mostly undertaken by corporate entities; however sheep farmers (with limited cropping) also converted to obtain higher levels of profitability. In the late 1990s many of the corporate entities exited the dairy industry due to low operating profits. When they exited the industry, many sold their farms to their current sharemilkers and thus created a new generation of farm owners.

Wave 3 was recognized in the 2000s. Within this period, established farmers from other sectors (such as large arable farms) converted their farms to dairy. The main driver of Wave 3 according to Pangborn (2012) was increased profitability of the farming system.

Based on the research from Pangborn (2012) and Pangborn and Woodford (2011), it is hypothesised that the complementary crop and dairy farms are most likely in the Wave 3 conversions. This hypothesis is consistent with industry informants noting that complementary crop and dairy farms owned and/or managed by the same farmer are a recent phenomenon. The recent development of these systems creates a research opportunity relevant to the dairy industry at this time.

The lack of published or available information about farming entities with both crop and dairy may be due to the recent development of these systems. Data on these farms are not available in databases from applied research and information transfer organisations (e.g.
FAR\(^1\), DairyNZ\(^2\). As a result there has been little research into the drivers of these farms and the levels of integration that exists in these systems. These farms often do not fit easily into the 5 Production Systems model\(^3\) (Hedley et al., 2006).

Although there has not been research focused purely on complementary crop and dairy in a pastured based system, the idea of complementary or mixed systems has been under discussion. There has been a resurgence of interest in crop-livestock farming internationally from both researchers and the popular media (Herrero et al., 2010; Hilimire, 2011; Pollan, 2006; Tanaka, Karn, & Scolljegerdes, 2008). In New Zealand, both the fields of science and management (in a farming context) have recently acknowledged integrated dairy and crop (Bryant, Lambert, Brazendale, Holmes, & Fraser, 2010; Dynes, Burggraaf, Goulter, & Dalley, 2010; Macdonald et al., 2012; Pangborn & Woodford, 2011). Dynes et al. (2010) and Pangborn & Woodford (2011) note that they anticipated the advancement of closer integration between crop and dairy in commercial farming. Pangborn and Woodford (2011, p. 86) stated: “We foresee closer integration between crop farming and dairying, with the increased use of annual crops for feed, particularly by cropping farmers who convert part of their farm to dairying.”

Other research on the Canterbury dairy industry has informed this thesis topic. Sinclair’s (2011) dissertation documented a variety of drivers for operating system 5 (high input) farms. The research found that contrary to popular belief, grain based dairy systems could be profitable in Canterbury and the number of system 5 farms had increased. Richards (2006) documented dairy runoff management and profitability in the Canterbury region. The results from this dissertation showed that many runoffs had diversified into beef fattening, cropping and growing feed for the open market. This diversified their income stream and increased their profitability and improved their risk profile. Although this research did not look at the synergies that existed between the different land-uses it highlighted that a level of dairy-related mixed-farming operations existed in Canterbury.

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\(^1\) FAR: Foundation of Arable Research is the industry-good applied research and information transfer organisation for the NZ arable industry.

\(^2\) DairyNZ: Is the industry-good organisation applied research and information transfer organisation for the NZ dairy industry.

\(^3\) The 5 Production Systems model is a systems model which categorises New Zealand dairy platforms based on the level of imported feed required by their system. The model is in appendix 1.
The lack of research in complementary farm systems, the seemingly current interest in crop and dairy systems and the results of past research indicated a ‘research gap’ and an opportunity for research.

1.3 Aim

The research aimed to explore the primary issue of:

*What are the complementarities that exist within a crop and dairy farming system in Mid-Canterbury, New Zealand?*

More specifically, the aim of this project was to investigate the interrelationship and synergies between crop and dairy production on either arable farms that had a partial dairy conversion or arable farmers that had invested in a milking platform in addition to their current arable enterprise. This investigation aimed to identify the level of integration or complementarity in these systems, the drivers behind the chosen mixed system, and develop an understanding of the merits or efficiencies of the chosen system, with comparison to an appropriate framework.

Interviews with industry informants suggested that these complementary farm systems existed in two forms. The two forms were:

1. Complementary crop and dairy systems run as one enterprise (operated as a single parcel of land)
2. Complementary relationships between crop and dairy farms owned and/or managed by the same farmers, but operated as separate business entities.

This research intended to gain insights into the synergies and drivers of these complementary farm systems. All case studies were in the Mid-Canterbury region which is defined as the area of the Ashburton District Council. The district is bounded by the Rakaia and Rangitata Rivers in the north and south, the Pacific Ocean in the east and the Southern Alps in the West.

An aspect that arose within the case studies is that in some cases the cropping and dairy farm are co-located and in other cases the farms are sited in different locations. These differences will be noted in the results and discussion sections.
1.4 Research Questions

1. What were the drivers of conversion?
2. What synergies exist between crop and dairy?
3. What was the process of adoption and development? How did the physical attributes of the properties influence both farm development and the available synergies?
4. What were the challenges and successes of the system? What are the future plans and proposed developments?
5. How do the identified complementarities fit relative to prior theoretical frameworks on farm system complementarities?
CHAPTER 2
REVIEW OF LITERATURE

2.1 Introduction
This literature review will briefly examine Canterbury dairy and crop systems and the development and comparative profitability of these systems. The review will then highlight the critical points of current knowledge on mixed farming systems, and examine the adoption of these systems in both westernised and developing countries. This review discusses the creation of mixed systems through farmer decision-making, examines the synergies between crop and dairy, and observes the different approaches and types of integration suggested through appropriate frameworks. The last area of focus is crop-dairy research from New Zealand and why there has been recent interest in farm integration involving a dairy platform. Much of the literature in this review is classed as ‘popular literature’, appearing in farmer conference proceedings, government documents and other online publications. The investigative nature of this research means that popular literature is both necessary and important in being able to provide information on the current industry within one region.

2.2 Overview of changing land use and farm development in Canterbury

2.2.1 Dairy Industry
Dairy farming has expanded rapidly in Canterbury since the 1980s (Pangborn & Woodford, 2011). This expansion of a farming sector is not a new feature of Canterbury. Since the settlement of Canterbury, the region has experienced significant land use change (Manhire, 2010, as cited in Dynes et al., 2010, p. i). The major drivers of land use change include the development of resources such as accessible stock water and irrigation and the relative profitability of the different land uses (Ashburton District Council, n.d. A; Dynes et al., 2010). In the late 1970s and early 1980s, attempts were made to milk cows on irrigated light lands of Canterbury with the ‘take-off’ of dairy in terms of substantial land use change beginning in the early 1990s (Pangborn & Woodford, 2011). The increase in dairy land was made possible by the availability of land from farmers who were exiting cropping and sheep production.
(Dynes et al., 2010; Pangborn & Woodford, 2011). In addition, a number of ‘mixed farms’ (sheep with crop) also converted to dairy. Some farmers became involved in equity partnerships or employed a sharemilker as a means of acquiring equity and knowledge on dairy farm management (Pangborn & Woodford, 2011).

Land use statistics reveal that dairy conversions have continued in the last decade with land area in dairy (milking platforms) and production in the Canterbury region showing an increase between 2001 and 2012 (Figure 1). Canterbury dairy production increased from 2% to 17% of New Zealand total milk production from 1982-83 to 2009-10 (Pangborn, 2012). The number of dairy herds in Canterbury has grown from 226 herds in 1982-83 to 846 herds in 2009-10 and the size of the average herd has grown from 89 cows in the 1980-81 season to 730 cows in the 2009-10 season (Pangborn, 2012).

![Figure 1: Canterbury Region: Land area under dairy (milking platforms) 2001-2011. Data based on information from LIC, (2012).](image_url)

From 1990 to 2011, ewe numbers fell 47% and the numbers of lambs tailed in the Canterbury region fell 43% (Statistics New Zealand, 2012). Additionally, between 2002 and 2007 the cropping area in Canterbury decreased by 6% (Manhire, 2010, as cited in Dynes et al., 2010, p. i). Dynes et al. (2010) noted a change in land use from mixed cropping farms with sheep to mixed cropping farms with dairy support. This land use change is a response to
feed demand from the dairy industry and relatively lower sheep and crop market prices (Dynes et al., 2010).

The Ashburton District Council refers to their district as a traditional sheep and grain growing region, which has had a recent shift to dairy and dairy support. The Council’s economic statistics showed dairying and milk production contributed 8.5% to the district’s economic output in 2010, up from 3.9% in 2000. By comparison, sheep and beef contributed 16.8% in 2010 which was down from 17.5% in 2000 (Ashburton District Council, n.d. B). The District runs from the Canterbury Plains into the Southern Alps hence the region includes high country which has topographical and climatic limitations to land use, being only suitable for sheep, cattle and deer.

A notable feature of the increase in dairy land is improved per hectare production. Production per hectare is higher in Canterbury than any other region (Pangborn, 2012). Production per ha is the result of stocking rate and per cow production. In the season 1982-83, the stocking rate stood at 1.7 cows/ha in Canterbury compared to 2.2 cows/ha in the North Island (LIC, 2012). In the 2010/11 season, the Canterbury stocking rate stood at 3.27 cows/ha compared to the North Island at 2.72 cows/ha (LIC, 2012). Average per cow production for the Canterbury region in 2012 was 395kgMS/cow. By comparison, the New Zealand average was 363kgMS/cow (LIC, 2012). The Ashburton District’s average milk production in 2012 was 406kgMS/per cow, the second highest (per cow) producing region in New Zealand (LIC, 2012). Canterbury has similar income and expenses per kilogram of milk solids to any other region, however due to higher production per hectare, operating surpluses per hectare are higher than elsewhere (Pangborn, 2012).

Dairy farming in Canterbury is intensive with large inputs of supplementary feed, irrigation and off-platform wintering. The majority of farmers purchase feed not only for winter but also to extend either one end or both ends of lactation (Dynes et al., 2010). The 5 Production Systems Model categorises dairy platforms based on the percentage of externally supplied

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4 Ashburton district is 6,175 square kilometres in central Canterbury. Agriculture underpins the Ashburton economy, and it is at the forefront of NZ’s agricultural industry. All the case-studies in this thesis are in this district.

5 A ‘district’ is a defined area within a regional council [Canterbury]. The Canterbury region is divided into 10 district councils to localise decision-making.
feed inputs. The definitions for each system are explained in appendix 1. Using the 5 Production Systems model, dairy systems in New Zealand are intensifying (figure 2). In 2005/06, 51% of all New Zealand farms were system 1 and system 2, but by the end of 2008 this had reduced to 42%, and the percentage of system 3 and 4 farms had increased from 46% to 54% with system 5 farms increasing from 1% in 2000 to 4% of farm systems in 2009/10.

In Canterbury, the majority of dairy farmers use their land as an intensive milking platform and rely on feed and grazing from other sources for dry cows and young stock. This supporting land includes run-offs separate to the defined milking platform either as adjoining land (often marginal) or separate farms and non-dairying land (either leased land or land farmed by others) to provide supplementary feed and grazing (MacLeod & Moller, 2006). Research on run-offs in the Canterbury region showed that although wintering dairy cows and supplying supplement to the dairy farm were among the most important uses, there were also other uses for a dairy run-off which contributed to the profitability of the system (Richards, 2006). These uses included heifer grazing, dairy beef and cash cropping.

Supplementary feed used on the milking platform can be from a run-off or from non-dairy land in the local area such as silage from a crop farmer. Alternatively supplementary feed
can be imported from overseas at a competitive price. Clark, Monaghan, Sharp and Thorrold (2007) mention that from 1997 to 2007 costs associated with supplements and pastures increased by 70% (not including nitrogen) making them the biggest operating cost (excluding debt servicing) for dairy farmers. Imported ingredients utilised include products such as bran, pollard, cotton seed, palm kernel expeller and linseed (MacLeod & Moller, 2006), and these contribute to the total imported feed used by systems two through to five in the DairyNZ, 5 Production Systems model. Palm kernel expeller (PKE) has increased 12-fold from 2004 to 2010 (figure 3).

![Figure 3: Total imports of palm kernel extract (PKE) 2004-2010. Annual tonnage Data based on information from NZFMA (2010).](image)

**2.2.2 Arable Industry**

The second relevant agricultural farming system in Canterbury is arable farming. In Canterbury, arable farms are defined to include the production of milling wheat, feed wheat, barley, oats, maize grain, maize silage, other cereals, field peas, herbage seed, vegetable seed, potatoes, beans, peas and brassicas (MPI, 2012a). In the year 2007, the region had 212,000 hectares in grain and fodder crop which was half of New Zealand’s total fodder and crop land (Statistics New Zealand, 2008). Furthermore, in 2004 the Ashburton District alone produced 50% of New Zealand’s grain and 60% of the small seed production (Evans, 2004).

Most farmers run a mixed cropping system where arable crops are grown in a rotation with pasture or clover for grazing and/or seed production. Possibly the most significant
complementary system in Canterbury is arable farms growing crops integrated with livestock. US researchers such as Hendrickson, Hanson, Tanaka & Sassenrath (2008) have viewed New Zealand arable crop-sheep systems as an example of successful farm integration.

Livestock are an important part of an arable farm for financial returns and also for restoring organic matter to support the depletive cropping phases. In most livestock-crop systems there are two to four years of crop production which causes degradation of soil properties; this is followed by two to four years of subsequent grazing of grass-clover swards which increases N input, soil aggregate quality, soil porosity and soil earthworm population (Haynes & Francis, 1990). This integration of crop and livestock also includes a wide variety of practices such as the utilisation of crop stubbles (Scott, 1982), inclusion of animal feed crops into crop rotations and the grazing of small seed crops (Dynes et al., 2010). Other types of integration include stored feed rather than in situ grazing e.g. ryegrass straw from a ryegrass seed crop for winter supplement, utilising effluent produced by the livestock system to fertilise arable land, and shared labour and resources (Feng, Letey, Chang, & Campbell Mathews, 2005).

The nature of the livestock enterprise in arable farming is changing. A common modification to the arable system is a movement away from livestock income from sheep breeding and lamb finishing to trading and contract based grazing systems (Dynes et al., 2010). These contract based systems allow the farmer to have fewer capital stock units with the current emphasis being dairy support (Dynes et al., 2010). Dairy support can include carrying non-lactating cows on farm for in-situ grazing as well as selling supplements as stored feed (cut and carry). The change from sheep to dairy support has been driven by the lower risk and higher returns available (MPI, 2012a). Further, MPI (2012a) noted that providing dairy support for dairying neighbours reduced fuel, time and labour expenses normally incurred by the arable farmer when delivering grain and seed to main centres.

There is persistent land-use pressure on crop farmers to convert to dairying due to the advantage of dairy farming’s increased profitability and consistent cashflow (MPI, 2012a). However, despite a decrease in land area for crop production, the total production of crops has increased due to yield increases (Pyke, 2011). The arable and cropping farms in the
Ashburton District contributed 9.3% to the district’s economic output in 2010 up from 8.9% in 2000 (Ashburton District Council, n.d. B). New Zealand crop farmers are innovative and modern in their approach to production, and although New Zealand arable production is small on a global scale, New Zealand crop farmers are recognized for their extremely high yielding crops such as barley, ryegrass seed, wheat and maize (Pyke, 2011).

Although arable farmers are physically highly productive they are facing pressures. These pressures include low commodity prices (see figure 4: wheat index compared to dairy index), high input costs (fertiliser and fuel), demands for environmental stewardship regulation, lack of government investment and lastly the land-use pressure from dairy farmers (Pyke, 2011). Some of these pressures are also reflected in the dairy industry, the most obvious being environmental concerns and the pressure for more sustainable systems.

Figure 4: Inflation-adjusted indices of agricultural commodity prices (1980-81 to 2007-08) (Pangborn & Woodford, 2011).
2.2.3 Comparing crop and dairy profitability

A tool for farm financial performance is the Ministry of Primary Industry’s (MPI), farm monitoring reports.

Figures 5, 6 and 7 use data taken the MPI farm monitoring reports for arable (MPI, 2012a) and dairy (MPI, 2012b) for the Canterbury region. The figures are based on assumptions stated in the 2012 reports but include comparative figures from earlier reports (2000-12).

These figures use the following calculations:

Cash operating surplus = gross farm income - farm working expenses

Farm profit before tax = cash operating surplus - interest - depreciation - rent.

The Canterbury dairy monitoring report for the 2011/12 season is drawn from information from 30 farms that were chosen to typify an average farm. The budget figures are averaged from the contributing farms and adjusted to represent a real dairy farm (MPI, 2012b).

The arable monitoring report for the season 2011/12 represents 500 properties larger than 100ha located in Canterbury. The model is created from information from 18 arable farms. These farms generate more than 50% of their income from growing crops, and have some type of stock enterprise as an integral part of the system. The 2011/12 model has an effective area of 300 hectares, 1289 sheep stock units and 92% of the effective area in crop. The mains crops are wheat, grass seed, and barley (MPI, 2012a).

The cash operating surplus was greater for dairy compared to arable for twelve of the thirteen years recorded since the year 2000 (Figure 5). Farm profit before tax was greater for dairy than arable nine of the eleven years recorded (Figure 6).
Figure 5: Cash operating surplus/ha for arable and dairy in Canterbury (2000-12)

Figure 6: Farm profit before tax/ha for arable and dairy in Canterbury (2002-12)
Figure 7: Dairy farm income and arable farm income (per effective area in crop), in Canterbury (2001-12.)

Because the MPI monitoring report includes sheep within the arable farm, figure 7 attempts to compare the gross farm income from only crop (divided by the productive cropping area annually) with the gross farm income from dairy (milk solids, dividend, cattle income/ha). The farm profit or cash operating surplus of crop only (without sheep), cannot be measured because expenses in the arable model have not been distributed between the sheep and cropping operations. The question that arises in regard to figure 7 is whether the mix of crops modelled in the monitoring report is a clear reflection of the crops grown on non-sheep arable farms in Canterbury.

2.3 Mixed farming systems

2.3.1 International mixed farming systems

The development of agricultural systems which combined crops and animals was established 8-10 millennia ago (Smith, 1995). This was to grow a range of products to feed a family as well as to allow the utilisation of crop residuals and the use of animal manure to improve fertility. In the last 60 years, crop and livestock farming have separated as farms have specialised and increased in intensity (Russelle, Endz, & Franzluebbers, 2007).
However, mixed farm systems are still used internationally as a means of increasing production, sustainability and intensity. These systems involve several sub-sectors such as crops, animals or fish which interact in a mutually beneficial way (Devendra, 1999). Edward et al., (1988) suggests that the interaction of these sectors creates a total benefit which is greater than the sum of the individual sector types. According to Devendra (1999) and Devendra & Thomas (2002), most literature on crop-livestock systems has come from developing countries. These authors apply the integrated farming system to small-holder farming in the continents of Asia and Africa, where much of this integration includes the use of animals for draught power (Devendra, 1999). However, many of the reasons for integrated farming or mixed farming could also be applicable to westernised farming systems. The integration of crop and animals can be used to maintain a low cost system, using crops in multi-purpose roles (human and animal consumption) and providing the farm with diversification (Devendra, 1999).

North American farms have been practicing specialization, but have renewed their interest in integrated farms because of concerns about natural resource degradation, profitability and sustainability of farm income, long term sustainability and increased regulation of concentrated animal feed (Russelle et al., 2007). Russelle et al. (2007) noted that integrated crop and livestock systems could create a diverse cropping system by including perennial and lucerne forages and utilising animal manure to enhance soil tilth, fertility, and carbon sequestration.

Southern and Eastern Australia use integrated systems in what is commonly called the ‘Wheat–Sheep Zone’ (Villano, Fleming, & Fleming, 2010). In this region the crop-livestock system is needed to stay profitable in the face of declining terms of trade and sustainability threats (Endz et al., 2005; Ewing & Flugge, 2004). Integration gives the system a high degree of flexibility to respond to economic signals and innovation. Ewing and Flugge (2004) note that the physical and financial stability of crop livestock production systems arises from the whole farm financial outcome, which is buffered against economic fluctuations with similar profits achieved across a range of physical strategies. Ewing and Flugge (2004) also recognize that in order to deal with sustainability challenges such as salinity and acidity there is a likelihood that integrated systems will retain their importance in Australia. Villano et al. (2010) reinforces this, stating that there are few farms in the region which specialize in a
single enterprise with most continuing to diversify across several enterprises and a flexible production strategy.

2.3.2 The problem with farmer decision making in a mixed system.

As highlighted by Australian researcher Cooper (2011), there has been extensive studies into the process of farmer decision making. Snowden (2003) classified decisions as being simple, complicated, complex or chaotic. McGackian (2006) applied Snowden’s (2003) theories of decision making to mixed farms, suggesting that mixed farms often undertake complex decision making. McGackian & Rickards, (2011) claim that complex decisions involve many factors and may have many ‘right’ answers. In mixed farming there are many considerations which are constantly changing. Often many of the factors involved are unknown, difficult to quantify or their influence on relationships is poorly understood (McGackian & Rickards, 2011). Additionally they note that the relative complexity of mixed system decision making can be increased in family operated farms due to the consideration of family elements in the decision making process. Such considerations include family labour, family preference, targets and services, opportunities in the local community, off farm income, large family expenses, holidays and farm succession. There is a range of farm production decisions encased in non-farm or non-production concerns (figure 8).

Figure 8: The many layers of factors that farmers take into account in their decision making. Adapted from McGackian & Rickards (2011).
This complexity means that the farmer cannot simply look at the merits of a new scheme; the farmer must look at how the new scheme would fit into the whole system. Work by Pannell et al. (2006) has identified key influences on whether a farmer is likely to adopt a new innovation or enterprise. These factors are summarised in figure 9.

An Australian social research project called the ‘Grain and Graze project’ confirmed the five influences on farmer’s willingness and ability to change (McGackian, 2006; McGackian & Rickards, 2011). When questioned in an interview situation, as to how they made decisions a typical farmer response included “can’t tell you the exact figures but we know what is profitable” (McGackian, 2006). The project found that although mixed farmers used gross margins, bench-marking, accountant figures and information from consultants to aid their decisions, the outcomes from these tools were not crucial in their final decision making (McGackian & Rickards, 2011).

The typical responses given by farmers were summarised into two main points:

Figure 9: An overview of the five central factors landholders take into account when assessing any new innovation or technology. Adapted from Pannell et al. (2006).
1. The tools to make the decisions were not adequate to make complex farm decisions and/or farmers didn’t know how to use them.
2. Due to the complexity of the decisions (including unknown synergies, variables and risks) detailed assessment of costs and returns is considered of little value.

The findings from this study were that social factors predominately determine decisions about land use. The Grain and Graze study suggested the mixed system (Australian crop and livestock model) designed by farmers is driven by four main factors. These factors are:

1. Hassle reduction: a desire to keep a system simple and avoid complexity.
2. Labour: the desire to use labour more efficiently and the ability to find it when required.
3. Recreational: the desire to find recreation time.
4. Personal preference: the desire for a system that include the enterprises which the farmer enjoys.

2.4 The Interaction between crop and livestock

2.4.1 Description of farms systems

Mixed farm systems have been assigned to system models by different researchers. Hendrickson et al. (2008) differentiated mixed systems based on intensity and developed five categories of differentiation.

1. Basic Agricultural Production Systems
   This is the simplest agricultural production system; it usually has no more than two enterprises. The example used by Hendrickson et al. (2008) is a wheat-fallow rotation. In this system the annual land use has been pre-determined and the producer’s management skills are focused on only one of the crops because there is only one enterprise for the economic unit at the one time. Another example is confined animal production. Management decisions are predetermined and may be made off-farm, the production is focused on delivering a single, consistent commodity to a food processor.
2. **Diverse Agricultural Production Systems**
   The production systems contain three or more crop or livestock types but strategic management of each enterprise is generally predetermined and follows a set of best management practices. The examples used by Hendrickson et al. (2008) include a fixed crop rotation or a crop-livestock farm in which the interactions between the crop and livestock farm are limited and enterprises are managed in a pre-determined manner.

3. **Dynamic Agricultural Production systems**
   These production systems rely on annual strategies in order to optimize the outcome of production, economic, and resource conservation goals thus allowing producers to use production components that result in optimal production with a minimal input cost. These systems differ to the diverse systems above because management is not pre-determined, instead crop types and livestock can be adjusted annually based on potential returns and weather conditions.

4. **Integrated Agricultural Production Systems**
   These production systems are agricultural systems with multiple enterprises that interact in space and time. The interactions result in a synergistic resource transfer among enterprises. An example used by Hendrickson et al. (2008) is an integrated livestock-crop production unit where manure from livestock is added to crop land and a portion of the grain or the crop residual is fed to livestock. However these systems may not be dynamic, as management may be pre-determined.

5. **Dynamic-Integrated Agricultural Production Systems**
   These are production systems with multiple enterprises that are managed like the dynamic agricultural systems in that they interact in space and/or time to create interactions resulting in synergetic resource transfer between the enterprises. Dynamic-integrated agricultural production systems are structurally similar to integrated agricultural systems but need a higher level of management.
New Zealand dairy farms are generally basic agricultural production systems as defined in the system model above by Hendrickson et al. (2008), with the primary focus of producing milk for a milk processor. However, there could be opportunities for New Zealand dairy farms to move towards the integrated agricultural production system or the dynamic-integrated production system model based on multiple enterprises operating in space and time (Hendrickson et al., 2008) in order to decrease inputs and increase efficiencies from both an economic and environmental perspective.

Schiere, Ibrahim and van Keulan (2002) described four agricultural approaches.

1. Expansive agriculture, where land is abundant.
2. Low external input agriculture, where shortage of land cannot be overcome by migration. A lack of capital means more labour and skill is required to increase production. Demand is limited by resource availability.
3. High external input agriculture where demand for output or profitability determines input levels; sometimes leading to environmental degradation.
4. New conservation agriculture, where production goals are matched with the resource base to achieve both profitability and environmental benefits.

Russelle, Endz and Franluebbers (2007) suggest that it is in the last category that crop-livestock integration would have the largest role to play in western farming; however there is no evidence to suggest New Zealand dairy farmers have the desire to fit into this category.

2.4.2 Defining complementarities in the farm system

Before system interactions can be explained, complementarities and synergy need to be defined. Complementary or shared enterprises are often referred to as integrated or mixed systems (Tanaka et al., 2008). The commonly used term ‘integrated farming’ creates ambiguity as it is used to describe a range of systems which are not monocultures. Tanaka et al. (2008) observed that there were a number of terms and concepts associated with ‘integrated crop and livestock production’ that are not universally or postively accepted by scientists. These terms and concepts include: alternative agriculture, organic agriculture, reduced-input sustainable agriculture and the perception that alternative agriculture is a return to low-technology production methods of the past. Further, ‘integrated systems’ get associated with diversified systems but these are defined as separate systems in section
2.4.4. To reduce the ambiguity, mixed crop and dairy farms in this thesis have been referred to as systems operating with complementarities.

Complementarity between two outputs can be defined as “any situation where increasing output contributes to increasing the marginal product of the other output” (Villano et al., 2010, p. 146). Milogram and Roberts (1995) defined complementarity to include the benefits that arise from making joint decisions about multiple goods and activities. Parmmigiani and Mitchell (2009) observed that this definition of complementarity encompassed the concept of system effects that arise when the whole is greater than the sum of its synergy parts.

Synergies are defined by Corning (2002) and recognized by Villano, Fleming and Fleming (2008) as the combined or cooperative effects that are produced by two or more elements or parts. In most farm situations there is a competitive relationship between farm enterprises but synergies can reduce the extent of this competition and accentuate the economic advantages of combining farm enterprises (Villano et al., 2010).

A distinction needs to be made between synergies from complementarities and scope economies. Economies of scope exists when for all outputs $y_1$ and $y_2$, the cost of joint production is less than the cost of producing each of the outputs separately (Panzar & Willig, 1975).

$$c(y_1, y_2) < c(y_1, 0) + c(0, y_2)$$

Complementary synergy may result in a greater output but with the possibility that it is at a greater cost (Villano et al., 2010). Thus the presence of complementarity does not guarantee, nor is it necessary or sufficient for scope economies to exist (Villano et al., 2010).

However, an enterprise mix on farms may be chosen to exploit scope economies, gained from diversification. Scope economies can accentuate the economic advantages of integrating farm enterprises and thus can be referred to as ‘cost complementarities’ (Villano et al., 2008). Further, when vertical integration exists (one product is an input in the production of another product) Perry (1989) states that if this internal transfer of the intermediate product is less costly than the market exchange, then this reflects the existence
of vertical economies of scope. This may arise through reduced transaction costs relative to those of non-integrated firms.

Within farming systems Villano et al. (2008) categorized four ways in which scope economies can arise:

1. **Jointness in outputs**: When one farm input can be used in the production of more than one farm output.
2. **Jointness in inputs**: More than one output is produced from the same set of inputs.
3. **Jointness between independent production processes**: when the production processes generate independent outputs but are linked where an output from one process is an input into the second process.
4. **Flexibility in production**: The ability for a business to adjust to changed circumstances at relatively little cost, thereby generating scope economies.

### 2.4.3 Proposed framework to find synergies in Canterbury mixed systems.

To further understand the synergies that exist in complementary or mixed systems for Canterbury crop and dairy, a framework which classifies the synergies will be utilised. Corning (2002) classified the different forms of synergy that relate to the presence of complementarities and Villano et al. (2010) applied the concepts to farm enterprises to create a framework for the Australian wheat-sheep zone. The five forms of synergy in the framework are: functional complementarity, augmentation, combining of farm resources, information-sharing and joint decision-making and cost and risk sharing. Figure 11 proposes how the crop and dairy farm model fits within the framework.
1. Functional complementarity can be defined as the “properties or capabilities that join forces to give the combination new functional characteristics” (Corning, 2002, p. 22). New functional characteristics often come about through research and development for example crop breeding research may result in a crop variety which has more nutritious stubble for winter feed (Villano et al., 2010). This example is shown by the blue arrows in figure 11. Other examples include using crop covers to increase soil fertility or enhance the biological control of pests; and the integration of livestock to achieve higher biomass output and optimal recycling of nutrients (Altieri, 2001).
2. Augmentation is when one product facilitates production in another process (Villano et al., 2010) while the first product remains unchanged (Corning, 2002). The processes of the integrated enterprises are linked because an output of one process is the input in another process. An example is where manure is an input to increase crop production. This example is shown by the green arrows in figure 11. A second example is using crop residues to feed animals (Villano et al., 2010).

3. Combining farm resources refers to “how specialized skills, tools, and production operations [are] combined into an organised system” (Corning, 2002, p. 27). Differences in seasonality of production in and between farm enterprises often results in a varied pattern of labour, land and managerial demand (Villano et al., 2010). Farming systems can be selected to smooth out labour and decision-making demands to enable farm resources to be used more productively over the farming year (Villano et al., 2010). In figure 11, the red arrows show the sharing of resources between the two systems. The shared resources could be a resource such land or labour, shared to smooth out seasonality demand.

4. Information sharing and joint decision making. Through diversification and integration, information sharing and joint decision can be beneficial to both enterprises. Information collected for one enterprise could be useful when applied to the other (Villano et al., 2010). Examples include local weather and climatic information, biological information about production processes, information processing and accounting skills gained by the farmer and the farm operators. These could be seen as an input gained without a cost or with a very low cost when applied to other enterprises (Evenson & Huffman, 1997).

5. Cost and risk-sharing refers to enterprises combining to share costs of farm inputs and services. Various buildings and machinery may serve more than one enterprise. Multiple possible outputs initiate flexibility enabling risk-sharing across different enterprises. A more diversified farm system (with multiple outputs) gives a greater ability to adapt to changed circumstances at a lower cost (Villano et al., 2010).
2.4.4 Differentiating between diversification and vertical integration
Villano et al., (2008) said synergies can be exploited and complementarities can be gained from diversification, while Sumner and Wolf, (2002) noted the potential for complementarity within vertical integration. This highlights two possible system methods in which complementarity can be gained within one farming business. Sumner and Wolf, (2002) studied how the difference between diversification and integration relates to dairy farm size in the United States thus defining diversification and integration in relation to dairy. Vertical integration is the production of farm inputs that might have otherwise been purchased from outside suppliers. Diversification is the presence of multiple production enterprises with distinct marketed outputs in a single management unit. While diversification by firms, as by investors, has long been conferred as a method of migrating risk, vertical integration is driven by factors such as the uniqueness of a firms inputs, the cost of access to relevant markets, and the quantity and quality of fixed inputs which are required by the firm (Sumner & Wolf, 2002). The similarity is, when applied to dairy farms both diversification and vertical integration involves farm enterprises beyond milking cows and selling milk (Sumner & Wolf, 2002).

2.4.5 Mixed farming approaches: Within-farm and among-farm integration
There are two levels of livestock-crop integration as described by Russelle et al. (2007) (a) within-farm integration, and (b) among-farm integration. Endz et al. (2005) states that both of these systems are worth further scientific study and in both types of crop-livestock integration, synergies and complementarities can exist.

Steinfeld (1998) argues that in time, agriculture will move from a local (within-farm) to a regional scale where integration operates among farms within a region or community. Integration developing to a regional level is appealing to large scale agribusiness and policy makers who have interest in large industrial sized systems with a smaller number of stakeholders. Hilimire (2011) notes that under regional integration there is much less actual integration on each individual farm. Endz et al. (2005) provide examples which highlight both systems as well-practised and efficient farming approaches. A list of information required in these systems indicates the high degree of management required, at either level of integration (table 1).
Table 1: Information required for decision making for integrated crop-livestock systems. (Russelle et al. 2007, p.g 329 )

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Information required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term profit</td>
<td>• crop yield</td>
</tr>
<tr>
<td></td>
<td>• crop residual and feeding value</td>
</tr>
<tr>
<td></td>
<td>• amount and distribution of pasture yield</td>
</tr>
<tr>
<td></td>
<td>• input costs</td>
</tr>
<tr>
<td></td>
<td>• output value (market, government program payments, other payments such as Carbon trading)</td>
</tr>
<tr>
<td>Multi-year factors</td>
<td>• rotation benefits (reduced need for N and pesticides, improved soil condition)</td>
</tr>
<tr>
<td></td>
<td>• symbiotic N(_2) fixation</td>
</tr>
<tr>
<td></td>
<td>• residual fertiliser</td>
</tr>
<tr>
<td></td>
<td>• weed populations</td>
</tr>
<tr>
<td>Whole-farm factors</td>
<td>• farm size and spatial distribution of field (rented and owned)</td>
</tr>
<tr>
<td></td>
<td>• machinery size and availability for different enterprises</td>
</tr>
<tr>
<td></td>
<td>• labour availability, ability and cost</td>
</tr>
<tr>
<td></td>
<td>• financing (availability, flexibility of banker, cost)</td>
</tr>
<tr>
<td>Risk factors</td>
<td>• yield variability (edaphic, climatic and biotic constraints)</td>
</tr>
<tr>
<td></td>
<td>• price variability (market, hedging opportunities, price stabilization programmes, covariance with yield, insurance)</td>
</tr>
<tr>
<td></td>
<td>• risk acceptance or aversion</td>
</tr>
<tr>
<td></td>
<td>• responsiveness (flexibility, willingness to adopt new practices)</td>
</tr>
<tr>
<td>Sustainability factors</td>
<td>• persistence of perennials (reseeding and purchased feed costs)</td>
</tr>
<tr>
<td></td>
<td>• weed populations (herbicide resistance and herbicide residuals)</td>
</tr>
<tr>
<td></td>
<td>• soil condition and sensitivity (erosion, soil organic matter content, salinity, acidification)</td>
</tr>
<tr>
<td></td>
<td>• off-site impacts (water quality, total maximum daily load limits, salinity, wildlife, aesthetics)</td>
</tr>
</tbody>
</table>

This research project is interested in both among and within-farm integration. Within-farm integration has benefits in relation to on-farm diversity (Endz et al., 2005). On-farm diversity addresses site specific problems (e.g. soil erosion) and exploits site specific opportunities (e.g. predator-prey relationship in ecological pest control). Another advantage of within-farm integration is a social benefit as individual farmers maintain more control of their production systems (Endz et al., 2005).
Within-farm integration can be divided into a number of further systems based on spatial land use. The following classification outlines the temporal and spatial combination of animals and plants in a within-farm integrated system (Hilimire, 2011).

1. **Spatially Separated**
   In this type of integrated system, animals are maintained in a separate part of the farm such as permanent pasture, feedlot or a barn. Permanent pasture is located on part of the farm that is never cropped and feed supplements and forage crops can be grown on other areas of the farm.

2. **Rotational**
   Animals and crops occupy the same field but at different times. An example is the traditional New Zealand arable mixed farming system.

3. **Fully Combined**
   Animals graze beneath or in between crops. This is common in orchards and vineyards where crops are too tall or unpalatable for animal foraging. Fully combined systems could also exist where animals are integrated post-harvest to feed on crop residue.

One of the important drivers of within-farm integration is risk and a farmers risk preference. Although uncertainty and risk surrounds all forms of activity, Culas and Mahendrarajah (2005) consider risk to be a greater problem in agriculture due to the influence of natural factors such as climate. The general risks most farmers face include: climatic factors, pest and disease, price uncertainty and policy surrounding agriculture production, marketing and trade. Diversification (of which integration is an example) can be an insurance against some of the factors of risk. A farmer may give up a larger expected return by means of specialisation in order to insure against risk though diversification (Culas & Mahendrarajah, 2005).

According to Endz et al. (2005) the advantages of among-farm integration over on-farm integration relate mostly to labour and economic efficiency. Further, among-farm integration conforms to the industrial model of centralisation and standardisation better than within-farm integration.
Steinfeld (1998) and Powell (2004) suggested that the evolution of crop-livestock integration began with separated crop and livestock, integration and then specialisation before the development of among-farm integration. Endz et al. (2005) found that among-farm integration was a transition in response to an event. The excess of manure nutrients at a farm scale and the opportunity to recycle manure nutrients through crops were examples of two events which led to among-farm integration.

2.4.6 Further categorisation to describe practices involving integration

Australian researchers Bell and Moore (2012) observed that there are many different styles of integration which lie on a continuum from no integration through to full integration. However they noted that it is not possible to simply rank these systems according to a single-dimensional “degree of integration”, rather Bell and Moore (2012) recognised that the situation was more complex.

Sumberg (2003) proposed that integration should be described in four dimensions; space, time, ownership and management. In the space dimension, activities were ranked by physical distance from each other, with co-location at the integrated end of the spectrum. The time dimension conveys the idea that enterprises occur concurrently (simultaneously) or can be separated in time (in-sequence). The remaining dimensions ‘ownership’ and ‘management’ are ‘organisational’ rather than ‘physical’. Ownership describes the degree that control and access to the assets of the multiple ventures are concentrated into the same hands. Management encases the idea that management of the different enterprises may not be the hands of the same individual or group.

Bell and Moore (2012) applied a variation of Sumberg (2003)’s four dimensions to Australian mixed farms in figure 11. The Sumberg dimensions were simplified by Bell and Moore (2012) to fit the Australian model. Ownership and management were merged into the heading ‘organisational’ because the Australian mixed farms, similar to New Zealand are family farms where ownership and the direction of management usually remains in the hands of one household or business partnership. Even in the common situation where members of a farming family take responsibility for operating different enterprises, strategic decisions will be made as a whole business and income will be shared, thus management is still aligned with ownership. As a result of Bell and Moore’s (2012) ‘simplification’, the
dimensions of integration are viewed as a set of four levels of crop-livestock integration. These four levels are explained in figure 11. The table in figure 11 lists a range of farming practices and classifies the practices according to the dimensions in which they bring about beneficial exchanges between crop and livestock production.
Figure 11: A nested categorisation to describe practices that involve interaction of crop and livestock enterprises on large-sized commercial farms. The practices are aligned with time, space and the organisational dimensions of integration. Adapted from Bell and Moore (2012).
2.5 Agricultural sustainability and the role of ‘synergy’ in mixed farming

The interest in sustainability in this review is due to recent dairy system development and research in Canterbury has focused on balancing profitability with environmental responsibility (DairyNZ, 2013). In an international context, mixed systems have been associated with sustainable systems (Devendra, 1999; Russelle et al., 2007; Stokes, McAllister, & Ash, 2006). The integration of crop and livestock offers synergies (between crop, livestock and soil) that farmers can build into their operations (Villano et al., 2010). These synergies of mixed farming can increase efficiency in the system (van Keulen & Schiere, 2004) and therefore build toward a more sustainable system. Russelle et al. (2007) noted integration can reduce risk because it diversifies production and that reducing risk could be a form of economic sustainability. In Europe integrated farming is advocated as a sustainable approach to agricultural production which can maintain farmer income and safeguard the environment (Morris & Winter, 1999).

Agricultural sustainability is a broad term used to encompass both the economics and environmental aspects of agriculture internationally. The concept of sustainability in agriculture has emerged as an important factor in both conventional plant and animal systems of production (Hendrickson et al., 2008). It is therefore a major component when analysing animal and plant systems in agricultural production. Sustainability can be defined as:

“An approach to producing food and fibre which is profitable, uses on-farm resources efficiently to minimize adverse effects on the environment and people, preserves the natural productivity and quality of land and water, and sustains vibrant rural communities” (UCSUSA, 2005 cited in Hendrickson et al., 2008, p. 268).

Lyson (2002) breaks sustainable agriculture down into three clear dimensions; 1) ecological 2) economic and 3) social – community. The economic aspects of sustainability have been regarded as relevant in the agricultural industry for decades. The social aspect of sustainability as a concept is far newer (Thiesse, 2010). Furthermore, it is the social aspect which is becoming a driver for change in developed countries (Thiesse, 2010). There is, however, difficulty around the definition of the social aspect. This arises because it is not based on economic research or science, rather on concepts, business strategies, opinions
and preferences of a personal nature (Thiesse, 2010). Weil (1990) defined the social sustainability concept and public welfare concerns as food safety, human exposure to toxic chemicals and environmental concerns based on human preference for landscape aesthetics. Thiesse (2010) suggests that the farmers’ view of risk could also be part of the social concept as it is based on the personal nature and the application of strategy by the farmer.

Certain crops grown on milking platforms can increase the sustainability of the dairy system (Johnstone et al., 2010). First, crop production can be used to increase supplementary feed made on farm and reduce the use of imported feeds. However, it must be noted that imported feeds are often chosen because they are a lower cost alternative.

Nutrient loading can be high in dairy farm soils that are regularly irrigated with shed effluent. There are negative effects on the environment and on animal health which can occur as a consequence (Houlbrooke, Horne, Hedley, Snow, & Hanly, 2008; Wang, Magesan, & Bolan, 2004). Maize (unlike some crops) is ideal for mining nutrients on dairy farms because it commonly produces a biomass above 20 tonne per hectare (Li et al., 2009). At average P, N and K concentrations in the maize plants tissue, crop removal can easily exceed 250kg N, 40kg P and 250kg K per/ha/season (Johnstone et al., 2010). In 2007, a three year project to monitor nutrient loading impacts through the strategic use of maize commenced (Johnstone et al., 2010). Nine on-farm trials showed that nitrogen fertiliser is not needed to maximise maize silage yield for a first season crop which was planted in nutrient-rich, effluent treated soils. Using maize on effluent soils not only reduced the fertiliser requirement, it was also shown to reduce residual soil mineral N levels at harvest (Johnstone et al., 2010).

Integration of crops on dairy farms has also been recognized as a method of using dairy shed effluent (Selvarajah, 1999) to improve soil properties and plant nutrient availability with less fertiliser. It is estimated that six to ten percent of daily dairy excreta is deposited in the milking shed or yards and when the shed is cleaned by high pressure hoses an estimated 50 litres of water-effluent is generated per cow (Mason, 1997; Selvarajah, 1999). Correctly applied, agricultural effluents can improve soil properties such as plant nutrient availability, soil pH, organic matter, cation exchange capacity, water holding capacity and soil tilth which can lead to an increase in the yield of pastures and crops (Eck & Stewart, 1995). From the
point of view of benefiting a crop farm, pasture can enhance soil quality when integrated into cropping systems due to the deep and abundant roots systems of pasture plant species and the ecological functions of pasture plants such as nitrogen fixers (A. Clark, 2004).

Crop production on dairy farms can also increase pasture renewal (MacLeod & Moller, 2006; Pyke, 2011). There is a low rate of pasture renewal on dairy farms which is perceived to be reducing the potential for improved genetics to increase pasture productivity (D. Clark et al., 2007). Thus increasing crop production may create the need for crop rotation plans and allow greater annual pasture renewal and therefore increase the efficiency of the farm system (Pyke, 2011).

When applying Lyson’s (2002) social issue, it has to be noted that social issues include not just the farmers, but the whole of society’s view from farm employees to urban onlookers. According to Clark et al., (2007) it is well publicised that society is becoming less tolerant of the negative impacts of dairy farming even though agriculture makes both economic and social contributions to society.

2.6 Current crop-dairy research in New Zealand

A Taranaki based project introduced crop sequences onto a dairy platform over a five year period (Macdonald et al., 2012; MAF, 2012). The project aimed to improve a dairy platform’s annual feed supply, herd productivity and overall profitability by introducing cropping sequences to increase on-farm dry matter (DM) production. The study recognised that forage crops can produce 45t DM/ha and high energy/ha (Macdonald et al., 2012; Minneé, Fletcher, de Ruiter, & Clark, 2009) but growing crops on dairy farms requires specialist management and agronomic skills to realise these production levels (Macdonald et al., 2012).

The trial compared a pasture-only farmlet to a cropping farmlet with an annual average crop area of 12.5%. On both farmlets palm kernel expeller was the only ‘bought-in’ supplementary feed. The crop sequences on the cropping farmlet were varied but included maize silage, turnips, chicory, rape, oats, barley and triticale. Both farms had similar average

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6 MAF (Ministry of Agriculture and Foreestries) New Zealand has been changed to MPI (Ministry of Primary Industry)/. Some documentation is still published under MAF.
pasture growth but the inclusion of crops added 1.7tDM /ha/year over the all grass system. In the first two years of the trial, milk solid production on the cropping farmlet was 2% lower than the all-grass farmlet, but in year 3 and 4 the cropping farmlet was 11% higher and in year 5 the cropping farmlet had a 27% advantage in milk production. A financial analysis of both farmlets indicated a slightly lower operating profit for the crop farmlet in the first two years, but a higher operating profit over the three following years. The researchers concluded that introducing crops (for feed) could increase milk production and profitability with careful consideration of crop choice and maximum DM yield while minimising the costs of production.

Research of System 5 farms in Canterbury by Sinclair (2011), found that to a degree these systems fit the definition of an integrated crop-dairy system. Sinclair (2011) documented a variety of drivers for operating a system 5 farm including reliable low cost access to supplementary feed, milk protein premiums gained, increased revenue and higher return on capital. Sinclair (2011) further reported that the operating profit of (case studied) system 5 farms was higher than the LUDF⁷ and Dairybase⁸. The farm systems studies were described as being flexible and adaptable, with all the case studies having made changes to their systems in the three years previous to the study. These adaptations to the system included business and management structure, land area, cow numbers and feed type. Integrated crop and dairy research in Canterbury carries on from this 5 systems research as it looks towards higher input alternative farming systems.

2.7 Areas of deficiency and summary of chapter 2

Detailed literature and statistics have recorded the change in land use to dairy production in Canterbury. Further, there is literature on the development of the dairy industry in Canterbury including benchmarking and statistics that highlight the improvement in farm productivity. By comparison, there is little literature on the changes in land use within cropping farms. Arable monitoring reports determining farm profitability are based on traditional farm systems with integrated sheep breeding and do not compare the relative

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⁷ LUDF: Lincoln University Dairy Farm. A high producing pasture-based system which provides an upper benchmark for Canterbury systems.
⁸ DairyBase is a web-based package that records and reports standardised dairy farm business information.
profitability of cropping system with integrated dairy support functions or milking platforms. The Taranaki crop-dairy trial highlights the potential for increased production and profitability when crops are grown for the dairy platform (vertical integration) rather than being sold for external consumption (diversification).

The limited literature on integrated systems with dairy in New Zealand suggests the operations and synergies within mixed systems are not well understood. Further, the drivers to create these systems and the decision-making processes of these farmers have not been researched. Figures 5, 6 and 7 indicate that dairy farming is more profitable than arable for twelve of the fifteen years compared.

Yet, if farmers are integrating milk platforms into their current cropping systems rather than fully converting, there may be other non-financial drivers influencing this land use change. Australian research (McGackian & Rickards, 2011) found that land use change within a family-operated mixed enterprise was often determined by social factors. There has been little research in New Zealand on the influence of social factors on farm decision-making and within-farm land use change.

The literature review of mixed farm systems found that the mixed farm model has been used to combat issues around risk, efficiency, the environment and in broader terms the idea of sustainability. Researchers, including Hendrickson et al. (2008); Villano et al. (2010) and Bell and Moore (2012) defined the main ideas needed to create a mixed farm model. These included the intensity of integration (measured through interactions in space and time) and synergies between crop and animal dynamics and management factors. In New Zealand the practicalities of the integrated system are recognised, but the experiences of farmers who have made the transition have not been explained.
CHAPTER 3
METHODOLOGY

3.1 Introduction

The key objectives of this research relate to understanding the development of mixed crop and dairy farms in Canterbury. Examining these farm systems will build a further understanding of land use change in Canterbury and may provide insights for crop farmers looking at options to enter the dairy industry.

3.1.1 Hypothesis

One key objective is to understand the drivers for constructing complementary crop and dairy systems. Discussions with industry informants led to external rival hypotheses on the drivers of this land use and where integrated farms are heading in the future. These hypotheses are summarised from interviews so may be subjective to the views of the interviewer.

Informant A

Dairy is simple system which does not have the climatic risks of crop. Cropping in New Zealand does not have the size to compete, and dairy support will move out of the plains. Integrated crop and dairy will exist only as a transitional period before the development of full dairy platforms and this is the current role it has in Canterbury.

Informant B

Crop increases the diversity in the farm system, dairy is volatile and crop provides another option if dairy prices are low. Cropping will continue to have a place in Canterbury. Integrated farms are a system in their own right and have a huge potential to expand in Canterbury with farmers benefiting from economic and environmental synergies.
It is also hypothesised that Canterbury crop and dairy farms are wave 3 conversions as defined by Pangborn (2012) in section 1.2. This author observed that the main driver of wave 3 conversions was the profitability or lack of profitability in the existing farm system.

### 3.2 Type of research

The method of inquiry chosen for this research has been a qualitative approach. This was because the qualitative method allowed the researcher to investigate a small area in more depth (Davidson & Tolich, 2003). Patton (1987, p. 44) states “qualitative methods are particularly orientated towards exploration, discovery and inductive logic”. Qualitative research also allowed the accumulation of rich data as it includes personal involvement and partiality (Davidson & Tolich, 2003). The personal involvement was important in order to understand the decision-making of the farmer and therefore the development of the farm system.

In order to understand how and why a farm is integrated, the whole system needed to be analysed including the original farm system before the dairy conversion. Understanding the original farm system is important for understanding the reasons for change. The qualitative approach allowed the farmer to explain the interactions between the crop and dairy units creating a further understanding of the reasons for the change in farm system.

The case study technique is a suitable strategy for this type of interaction. A case study is “the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances.” (Stake, 1995, p. xi).

The adoption of this research technique will allow insight into the farmer’s system and the circumstances in which it arose. The ‘in flesh’ nature of the interview allowed interview questions to be developed and changed within the interview to ensure that a full understanding of the farmers system was reached.

The case study technique was chosen because it can be used as a way of understanding decisions. “Case studies illuminate a decision or a set of decisions; why they were taken, how they were implemented, and with what result” (Schramm 1971, cited in Yin, 2003, p. 12). A case study lacks representativeness, but this will not limit the study because the aim is not to represent a group, but rather to document the decisions made by individuals.
3.3 Selection of the sample

Case study farmers were selected using purposive sampling. A number of industry professionals acted as key informants in this selection. Patton (1987) described purposive sampling as selecting ‘information rich’ cases. This was important because there was only a limited pool of farmers with the appropriate systems for the study and thus only a limited number of case studies available.

The in-depth analysis was limited to seven case study farms to gain insight and understanding into the farm system. The limited focus allowed detailed information to be attained for the purpose of obtaining objective conclusions.

3.4 Data Collection

Two industry informants were interviewed before the seven case study farmers. These informants provided background into the history and the mind set of Mid-Canterbury farmers.

The data collection was in the form of recorded interviews. Interviewing is the best method because of the detail and quantity of the information required. The case study interviews took place at the farmer’s property. The interviews lasted between one and two hours, with further questions and confirmations completed over the phone so as to not place pressure on farmer’s time. Farmer’s partners were invited to be part of the interview. The interview process was both structured and unstructured. A level of structure was needed to ensure all points were covered and all information required was gathered. However, a level of unstructured or ‘relaxed’ interview technique was used to understand the decision making and views of the farmer. In order to gauge the importance of the information and to not alter or distort what the farmer values, farmers were asked to ‘tell their stories’ with structure prompts to keep the interview within the field of interest. Rubin and Rubin (1995) suggested that in an interview, the actual stream of questions needs to be fluid rather than rigid, while pursuing the line of inquiry. The questions were of an open ended nature so as to appear as a ‘guided conversation’.

The entire interview was recorded and field notes were taken during the interview to aid questioning. In most cases, farmers provided farm maps or diagrams to explain how their
farm systems integrated or complemented each other. Recorded interviews and farm diagrams were methods of ensuring the accuracy of information. Audio recording also allowed the exact quoting of farmer responses. All information collected in the interviews was transcribed and subsequently led to individual case study profiles.

One case study farmer (case study A) chose numeric means (EBITS) to highlight his personal decision making process, however, the other interviewees chose a more qualitative approach. This was due to the difficulty of splitting expenses between the enterprises and partly because they felt their system still contained a number of investment and start-up costs. This meant that the levels of profitability described were the farmer’s opinion, with no ability to verify or translate through benchmarking of other published data.

### 3.5 Confidentiality Issues

Initial contact with farmers was by a letter explaining the purpose of the research and the confidentiality of the research. A subsequent phone call was used to ask the farmers if they would participate and to organise an interview. At the start of the interview, every farmer was assured that all information disclosed was confidential and would not be identifiable back to the individual farmers. Permission was asked before any information was recorded on an audio record. Farmers were assigned a letter (e.g. Farmer A), which has been used throughout the chapters covering case study profiles, discussions and conclusions. Only people directly involved with this study had access to full unedited interviews. Although all efforts have been made to avoid readers from recognising a case study respondent (farmer or property), the researcher does acknowledge that these privacy efforts may become void if the reader is a close acquaintance with the particular farmer.
CHAPTER 4

CASE STUDY PROFILES

4.1 Introduction

This chapter presents the case profiles of seven farmers who participated in this research. These profiles contain only the information that was gathered in the interview process. All the farmers were located in the Mid-Canterbury or wider Ashburton district, in the South Island of New Zealand. Farmers have been assigned their own letter for confidentiality reasons and to allow for referencing in the discussion section of this thesis.

4.2 FARMER A

4.2.1 Introduction

In 1989 Farmer ‘A’ purchased a 160 hectare mixed cropping and sheep farm with border dyke irrigation. For the purpose of this case study this farm will be referred to as the ‘home block’. During the same year, Farmer A accumulated blocks of land to create a second mixed cropping farm of 120 hectares, 7km away. The long term objective of the two land purchases was to eventually consolidate to one large farm; however the location of the farms (edge of town surrounded by 2-8ha blocks) gave Farmer A limited room to expand the individual properties.

From 1989-1999 the home block ran 1500 breeding ewes, 500 Friesian bulls and 60ha of crop. The crop rotation was wheat, barley, peas, evening primrose and ryegrass white clover. In 1999 Farmer A sold the 120ha block and converted 160 hectares of the home block into a dairy platform. Farmer A then bought more land and increased the home block to 220ha. The home block is a 50:50 share with Farmer A’s brother. The 2000-2001 season was the home block’s first milking season. During this same period, Farmer ‘A’ bought a 225ha cropping farm in partnership with Farmer A’s brother and sister. This 225ha cropping farm is a completely separate business with the inclusion of Farmer A’s sister in the ownership structure. Thus the two farms are separate entities generating their own incomes. It needs
to be noted that all the farming knowledge comes from Farmer A and Farmer A is the overseer and makes all farm decisions.

Due to being separate entities both in terms of ownership structure and location, the two farms are not fully integrated. The farms are however integrated in such a way that they gain mutual benefits, as will be discussed in 4.2.3. Farmer A stated the relationship between the farms allowed the dairy farm to optimise and supervise dairy support while the crop farm can optimise crop profitability. Farmer A’s view is that crop farms running only dairy support land are not profitable, although no financial analysis to support this view was provided.

4.2.2 Reasons for conversion and the chosen farm system

When, Farmer A was making the decision to convert the home block in 1999, the estimated profitability of the two systems was equal (the profit from the dairy system including the capital debt service for improvements to convert was the same as the profit made in crop). Farmer A based the dairy calculations on 950kgMS/ha (the local production rate at the time) at 2.6 cows/ha and 370kgMS/cow. The decision to convert was on the basis that a cow shed was a 25 year commitment and therefore the decision had to be made with a 25 year view. At the time of conversion Farmer A believed the potential profitability gains were higher for dairy than mixed cropping.

Farmer A works full time off farm and at the time of the conversion the dairy farm was an attractive option as the calculated profit included an extra full time labour unit. By comparison, the mixed cropping farm only had one part-time labour unit, in addition to Farmer A. Because Farmer A worked off farm, the dairy farm with an extra labour unit was easier than the original mixed cropping system as Farmer A would “worry about bulls get out” while working away from home with no-one on the farm. Also, due to the nature of Farmer A’s job and the proximity of the farm to an urban area, Farmer A recognised the importance of having a tidy looking farm which optimized profitability, justified the high land value and had a land use which fitted the attributes of the farm.

Dairy farming on the home block was more attractive to Farmer A than cropping because the home block has scattered trees (every 30m in the paddocks), native plantings, shelter belts and border dyke irrigation that made the farm less suited to cropping and better suited to pasture production. Farmer A had no immediate plans to further update the irrigation
system and no intention of removing the trees. However, since the conversion Farmer A has updated most of the farm irrigation system to increase efficiency but has done so with sprinkler systems between the trees. Farmer A notes that the cows enjoy the trees and he appears to view the trees as a farm attribute rather than a frustration to the farm system.

Succession was not a big factor in the conversion on the dairy farm as Farmer A has other investments. Risk, however, was the main reason for not also converting the 225ha crop farm into dairy (at the same time). Farmer A has other dairy investments and non-agricultural investments and the crop farm added further diversification to his portfolio. Farmer A’s brother also did not want to convert to dairy due to his personal risk strategy. The crop farm has a level of security for its production due to its relationship to the dairy farm. The crop farm is the dairy farm’s only source of supplement and only run-off area.

4.2.3 How the systems run and how they are integrated

The 225ha crop farm has two rotations which mirror each other in that both rotations are six years in length. This rotation length was chosen because carrots, radishes, potatoes, ryegrass for seed and fodder beet, which contribute to the rotations, should not be grown more often than once in six years in one paddock.

Rotation 1:

Ryegrass seed - fodder beet – maize – wheat – white clover seed - wheat

Rotation 2:

Ryegrass seed – peas – kale – potatoes – wheat – carrots and radishes – wheat

Rotation 1 starts with ryegrass seed which is harvested in February, and is then grazed with lambs or in-calf heifers (from the dairy farm) from March. The paddock is then shut up for silage, which is cut on the 25th of October. Silage is either used on dairy farm or stored on the crop farm and fed as a supplement with fodder beet. The second crop in the rotation is fodder beet planted the 1st of November. Fodder beet winters half the dairy herd. After fodder beet, maize is sown in the spring and harvested the following April. Maize is sold to a feedlot or used on the dairy farm for silage. Milling wheat follows maize. White clover seed is sown after wheat and harvested in February. White clover may also be used for grazing.
The final crop in the rotation is wheat for feed, sown as winter wheat in May and then re-sown in ryegrass after harvest in February.

In rotation 2, ryegrass seed runs the same as rotation 1. Ryegrass is followed by processing peas sown at the end of July and harvested in November with the vines made into baleage. Kale follows peas and is used to winter the second half of the milking herd. After the kale in the spring a 50:50 share potato crop is grown in partnership with a processor. This is followed by wheat for milling and then a paddock 2/3 in carrots and 1/3 in radishes for seed. The final crop in the rotation is feed wheat.

The key clients of the crop farm include the dairy farm, a feedlot, a vegetable processor and specialist seed growers. The dairy farm pays the market value for all the feed and grazing provided by the crop farm. The dairy farm does not buy any supplements in addition to what it buys from the cropping farm; however this year the dairy farm leased a neighbouring paddock to grow fodder beet. The additional fodder beet is being harvested and fed to the cows on the milking platform (fed out in paddock) with ryegrass straw from the cropping farm. This fodder beet is being fed at the end of the season before and during drying off. The advantage of this method is that this reduces the time taken to walk the cows to the paddock and therefore minimises stress on the animals. An additional advantage of feeding in autumn is that stock adjusts to the fodder beet, reducing problems when transitioning onto in-situ fodder beet and kale after drying off says Farmer A. In the last week on the dairy farm, the cows will be given 5kg/cow of harvested fodder beet to maintain body condition score and ensure a smooth transaction onto full winter supplement.

The dairy farm buys a maximum of 650kg silage per cow from the crop farm. Last season (2011/2012) the farm bought (from the crop farm): 310kg of maize silage and 217kg of grass silage. Of this, 100kg/cow was fed in the spring and 180kg/cow was fed in the autumn and the balance over the winter. Farmer A notes that because of the additional fodder beet (as earlier discussed) some of the maize silage will be stored for the following season. In the winter, the crop farm feeds grass silage with the kale and fodder beet to meet dietary needs.
Table 2: Farmer A, current estimated Crop income and EBIT Aim (2011/12).

<table>
<thead>
<tr>
<th>Crops</th>
<th>Products</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$/ha</td>
</tr>
<tr>
<td><strong>Rotation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass seed</td>
<td>seed</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td>in-situ feed (35 lambs)</td>
<td>$40/head</td>
</tr>
<tr>
<td></td>
<td>silage</td>
<td>3.5t @ $0.20</td>
</tr>
<tr>
<td>Fodder beet</td>
<td>winter feed</td>
<td>20t @ $0.23</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>21t @ $0.22</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>12t @ $0.40</td>
</tr>
<tr>
<td>white clover seed</td>
<td></td>
<td>750 @$0.55</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>12t @ $0.40</td>
</tr>
<tr>
<td><strong>Annual income</strong></td>
<td><strong>6yr rotation</strong></td>
<td><strong>average</strong></td>
</tr>
<tr>
<td><strong>Rotation 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass seed</td>
<td></td>
<td>5000</td>
</tr>
<tr>
<td>Peas</td>
<td>(peas and vine baleage)</td>
<td>2300</td>
</tr>
<tr>
<td>Kale</td>
<td>winter feed</td>
<td>11t @ $0.23</td>
</tr>
<tr>
<td>Potatoes</td>
<td></td>
<td>68t @ $1.86/2</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>12t @ $0.40</td>
</tr>
<tr>
<td>Carrots and radishes</td>
<td>seed</td>
<td>432t @ $0.30</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>12t @ $0.40</td>
</tr>
<tr>
<td><strong>Annual income</strong></td>
<td><strong>6yr rotation</strong></td>
<td><strong>average</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>weighted</strong></td>
</tr>
</tbody>
</table>

EBIT Aim (income after expenses) 2,500
Return on capital (current value) 5.10% ($42,000/ha)
The cost of wintering the dairy cows on the crop farm is 22-24 cents/kgDM. Farmer A has never considered not wintering on the crop farm. Farmer A strongly notes that there are a number of benefits for the crop farm from its association with the dairy farm, primarily in providing a market for ‘waste’ crop products such as straw, baleage, and silage. Farmer A states the two enterprises allow for a six-year intensive rotation, with efficient land use.

Farmer A noted that the cow manure also benefited his cropping system. Farmer A stated that he did not need to apply any nitrogen fertiliser to the maize crop because of the amount of manure from the previous fodder beet crop. Farmer A had numbers obtained from Lincoln University researchers which showed that based on Farmer A’s cows consuming 10 kg of fodder beet a day (break fed) with three kilograms of grass silage, the cows would produce 30,000 urine patches. This is three urine patches/1 m$^2$ or 1.2 m$^2$ of urine/m$^2$, thus providing enough Nitrogen (with the application of Eco-N$^9$) for the subsequent maize crop.

4.2.4 Profitability (and justification of the farm system)

The historical status quo EBIT for the crop farm is $2,200 hectare. This is more conservative than the EBIT in table 1 ($2,500) which was the budget for the season (current season at time of interview). The status quo EBIT set by Farmer A is the average expected annual return used over a number of years and is conservative benchmarking tool he uses to compare and measure the two farms.

In the 2010/11 season, the farm did not meet these earnings with an EBIT of $1500/ha. The original projected dairy farm EBIT for Farmer A (first season 2000-2001) was based on 950 kg MS/ha at 2.6 cows/ha and 370 kg MS/cow and Farmer A believed the profitability gains would increase. Since 2000, production has increased 60% (note: this is average for the area) with last season’s production at 1643 kg MS/ha.

Farmer A can still justify the crop farm based on the earnings for dairy when interest on the conversion is included. Farmer A also expressed the belief that the dairy farm has greater volatility than the crop farm (table 3). If the dairy price falls to $5.50 then dairy profit net of interest is a third of the crop farm (assuming crop a $2000/ha –average last three years).

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$^9$ Eco-N is a nitrogen inhibitor. The active ingredient is dicyandiamide (DCD).
Due to Farmer A continuing to have the same view on risk and the same personal circumstances (investors) he will continue to run both a dairy and crop farm system.

Table 3: Comparison of crop and dairy profitability for Farmer A

| **Comparison of Crop and Dairy - how Farmer A justifies the crop farm.** |
|:---------------------------------|:-------------------|
| **Crop Farm**                  | **$/ha**          |
| Status Quo EBIT                | 2,200             |
| EBIT last year                 | 1,500             |
| EBIT predicted this year       | 2,200             |

| **Dairy Farm**                |                   |
| Status Quo Income             | 1600kgMS @ $6.30 (incl. share) |
| Crop to Dairy conversion     | 10,000            |

**Investment**

- Conversion: 11,000
- irrigation upgrade: 4000
- Fonterra shares: 7000
- cows (incl. replacements): 8500
- minus working capital: -1500
- and machinery: -1000

**TOTAL CONVERSION COST**: 28,000

**Interest @ 7.5% on conversion cost**: 2,100

**Dairy EBIT**

**As per kgMS basis**

<table>
<thead>
<tr>
<th>Milk Price</th>
<th>Beef</th>
<th>Costs</th>
<th>$/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.30</td>
<td>0.30</td>
<td>-4.10</td>
<td>2.50</td>
</tr>
</tbody>
</table>

**1600kgMS x $2.50**: 4000

**BUT**

**INTEREST COST**: 2,100

**Earnings after interest**: 1900

*Disclaimer: All information in these tables came directly from the farmer and is entirely his analysis.*
Table 4: Farmer A, dairy EBIT at $7.90 and $5.50 per kilogram of milk solids.

<table>
<thead>
<tr>
<th>Dairy Volatility based on 1500kgMS/ha</th>
<th>As per kgMS basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dairy price at</strong></td>
<td><strong>$7.90/kgMS + $0.30 beef - $4.10 expenses</strong></td>
</tr>
<tr>
<td>Dairy profit/ha</td>
<td>$6,150</td>
</tr>
<tr>
<td>Interest/ha</td>
<td>2,100</td>
</tr>
<tr>
<td><strong>EBIT</strong></td>
<td><strong>$4050/ha</strong></td>
</tr>
<tr>
<td><strong>EBIT</strong></td>
<td><strong>$650/ha</strong></td>
</tr>
</tbody>
</table>
4.3 FARMER B

4.3.1 Introduction

Farmer ‘B’ was brought up on a town supply dairy farm. Farmer B and his brother bought a dairy herd and leased a dairy farm in a different region from 1984 to 1989. In 1989, when this farm was sold, Farmer B bought a dairy farm in the Ashburton district of 100ha. Farmer B milked on that farm for five years and then worked off-farm for two years. Farmer ‘B’ then returned to the dairy farm and increased the size of the dairy farm by purchasing two blocks (1996). Farmer B decided he did not want to milk cows and sold one of the newly purchased dairy blocks (12ha) and the cows to a 50:50 sharemilker. The sharemilker milked on 150ha for eight years. When the sharemilker moved onto an equity partnership, Farmer B bought a herd of cows and has used lower order sharemilkers to milk the remaining 138ha. This 138ha dairy farm will be referred to as the ‘Dairy 1’. Selling the dairy herd and a block of land in 1996, allowed Farmer B to buy the fully irrigated 240ha cropping property where Farmer B lives today, this will be referred to as the ‘crop farm’.

In 2002 Farmer B bought an additional 200ha dry land block near Ashburton and developed it with irrigation. This block operated as the grazing block wintering cows (from Dairy 1) and in the first season ran a mob of 1100 ewes. Ewes were replaced by intensive cropping until 2011 when the farm was converted to dairy. This farm will be referred to as ‘Dairy 2’. Dairy 2 was easy to convert as it already had irrigation, troughs and good lane-ways from operating as a dairy support unit. The main cost in this conversion was the dairy shed. This dairy farm has just completed its first season (2011/12) with a lower order sharemilker. Therefore, in 2011-2012 Farmer B had a 138ha dairy milking platform, a 200ha dairy milking platform and a 240ha cropping farm.

4.3.2 Reasons for the conversions

When Farmer B moved from dairy to cropping in 1998, it was a life-style choice. Farmer B saw cropping as an attractive lifestyle and an alternative to milking cows. Farmer B also wanted to spread his risk so “all eggs are not in one basket”. Farmer B sees himself as different from other farmers in the area because he started off as a dairy farmer and added the 240ha crop farm.
Farmer B converted Dairy 2 in 2011 because the cropping system was no longer profitable. “Until last year the crop returns were still falling and we effectively sat down and thought: that 200ha down the road just isn’t making any money.... we were working harder and harder doing more and more crop and running backward and forwards with machinery and harvesters etc.. and we asked ourselves, why are we doing this? We are working flat out and just not making any money”

Farmer B put lower order sharemilkers on both dairy farms for a number of reasons. Lower-order sharemilkers meant that while Farmer B did not have to do any of the daily running of the farm and manage the labour units, Farmer B still had a high level of control. Farmer B sees this control as paramount when running successful complementary systems.

4.3.3 The farm systems

4.3.3.1 Crop farm

The cropping farm consists of eight main paddocks of 30 hectares all under pivot irrigation. There are two crop rotations; however Farmer B noted that rotations change depending on price and risk.

Currently Farmer B’s rotations are:

**Rotation 1**

Peas - swedes – barley - kale

**Rotation 2**

Grass seed – kale - barley – peas – clover (sometimes) – grass

The peas are processing peas with the vines used for baleage. The barley is under contract with a malting company but some years malting barley will be grown for seed. When it is grown for seed it receives a premium. Clover is planted for seed. The swede crop fattens lambs in the winter. The crop farm runs 6000 lambs and is currently making a greater profit from lambs than wintering cows. At a $6.20/kg schedule, lambs are earning better than green feed for cows.
The farm has 80ha of kale to winter the cows from both farms (Dairy 1 and 2) and these are grazed at the district grazing price. Calves and yearlings are also grazed on the crop farm.

In the past, Farmer B has grown carrots and potatoes. Carrots for seed were a challenge because they are 13 month crop with high risk and often low returns. Share cropped potatoes had a similar problem as they did not allow for a second crop in the year, reducing the profitability.

4.3.3.2 Dairy farm 1
Dairy farm 1 is 138 effective hectares with 500 cows or 3.6 cows/ha (as of the 1st of December). Of the 138ha, three quarters is under border dyke irrigation and the remainder is under spray irrigation. Farmer B described this farm as “realistically having a lower effective area because land in head races does not grow anything”. Farmer B also noted the inefficiencies of the border dyke system which sometimes lets down the farm during the dryer periods of the year.

Dairy farm 1 is reliant on supplementary feed. The estimated supplementary feed is one tonne per cow spread over the season. This is divided into 600kg/cow of barley and 400kg/cow of silage. Additional to this, 100kg/cow of maize was fed last season in the spring.

4.3.3.3 Dairy farm 2
Dairy farm 2 is the newly converted dairy farm on 200ha and has just completed its first season. The farm has 700 cows and 185ha of effective milking platform, with 12ha of land in kale. Farmer B chooses to put 12ha of the farm into kale rather than increase the herd because 700 cows easily fit into the yards and can be run as one herd. If the farm increased stock numbers and ran two herds then another labour unit would be required. Farmer B said an extra 40 cows would not “make enough” to pay for another employee under lower order share milking. Additionally, Farmer B noted that the 12ha of kale is good for the farms re-grassing programme creating cleaner paddocks than when the grass is renewed from grass.

The farm was converted with a 54 bale rotary shed that could be run by two people. Farmer B did consider shed size when he completed the conversion and chose the 54 bale shed because he wanted to make the farm simple and not labour intensive. Farmer B said that a
70 or 80 bale shed, with one person cupping on, was not ideal. Farmer B noted the simplicity of the farm is increased by wide lanes and large paddock sizes.

Dairy farm 2 is a ‘well watered farm” and has a stocking rate of 3.8 cows/ha this season. Last season (because it was the first season as a dairy platform) the farm was under stocked at 650 cows thus the farm made 700 bales of silage. The in-calf heifers are wintered on the 12ha of kale on the farm and the rest are wintered on the crop farm.

This season the farm will feed out 400-500kg of grain (barley) and some silage supplement in the milking season. The grain is bought from a neighbour to reduce cartage. Additional to this, 100kg/cow of maize will be fed in the spring.

In the first season milk solid production was at 467kgMS/cow. Farmer B expects higher production this year as last season the cows “came skinny from the North Island”.

4.3.4 How the systems are complementary

Farmer B says his farm system choices are all about risk management. The crop farm has ultimately not been converted to dairy because at a management level and a risk level the businesses as a whole are successful.

The complementarities of these systems are controlled by Farmer B as the owner and active participant in the farms (due to lower-order sharemilkers). This active participation allows Farmer B access to information and shares decision-making across the enterprises. These complementarities are:

1. Farmer B uses the crop farms cropping machinery to do all the cultivation work on the two dairy farms.
2. Farmer B grows winter feed on the crop farm for dairy support. The crop farm grazes at the ‘district grazing price’ and keeps expenses in-house. Farmer B says if something better did come up on the crop farm, then he would send the cows somewhere else. But wintering the cows himself does ensure they get the best care. Farmer B buys silage (from the crop farm) to supplement cows over the winter. When asked if he would consider increasing lambs, Farmer B answered “only if I could get good grazing for the cows” Farmer B doubts he would find someone willing to put in the same level of care for the
cows. Farmer B also noted that cows are a guaranteed price while the schedule for lambs can drop.

Farmer B notes that run-off blocks “don’t pay” thus there are advantages to running a run-off type system within a cropping system. Farmer B also commented that dairy farmers don’t have the knowledge or tools to grow crops which deter them from these integrated systems.

Farmer B does not grow the grain fed to the dairy cows. Farmer B buys grain from farms neighbouring the dairy farm as transport costs are lower. “I can’t grow grain any cheaper than they can and growing the grain closer makes the cost of carting so cheap... it’s easy this way”.

Lastly, Farmer B acknowledges the climate and the soils on the crop farm create a favourable environment for cropping which encourages Farmer B to continue this enterprise. Farmer B says that they have not integrated crop and dairy on the same farm because they did not want to get into a situation of subsidisation. Also Farmer B says “there is no money in selling grass for silage”.

4.3.5 Developments in the future
Farmer B is happy with the setup of the farms. In the future he may look at putting in summer turnips as they may perform better on the border dyke irrigation. In the long term Farmer B recognises that Farm 1 would benefit from full spray irrigation but says this will depend on the irrigation scheme developments. Farmer B also notes that environmental regulations may phase out border dyke irrigation. Farmer B in the short-term intends to continue the crop farm with dairy support, although, he says the crop rotations will change depending on price and demand. Farmer B also noted the crop farm could change depending on what the dairy industry demands noting that farms could move closer to a 50% supplement system (system 5).

4.3.6 Frustrations in the industry
Farmer B says that there are some frustrations in the crop industry especially with the ‘middle man’ in the market. “It’s very frustrating to the arable farmer to grow grass seed, send it to the cleaner and pay for the flash bags and receive $2.50/kg, to then see the dairy farmer buy that bag which the arable farmer grew, processed and bagged for three times
the price”. Farmer B believes that it is time crop and dairy farmers worked more closely together.
4.4 FARMER C

4.4.1 Introduction

Farmer C’s property is a family owned farm from previous generations. The farm was a traditional sheep farm with some dry land crop. Farmer C and his brother originally leased the dry land farm from their parents, but in 1982 the farm was split between the two brothers and fully irrigated. After the farm was irrigated, the breeding ewes were sold and the brothers moved into trading lambs and more intensive crop. The cropping operation continued to intensify with a focus on specialised vegetable seed. When Farmer C’s brother no longer wanted to farm, Farmer C and his wife leased the brother’s portion of the farm, purchasing it three years later. Farmer C has continued the intensive crop operation buying and selling land along the boundary to bring the total farm size to 630 hectares in one block by 2006/07.

In the 2006/07 season, the 630 hectares was partially converted to dairy. This conversion created a fully integrated dairy-crop farm without set boundaries for the milking platform. The milking platform generally averages 270-280 hectares.

Farmer C was one of the earliest conversions to integrated crop and dairy in his area. Farmer C notes that converting was not a quick decision with two years thinking about the process. Farmer C had no dairy experience and there was no knowledge on the success of crop-dairy integration as it was a new idea in the area.

The cost of conversion included three new houses for staff built over the last five years and the dairy shed. Farmer C chose a 60 bail rotary because it can be run by one staff member with automation.

The farm currently grows high value crops including vegetable and grass seed and winter green feed for the dairy operation.

The farms irrigation is made up of roto rainers, pivots and laterals, with the intention of replacing roto rainers with pivots. The farm has plentiful water with no limits on annual water take. The farm runs as one entity but with separate trading accounts. In the short term, Farmer C has no plan to separate the farm into separate entities as this may minimise any benefits of integration.
4.4.2 Reasons for conversion

Farmer C says the reasons for the dairy conversion were risk management, reduced workload and spreading of income.

Farmer C’s wife stated “The sole purpose [of the conversion] was not to make money it was all about risk management. On the crop farm all of the income was determined in a six week window (January-March) and this system was getting stressful and unreliable”. Farmer C stated that there was a lot of disappointment because the returns just were not what they should have been. On top of this, there was pressure and stress to “keep an eye on things” while the conversion has created easier management with less day to day stress.

Both Farmer C and his wife noted an important driver of the conversion was the excitement of entering a new industry and learning new skills.

After the conversion, Farmer C changed his cropping strategy. He reduced the low paying crops and now focuses on the higher paying, but higher risk crops. Farmer C feels he can do this because he now gets a base income from the dairy platform mitigating the risks of the cropping enterprise.

4.4.3 The crop system

The farm does not have a set rotation, rather choices and decisions are made each season based on the profitability of the crop under consideration.

When planning the rotation, the specialty seeds (carrots and ryegrass) have the highest priority due to their high value. Carrots for seed can be in a paddock every nine-ten years and some years the carrots could be in a paddock right next to the dairy shed. If the paddock was in pasture (for the dairy platform) previously then after the carrots, the paddock usually goes back into pasture (using the carrots as part of the regrassing cycle).

The other crops are: wheat, barley, peas, Asian brassicas, rape and kale. Again because of the ability to tie the crops into regrassing programmes there is no set rotation, as the farm does not operate with a strict rotation. Decisions are based on what is best in terms of profitability, limitations imposed by the previous crop, and timing in the season.
Rape and kale are used to winter all the dairy cows with straw supplements from the cropping operation. The farm also sells excess silage (not used on the home dairy farm) to other dairy farms.

The cropping operation has two full time staff and one part time when required.

4.4.4 The dairy system
Farmer C describes the dairy platform as System 3 (based on the DairyNZ 5 systems model). The core platform is 270-280ha but this area changes over the season. At the end of the 2011/12 season the dairy platform was at 250ha but coming into the 2012/13 season the dairy platform will be 330ha. This allows for an all-grass system over the spring period. The farm wintered 1,240 cows (intends to sell some) and at the peak of the 2012/13 season Farmer C intends to have 1,150 cows milking. This is an increase of 50 cows since 2007/8. The additional 50 cows have justified a much needed extra full time labour unit. Last season the dairy farm produced 2,120kgMS/hectare. Farmer C notes that not many straight dairy farms in the area get that level of production.

Over the milking season supplements may be bought if they are cheaper than making them on-farm. This season the cows during the milking season will consume grain at 470kg/cow and molasses at 1kg/cow/per day (up till the end of mating then 0.5kg/cow). Last season the farm did not need to buy any silage; in the past the farm has bought maize silage but this has been dropped out of the system as it has not been needed.

The dairy farm is operated by a lower order sharemilker which provides a level of control for Farmer C while removing the stress of day to day management and labour management. The sharemilker has four full time staff. Farmer C notes that the sharemilker is the best option because we “can’t do it all” and it is best to have someone with passion and enthusiasm for the industry. Farmer C realizes he might make more money with a manager, but says he doesn’t want to go down that path.

4.4.5 Synergies of the systems
First, the gap in returns between cropping and dairy is too great to substitute a good paddock of grass for a crop according to Farmer C. However if the grass is ready for replacement then Farmer C can justify putting in a carrot crop before regrassing, noting that
this helps the clean-up process. Further, Farmer C notes that his farm may have better pastures than pure dairy farms due to this regrassing technique. The dairy platform currently only has two paddocks that have not been replaced since the dairy system started in 2006/07.

When the cropping land is used for dairy and then planted back into crop Farmer C notes that these paddocks may produce better yields. However Farmer C says this is not the driver of the system.

All cows including replacements are being wintered on the farm and this gives a further level of control. Farmer C notes that having the wintering and replacement cows on farm provides security and provides control over feed quality and intake. Grass silage and barley straw (made on farm) is also fed out in winter. If there is grass silage left over it gets sold. Farmer C makes use of the ryegrass seed crops by grazing them early in the season and then again following seed harvest. Farmer C wife notes that this allows flexibility between the dairying and cropping areas on the property.

A big advantage in the system is being able to ‘internally contract’ (use the arable machinery on the dairy farm). Farmer C notes that they spend a lot of time on the dairy farm with the gear. Farmer C spreads all his own fertiliser and can make decisions as to where and when to spread when the conditions (rain, cow location, irrigation) best suit him. Farmer C believes that this reduces waste and is more environmentally friendly as it can be done when the conditions are right instead of when it suits the contractor. Working on the dairy platform also keeps the arable staff busy.

Growing ryegrass for seed is advantageous to the system as it means that there are new pasture species on the property. Farmer C, lastly, notes that the integrated system may be perceived to be environmentally better than a pure dairy farm which may be advantageous in the future.

4.4.6 Future

Farmer C says there is the potential for a second dairy shed on the property. However, the current mixed system provides income security. Farmer C’s wife notes that in their second season of dairy, the cropping part of the farm had higher returns than the dairy; she notes if
the payout is $5.50 then this could happen again. They also observed that “price is one thing but season is another”. Farmer C also mentions that the family has a passion for cropping (his two sons also share this passion).

When asked if they would consider any other stock units such as store lambs, Farmer C said; “The risk of lambs is the same as the risk in crop. Any extra feed goes to the cows and the times of surplus are generally small. Although I could do with some lambs for grazing management at times, the window is small and they could hang around for ages, plus, I do not enjoy farming store lambs.”

Farmer C says that he has a different attitude now that crops are not 100% of the farm income. He notes high satisfaction levels from the current business noting the advantages of control including wintering the cows and owning all the cropping gear. Farmer C is happy with the current system with irrigation development his only change in the future. He describes his system as simple and says stress levels are low with the additional level of security in the business.
4.5 FARMER D

4.5.1 Introduction

Farmer D will refer to two brothers who farm together. Farmer D’s farm was a traditional arable property. The first 220ha was purchased in 1935 by Farmer D’s grandfather. In 1970 Farmer D’s father took over the management of the farm. When the two brothers left school, one returned to work on the home farm and the other worked on a dairy farm for four years, before both brothers became involved in the management of the property.

In 1989, the brothers purchased 200ha of irrigated land. In 1991 they bought an additional 110ha and in 1995 a further 100ha, both adjoining. In 2001 they bought 270ha as a dryland block which they developed and irrigated and in 2011 they bought 50ha (currently under development for irrigation). This brings the farm’s total land area to 950ha. The 950ha includes the cropping farm of 530ha and the dairy farm of 420ha. The dairy farm is 3km down the road from the homestead and cropping farm.

The buying of land originally allowed the brothers to grow the business and be large suppliers (on a national level) of certain crops before their dairy conversion in 2007. When they originally converted they had a 420ha block with a 400ha milking platform and the remaining 20 hectares of the block in crop. They have slowly increased the size of the dairy herd and the dairy platform and currently run at what they recognize as ‘maximum capacity’ for the dairy block with a stocking rate of 4.5 cows/ha on the full 420ha. In 2011 the brothers bought 50ha adjoining the crop farm to replace the 20ha of cropping land switched to dairy. This 50ha is in the process of being irrigated.

4.5.2 Reasons for conversion

In 2007 the brothers made the decision to partially convert to dairy. Previous to the dairy conversion the farm was fully managed the brothers and operated as a sheep and cropping unit. They were the largest growers of milling wheat, Nui Ryegrass and peas for their varying processors. At this time the farm was running 2000 ewes, 8000 lambs, 1500-2000 grazing dairy cows, 100 bulls plus the crop operation. The reason for converting to dairy was because they were working ‘flat out’ and not getting a reward. Both brothers felt this was especially the case with the sheep enterprise. A dairy conversion was seen as a way to ‘future proof’ the business, make management easier and increase the time available for
planning and hobbies. Succession plans were thought about when deciding to partially convert but were not a major driver to making the change. The farm was already irrigated so the biggest cost was the dairy shed. The brothers choose a 70 bale rotary because they felt it was still small enough to be managed by one person with automation. One of the brothers had worked on a dairy farm when he had finished school so they felt they had a good understanding of the system.

4.5.3 The crop system
The crops on the farm are: milling wheat, barley, grass seed, peas, kale seed and winter grazing, plantain for seed and green feed for the dairy herd.

The wheat is spring sown after the green feed and is sometimes used on the dairy farm but it depends if they can get a higher price. The farm has two combine harvesters for harvest because of the small window of time (especially as the sowing date can be late due to cows coming off the winter feed).

There are no sheep in the cropping system. Breeding ewes were removed from the system when the dairy farm was converted. The brothers originally kept finishing lambs but found they did not fit into the system. Lambs have not been on the property for the last two seasons and lambs will not be reconsidered in the short term as they put pressure on the system if they have to be carried into winter.

The crop farm makes silage (when there is grass available) for the dairy farm or for winter supplement. The farm winters all cows. All replacements are grazed off the property because cropping is higher value than grazing. Farmer D also notes that if there were opportunities to grow something of a higher value than winter feed, then they would consider sending the cows off farm for wintering. Farmer D also says that the value of winter feed to them is high because it allows control of the dairy system.

4.5.4 The dairy system
The dairy block, which is 420ha, is 3km down the road from the main cropping farm. Currently, the total dairy platform is 420 ha, with the original 20ha of cropping land incorporated into the platform. There were 1900 cows being wintered in 2012.
The farm operates at 4.5 cow/ha producing 485kgMS cow. In total each cow gets 1200kg of supplements in a milking season. This includes 800kg of grain. The dairy farm originally milked 950 cows on 400ha with the remainder integrated with crop. Originally, this crop was part of the regrassing programme. The brothers say the dairy platform can expand no further.

The dairy is run by a lower order sharemilker who employs six full time labour units. The brothers chose to use a lower order sharemilker as this allowed them to own the dairy herd and thus control the genetic base. They also noted their debt levels made a 50:50 sharemilker unviable and they did not choose a farm manager as they did not want a role in staff management.

4.5.5 Synergies of the systems
Having the crop and dairy enterprise running as one business and with the proximity of the dairy farm to the cropping farm allows the dairy farm to retain a stocking rate of 4.5 cows/ha. This is because the cows can be kept on winter grazing longer in spring, and can be walked down to the dairy platform in small groups increasing the spring feed available on the platform. This also allows the farm to increase the number of days in milk, by drying off cows in small groups and continuing to milk the better producing cows in autumn.

Another benefit of the system is the closeness of feed supply. The brothers explain that obtaining supplementary feed from the crop farm adds value to what is produced on the dairy farm because there is no middle man, weigh charges, or commission and cartage is minimal. The brothers also note that they can turn crop residuals into baleage increasing the value of the crop.

The brothers use their cropping equipment for regrassing, lane maintenance and fertiliser spreading. This keeps their costs down and means they don’t have to rely on contractors, which further justifies their machinery. The brothers feel that the cropping farm employees also have a better work environment with increased diversity and less stress with the dairy system removing cropping land and sheep.
4.5.6 Future

The farms do not need any further development. They are irrigated with seven pivots (two on the dairy farm), four laterals and five rotor rainers. The brothers said they would consider converting the crop operation to dairy but not in the short term. They said that if they fully converted, they would probably look for another investment to spread their risk. They suggested that they would consider investing in another cropping farm. The brothers also noted that they would consider succession before converting the entire property but at the moment both brothers have very young children so this is not yet a concern.
4.6 FARMER E

4.6.1 Introduction
Farmer E is the fifth generation on his farm. Today the farm is 1,200ha consisting of a sheep, beef and cropping farm of 950ha (’E’ mixed farm) and a 250ha dairy platform (’E’ Dairies).

The farm was divided between Farmer E and his brother. Farmer E ran a sheep and cropping unit (950ha) and Farmer E’s brother worked off farm and leased his block (250ha) to various people. In the 1990’s Farmer E considered a dairy farm conversion with border dyke irrigation and a herringbone shed. At this time the milk price was $3.00 and Farmer E could see the dairy system being profitable however it didn’t eventuate because the DDT\textsuperscript{10} on the chosen area of the farm was too high.

In 2000 Farmer E purchased his brother’s land bringing the total farm size to 1200ha. At this time Farmer E was in a cropping partnership but Farmer E felt that cropping was not profitable and water was a limiting factor in his business. The property also ran 6000 ewes including replacements. In December 2008 Farmer E made the decision to convert and in June 2009 the 250ha dairy platform was running.

The mixed farm and the dairy farm are run as two separate entities. They are adjoining with tracks and gates between the properties.

4.6.2 Reason for conversion
After Farmer E purchased his brother’s land he tried cropping the additional 250ha, but returns were low. At the time a conversion to dairy seemed like a way to increase profitability and provided an opportunity to create an easily divisible system with succession in mind. Farmer E also recognised that he had on opportunity with both the scale and the adjoining nature of the properties to build relationships between the properties to benefit both enterprises. Farmer E considered the benefits of integration before the conversion.

\textsuperscript{10} The pesticide DDT was used widely in Canterbury in the 1950s and 1960s to control grass grub. Farmers ended up with high levels of DDT residuals (DDE) in their soils. Through normal grazing practices DDE can be ingested by cows, concentrated in their fat and released in their milk. DDT was banned in New Zealand in the 1970’s and DDT residuals will break down very slowly in the soil over time (Pangborn, 2012).
Farmer E said the decision to convert was influenced by a discussion group and the success of other farmers that had converted.

Farmer E had also observed that a dairy system was easy to budget and a simple business once established.

4.6.3 The mixed farm system (sheep, beef and crop)
The mixed farm is 950ha and is currently fully managed by Farmer E. The farm runs 1700 breeding ewes and 450 beef steers.

The farm has 150ha sown in white straw crops (currently barley and wheat), 10ha in grass seed, 35ha potatoes, 40ha maize silage, 60-70ha kale (winter feed), 20ha green feed oats, 20ha peas and 10ha in rape seed. The remainder is in permanent pasture for grazing. This includes some experimental pasture including a trial with lucerne this season.

Currently 30% of the farm is under pivot irrigation (three pivots) and 10% is under border dyke irrigation. The remainder is dry land. Historically, the farm has been limited by water but with the development of water storage, this is no longer a problem. The farm also has one unused water right which Farmer E says he needs to activate.

The farm has four full time staff.

4.6.4 The dairy system
The dairy farm was developed in a joint venture with a dairy investment and development group. There is an 80:20 equity split (Farmer E: investment group). The investment group acted as project managers during the conversion process and continue to provide Farmer E with back office support including monthly reports, budgets and two monthly discussion groups with Farmer E. The understanding is Farmer E will buy out the dairy investment group in the near-future.

The farm has a 56 bale rotary; this size was recommended by the dairy investment group. The shed has minimal automation with the exception of a grain feeder and Protrack\(^{11}\) (installed later). Farmer E explains that he is aware of the benefits of a small shed and does

\(^{11}\) Protrack is a farm automation system. It can be used for individual cow monitoring and recording, drafting and targeted feeding in the milking shed.
not intend to expand the size of the shed or the area of the dairy farm. Farmer E does however; intend to increase the automation in the dairy shed.

The farm has a manager who has no financial involvement. The manager is accountable for production and labour including labour employment. Farmer E chose a manager because he didn’t want to lose a further financial share in the business and with a manager he did not have to manage staff. The dairy farm has five full-time and one part time labour units.

The dairy farm is irrigated by a 743m centre pivot (with 84m folding arm) and a roto rainer. Farmer E built three new houses on the dairy farm during conversion, so dairy labour was completely separate from the remainder of the farm.

The 250ha dairy platform milks 962 cows at a stocking rate of 4.1cows/ha. Milk production last season (2011-12) was 470kgMS/cow. The cows get 700kg/cow of supplements on the milking platform. These supplements are all bought from Farmer E’s mixed farm and consist of maize silage, grass silage, wheat and barley.

During the first season bad weather presented challenges. The annual production for the first season was 392kgMS/cow, however there has been an annual increase in milk production and Farmer E feels the farms potential is 500kg MS/cow.

4.6.5 Synergies of the systems

The mixed cropping farm winters all cows and provides grazing for all replacement stock. The adjoining location of the farms creates the opportunity for the dairy platform to solely accommodate lactating cows with all dry cows/late calving cows kept on the mixed cropping farm. Stock can be kept on winter grazing paddocks adjacent to the dairy farm and be individually walked over to the milking platform at calving. In autumn, cows can be dried off in small groups and moved through to the mixed farm increasing the feed supply to those still producing. Farmer E also explains that the location makes it easy for the dairy workers to come across to the estate and set the breaks over winter or organise additional grazing for dry cows.

The mixed farm provides silage, wheat and barley for the dairy platform at market value.
Farmer E explains that selling supplementary feed to the dairy farm removes the middle man and reduces cartage costs. This synergy ensures a market for silage and white straw crops grown on the crop farm and assures the dairy farm of the quantity and quality of feed supplied. It increases the value of crops through straw and residual grazing. The dairy farm is the primary reason for the mixed farm growing barley, wheat and maize and the dairy farm has required no additional feed above what has been purchased from the mixed farm.

The dairy farm helps to justify cropping machinery - this machinery is also used on the dairy farm for fertiliser spreading, regrassing and lane maintenance. This reduces reliance on contractors and ensures things can be done at the time that best suits the dairy platform.

Risk management and diversification is an important driver and synergy in the operation of the two enterprises. Risk is spread between the beef, lamb, milk, small seed, cattle and potatoes prices. Farmer E says the dairy farm has allowed the crop farm to take bigger risks and try new techniques. This includes higher risk crops such as rape seed and potatoes and also trial crops such as lucerne on a dry land paddock. Farmer E notes that overall it was increased irrigation that led to growing higher value crops rather than the dairy farm.

Farmer E applies dairy effluent onto the mixed farm (crop land). He notes that he expects to see an increase in fertility on this land in the future. Based on these results Farmer E said a future synergy could be swapping some cropping land for dairy platform land to take advantage of the nutrients for high value crops. Farmer E runs dairy beef on the cropping farm. Farmer notes that the synergy of raising the dairy cross calves has been very successful in further increasing diversification.

Farmer E has observed that staff integration between the systems was not a possibility; that permanent employees on the estate almost appeared resentful of the dairy farm. Farmer E also recognised that the type of staff and their roles were very different between the enterprises. He noted that the dairy system followed structured rosters and routines while on the sheep and crop system, labour demand was more variable. Farmer E explained that good staff management on the dairy farm required an efficient, KPI driven manager. Farmer E said he was always happy to help out on the dairy farm during the tough times but was aware that his presence and the presence of the estate workers or Farmer E’s family could interfere with the dynamics of the team. “If it’s not a family thing then don’t cross over,
there is a hierarchy and boundaries” Thus Farmer E noted that the dairy farm operated as a stand-alone business for day-to-day management.

4.6.6 Future
The future plan for the mixed farm is to decrease sheep numbers and increase high value crops. Farmer E has been running the farm for 28 years so he believes he knows what works, and now with the dairy farm providing some security he can test some of his ideas and try new seed crops. With the cash return from the dairy farm, Farmer E notes he can develop the mixed farm without debt. His plan for the dairy farm is to keep investing in new technology. Farmer E has no short term plans to convert further but he says he could convert land under one of his cropping pivots to dairy. Farmer E aims to milk 1000 cows on his current dairy farm but will not expand the farm any further.
4.7 FARMER F

4.7.1 Introduction

Farmer F’s farm is a family farm, purchased by his parents in 1978. In 1984 Farmer F and his wife entered into a partnership with Farmer F’s parents. The property was mainly dry land with some irrigation and was a crop, sheep and beef farm. The farm had 3000 breeding ewes.

In the early 1990s, Farmer F and his wife purchased the farm in their own right and were looking for diversification. At this time they researched a range of option including vineyards (as an additional property) but made the decision to look towards dairy and by the 2000’s, were a 300ha intensive cropping farm. The property was fully irrigated and Farmer F had invested in new machinery. Farmer F described the farm as a high input high output system, with wheat, vegetable and seed crops.

Some land was converted to dairy in 2008. The dairy farm was initially 220ha, 100 hectares of the land was from Farmer F’s crop farm and the remainder was purchased from a neighbour (120ha). The additional acquisition of 100ha brought the dairy farm to 320ha.

In 2008 Farmer F started a business in precision irrigation. This has further allowed intensification of both the crop and the dairy with precision technology, soil mapping, crop sensors and grid soil sampling.

4.7.2 Reasons for conversion

Farmer E was looking for diversification. The decision to partially convert to dairy was based on increasing diversity and spreading risk. Profitability was not a factor as the crop farm was seen as very profitable.

The cropping farm was a mix of light and heavy soils. The 100ha taken from the crop farm to convert to dairy was the light soil portion of the farm. This soil was better suited to dairy. Due to the dairy farm having poorer cropping soils the farms never rotate cropping paddocks for dairy pastures.
4.7.3 The crop system
The 200ha crop farm is fully owned and managed by Farmer F. Farmer F has one full time employee.

The farm grows: wheat, radish, carrot, pak choy, beans, chicory, hemp, red beet, broad beans, fescue, green feed and ryegrass for seed.

The general rotation is one third of the farm in ryegrass for seed, one third in vegetables for seed and the remaining third in wheat. Farmer F does not consider the vegetables and seed crops high risk because although they have a high level of inputs and he attains a reasonable level of return.

The farm does not grow winter brassicas but instead winters 500 cows on green feed oats and cereals and ex-ryegrass seed crops. Farmer F explains that this is because he can earn more from wheat, and sowing wheat in March increases tonnage. Thus there is no room in the rotation for winter brassicas.

4.7.4 The dairy system
The dairy farm is an equity partnership. Farmer F owned half the land for the dairy farm and the equity partner bought the other half of the land from a neighbour of Farmer F. Farmer F started with 30% equity and now has 50% equity in the farm. Farmer F says the equity partnership has allowed different skills to be bought into the farm. Farmer F managed the conversion himself.

The dairy farm is 320ha with 1250 cows. The stocking rate is 3.8 cows/ha. Farmer F described the farm as a fully irrigated, pasture based, high input system. The cows are feed 800kg of supplement per cow. This is made up of: grain, canola, palm kernel and silage as required. The grain is fed-out in the shed to match the cow’s individual needs. The physical division of the cows is into three herds but there are 24 feed groups to meet the individual supplementary feed requirements. The farm produces 2200kgMS/ha and cows are selected to handle grain feeding and production between 500-600kgMS/cow. The farm is investing into genetics to increase cow size and milk production.

500 dairy cows are wintered on the crop farm and the rest are wintered with neighbours/in the local area. All replacements are wintered off both farms.
The dairy farm is run by a 24% lower order sharemilker, with a 6 labour units. The sharemilker moved up from being a manager. Farmer F said he would not change to a 50% sharemilker as he would lose too much control. Farmer F explained he would have a greater income if he had a contract milker or a manager but he did not want to manage staff. Farmer F says it’s easier to manage staff when you are directly working with them rather than managing through a manager.

**4.7.5 Synergies of the systems**

The biggest advantage of the two farms according to Farmer F is the ability to share knowledge. Farmer F can apply knowledge learned from the crop or precision irrigation business to the dairy farm.

Farmer F sells straw and silage cut on the crop farm to the dairy platform at market price. Farmer F does not often sell grain to the dairy farm because he can buy grain cheaper than the returns he receives for his grain. Farmer F notes that the dairy farm gains from his understanding of the markets and operating like a business man. Farmer F notes that one season he made a monetary saving of $100/t of grain for the dairy farm from understanding the market.

The crop farm winters 500 cows for the dairy farm. The ability to winter part of the herd on the crop farm often allows cows to be held off the platform longer. Farmer F notes this is within reason and is dependent on the profitability and grazing of the crop farm. The adjoining blocks can allow for early drying off and removal from the platform and occasionally cows can be milked off the crop farm when there is excess ryegrass in autumn.

Crop farm machinery is not often used on the dairy farm but occasionally regrassing and fertilizer spreading can be done at market price if the equipment is not needed on the crop farm. The heavy roller is shared by both farms.

**4.7.6 Future**

The future of the farms for Farmer F is to keep up with technology and push productivity. Succession is important to Farmer F in terms of creating a profitable business to benefit his children rather than keeping the land itself. If farmer F’s children want help in their chosen
vocation then Farmer F believes he can could exit the agriculture industry or sell one of the businesses in the future. Farmer F’s crop farm is a profitable business in its own right and he would not convert it to dairy.

Farmer F discussed the potential to spread dairy effluent on the crop farm. Farmer F does not currently spread effluent outside the dairy platform due to the inconsistencies of the product. However Farmer F said there may be opportunities to spread effluent onto the crop farm in the future with improvement of technology. To remove inconsistencies he would have to improve the processing of his effluent pond and use variable rate irrigation. Farmer F is currently in the process of investigating variable rate irrigation for the dairy farm and one cropping pivot. If effluent could be removed from the platform Farmer F notes it would reduce the environmental footprint of the dairy farm.
4.8 Farmer G

4.8.1 Introduction
Farmer G’s parents originally farmed 200ha. In 1987 they increased the farm to 350ha and in the late 1990s increased the land area to 450ha. The property was a mixed farming operation. In the 1980s the farm was sheep, crop and deer and in the 1990s the deer numbers increased as they became more profitable. In 2000 the farm changed its focus toward crop and dairy grazing.

Farmer G completed his university education in 2000 and after working for a seed company returned to the farm in 2003. Farmer G ran the mixed cropping operation and in 2003 also bought an additional 60ha to add to the mixed farm. The farm ran 1,500 deer, 600 breeding ewes, and finished 2,000-3,000 lambs. The property also ran dairy support and grazing bulls, dairy heifers and velveting stags. The farm cropped 150ha of ryegrass for seed and varying areas of barley, wheat, winter forage and brassica seed. Farmer G described the farm as a complex operation with intense management. As a result, between 2003 and 2005, Farmer G reduced capital stock and changed the focus to cropping and dairy support.

In 2005, Farmer G built the first cow shed on the property, converting 200ha to dairy. This dairy platform fully replaced the deer unit. In the second season of dairy operation, Farmer G planned a second dairy shed. In season three the two dairy sheds were milking 1,600 cows on 400ha. Farmer G then purchased an adjoining 220ha and finished building a third dairy shed in December 2011 – running the remainder of the season with 2,200 cows through three sheds. Farmer G also purchased a run-off block of 100ha. This season (2012/13) the three sheds will milk a total of 2,500 cows across the 660ha (effective total) dairy platforms. The total cropping programme this season will be on the 100ha run-off block.

4.8.2 Reason for the Conversions
In the 1990s Farmer G’s parents looked at converting the farm to dairy but decided against conversion. Farmer G believed that this was because at the time the return on capital for dairy was similar to mixed cropping. Farmer G also noted that he worked on a dairy farm when he was younger and had not enjoyed the experience. Farmer G thinks this may have put his parents off converting.
A driver for Farmer G making the decision to convert in the early 2,000s was a proposed change in water rights. Farmer G said that there was the introduction of separate water rights for different land uses and they hoped the conversion to dairy might improve their current water right. However, Farmer G said in the end this was not the case.

Another driver for change was the simplicity of the dairy system reducing both the complexity of the crop system and improving the ease of management.

Farmer G said dairy was attractive because it guaranteed cows for wintering, young stock to graze and reduced the negotiating over prices. After the first conversion, profitability and succession drove the subsequent dairy sheds. The second dairy shed at the time was seen as a way to make the farm more divisible for succession purposes.

4.8.3 Dairy System
The farm has been divided up into three ownership structures. The first dairy farm is through a land holding company. The second farm is in a family trust and the third as a joint venture between Farmer G and a partner. Farmer G now has the ‘dairy operation’ where he operates/oversees the three independent farms plus the runoff as one unit. Farmer G has lower order sharemilkers in two sheds and a manager in the third. The reason for the lower order sharemilker was to reduce the number of labour unit’s Farmer G was directly managing. At one time the three farms and the runoff can have a maximum total of 17 labour units. Farmer G says he would not consider 50:50 because he would lose the synergies of management between the dairy farms and the runoff and feed supply.

Last season, the three sheds ran 900, 900 and 820 cows producing 448kgMS/cow. Farmer G describes himself as a system 3 or 4 farm feeding supplements “in the holes of pasture supply”. He feeds 500kg/cow of grain and 100kg/cow silage supplements. Supplements are purchased from the runoff and from external sources. One third of the cows are wintered on the run off and the rest on neighbouring land. Replacements are grazed off farm.

4.8.4 Crop/Runoff farm
The 100ha farm has a rotation of kale – barley – grass.

The farm produces primarily for the dairy farms but may sell any excess silage outside the group. Farmer G notes he is always considering new crops. When asked if he would consider
high value crops such as seed crops instead of dairy support, Farmer G said he was not interested because he liked the simple system. Farmer G said that he could possibly purchase barley cheaper than he could grow it for the dairy farm, but noted it was a clean rotation and provided all the straw required for the farms. He also said he had grown carrot and ryegrass seed in the past and the management, time and high inputs needed for successful seed crops were not worth the risk or return.

4.8.5 Synergies of the systems
A synergy of the farm system according to Farmer G is the ability to move staff between the dairy farms with the managers and the crop farm allowing the staff to help each other out during the tougher periods of the year. Equipment from the crop farm can be used for regrassing and drilling on the dairy farms.

Another synergy Farmer G recognises is in the scale of the system and the accessibility of the run-off provides a level of self-sufficiency which manages the risk of an increase in grazing and wintering prices.

4.8.6 Future
Farmer G has no plan to invest in another dairy farm or expand the permanent area of the dairy platforms however he is considering leasing land to increase the 850 cow platform to carry 900 cows.

Farmer G would also consider buying another 100ha of runoff to be almost self-contained (would still graze replacements off the farm). However Farmer G said he would be losing $40,000-$100,000 annually to buy more land for winterfeed. Farmer G considered the additional support land as an option for security in case of an increase in grazing and wintering costs.
4.9 Summary of Case Studies

Table 5: Summary of the seven case studies (1) Abbreviations: RG-ryegrass, C-clover, MP-milking platform PKE-palm kernel extract, EST-estimated.

<table>
<thead>
<tr>
<th>Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dairy 1</td>
<td>Dairy 2</td>
<td>Dairy 1</td>
<td>Dairy 2</td>
<td>Dairy 1</td>
<td>Dairy 2</td>
<td>Dairy 1</td>
</tr>
<tr>
<td>Total Land Area (effective ha)</td>
<td>445 (separate land parcels &amp; entities)</td>
<td>563 (separate land parcels)</td>
<td>630</td>
<td>950</td>
<td>1200</td>
<td>520</td>
<td>760</td>
</tr>
<tr>
<td>Crop Area (ha)</td>
<td>225</td>
<td>240</td>
<td>350-360</td>
<td>530</td>
<td>950 (incl. sheep, beef)</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Milk Platform (MP) (ha)</td>
<td>220</td>
<td>138</td>
<td>270-280</td>
<td>420</td>
<td>250</td>
<td>320</td>
<td>227</td>
</tr>
<tr>
<td>% area under milking platform</td>
<td>49%</td>
<td>57%</td>
<td>44%</td>
<td>44%</td>
<td>26%</td>
<td>62%</td>
<td>87%</td>
</tr>
<tr>
<td>Dairy Cows (peak)</td>
<td>770</td>
<td>500</td>
<td>700</td>
<td>1100</td>
<td>1900</td>
<td>962</td>
<td>620</td>
</tr>
<tr>
<td>Stocking Rate (cows/ha)</td>
<td>3.5</td>
<td>3.6</td>
<td>3.8</td>
<td>4.2</td>
<td>4.5</td>
<td>4.1</td>
<td>3.9</td>
</tr>
<tr>
<td>Total supplementary feed MP (kg/cow)</td>
<td>1177</td>
<td>700</td>
<td>700 incl. silage</td>
<td>700 est incl. silage</td>
<td>700</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>EST % of the supp. feed bought externally</td>
<td>0%</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>% of the supp. feed made on crop or MP</td>
<td>100%</td>
<td>&lt;50%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>border dyke (BD), spray</td>
<td>BD 3/4 spray</td>
<td>spray</td>
<td>spray</td>
<td>spray</td>
<td>spray</td>
<td>spray</td>
</tr>
<tr>
<td>Crop</td>
<td>cash crops</td>
<td>cash crops</td>
<td>cash crops</td>
<td>cash crops</td>
<td>cash crops</td>
<td>cash crops</td>
<td>Barbados</td>
</tr>
<tr>
<td>Crop land use</td>
<td>run off</td>
<td>run off</td>
<td>milking platform</td>
<td>supplementary feed</td>
<td>run off</td>
<td>run off</td>
<td>supplementary feed</td>
</tr>
<tr>
<td></td>
<td>lamb fattening</td>
<td>minimal supp. feed</td>
<td>supplementary feed</td>
<td>sheep (1700 B. ewes)</td>
<td>lamb fattening</td>
<td>minimal supp. feed</td>
<td>sheep (1700 B. ewes)</td>
</tr>
<tr>
<td>Production</td>
<td>457</td>
<td>500</td>
<td>457</td>
<td>505</td>
<td>485</td>
<td>470</td>
<td>550</td>
</tr>
<tr>
<td>kgMS/cow</td>
<td>1600</td>
<td>1800</td>
<td>1775</td>
<td>2120</td>
<td>2183</td>
<td>1927</td>
<td>448</td>
</tr>
<tr>
<td>kgMS/ha</td>
<td>specialty seeds (X4)</td>
<td>seed crops (RG, C)</td>
<td>specialty seeds</td>
<td>seed crops (RG, C)</td>
<td>white straw crops</td>
<td>seed crops (rape, RG)</td>
<td>white straw crops</td>
</tr>
<tr>
<td></td>
<td>maize</td>
<td>wheat</td>
<td>barley</td>
<td>peas</td>
<td>crab</td>
<td>kale</td>
<td>kale</td>
</tr>
<tr>
<td>Crops Grown</td>
<td>1800</td>
<td>1775</td>
<td>2120</td>
<td>2183</td>
<td>1927</td>
<td>1778</td>
<td>1778</td>
</tr>
<tr>
<td></td>
<td>barley</td>
<td>barley</td>
<td>barley</td>
<td>barley</td>
<td>kale</td>
<td>kale</td>
<td>kale</td>
</tr>
<tr>
<td></td>
<td>peas</td>
<td>swedes</td>
<td>kale</td>
<td>kale</td>
<td>plantain</td>
<td>kale</td>
<td>plantain</td>
</tr>
<tr>
<td></td>
<td>kale</td>
<td>Asian brassicas</td>
<td>kale</td>
<td>kale</td>
<td>green feeds</td>
<td>kale</td>
<td>kale</td>
</tr>
<tr>
<td></td>
<td>kale</td>
<td>kale</td>
<td>kale</td>
<td>kale</td>
<td>maize</td>
<td>kale</td>
<td>maize</td>
</tr>
<tr>
<td></td>
<td>oats</td>
<td>oats</td>
<td>oats</td>
<td>oats</td>
<td>oats</td>
<td>oats</td>
<td>oats</td>
</tr>
<tr>
<td></td>
<td>hemp</td>
<td>hemp</td>
<td>hemp</td>
<td>hemp</td>
<td>hemp</td>
<td>hemp</td>
<td>hemp</td>
</tr>
</tbody>
</table>
### Table 6: Summary of the seven case studies (2)

<table>
<thead>
<tr>
<th>Category</th>
<th>FARMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops grown/waste products for MP</td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>RG, C seed - silage</td>
<td>pea vines - baleage</td>
</tr>
<tr>
<td>maize silage</td>
<td>kale (all wintering)</td>
</tr>
<tr>
<td>pea vines - baleage</td>
<td>RG grazing replacements pastures silage</td>
</tr>
<tr>
<td>fodder beet (cut &amp; carry)</td>
<td></td>
</tr>
<tr>
<td>wheat</td>
<td></td>
</tr>
<tr>
<td>fodder beet</td>
<td></td>
</tr>
<tr>
<td>kale</td>
<td></td>
</tr>
<tr>
<td>RG, C seed - silage, grazing</td>
<td></td>
</tr>
<tr>
<td>Imported feed (externally supplied)</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>barley</td>
</tr>
<tr>
<td></td>
<td>maize</td>
</tr>
<tr>
<td></td>
<td>silage</td>
</tr>
<tr>
<td>Decisions</td>
<td>Dairy 1</td>
</tr>
<tr>
<td>Year of conversion (season 1)</td>
<td>2000</td>
</tr>
<tr>
<td>Shed Size (rotary size)</td>
<td>50 bale</td>
</tr>
<tr>
<td>Dairy Management</td>
<td>manager</td>
</tr>
<tr>
<td>Reasons for Conversion</td>
<td>profitability risk</td>
</tr>
<tr>
<td></td>
<td>best land use - environment</td>
</tr>
<tr>
<td>Major Synergies</td>
<td>runoff - including nutrients</td>
</tr>
<tr>
<td></td>
<td>mgmt &amp; info sharing</td>
</tr>
<tr>
<td></td>
<td>supp. feed risk sharing</td>
</tr>
<tr>
<td>Relationship (defined in discussion)</td>
<td>complementary</td>
</tr>
</tbody>
</table>
CHAPTER 5
DISCUSSION and CONCLUSIONS

5.1 Introduction

The purpose of this chapter is to discuss the research findings. Section 5.2 provides evidence of production advantages and section 5.3 examines the hypothesis outlined on page 37. Sections 5.4 to 5.8 present the research findings in relation to the five research questions from section 1.4. Each research question has a concluding summary.

The five research questions are:

5.4 What were the drivers of conversion?
5.5 What synergies exist between crop and dairy?
5.6 What was the process of adoption and development? How did the physical attributes of the properties influence both farm development and the available synergies?
5.7 What were the challenges and successes of partial conversion? What are the future plans and proposed developments?
5.8 How do the identified complementarities fit relative to prior theoretical frameworks on farm system complementarities?

The subsequent sections (5.9-5.10) will discuss the limitations of this research and the opportunities for future research.

5.2 Evidence of production advantages

In comparison to the production averages in the Ashburton District for 2011-12 (LIC, 2012), all the case study farmers had a higher stocking rate per hectare and greater milk production per cow (table 7). The synergistic relationships between dairy and crop may facilitate these production advantages. These advantages include the ability to maximise the length of the milking season, graze crop land, remove non-milkers from the milking platform quickly,
ensure body condition over winter and make the most of supplements including waste products from the crop farm.

The case study farmers achieved extended milking season length through cut and carry feed, staggered drying off and later return to the dairy platform for cows in the spring, the grazing of seed crops and increasing the size of the milking platform as required.

The average herd size and farm size was also above the district average.

Table 7: A comparison between the averages for the Ashburton District and the case study averages.

<table>
<thead>
<tr>
<th>Stocking rate (cows/ha)</th>
<th>Averages for the Ashburton District (LIC) 2011-12</th>
<th>Average for the case studies</th>
<th>Range from the case studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd size (total no. cows)</td>
<td>859</td>
<td>881</td>
<td>500 to 1900</td>
</tr>
<tr>
<td>Effective hectares (milking platform)</td>
<td>243</td>
<td>247</td>
<td>138 to 420</td>
</tr>
<tr>
<td>Milksolid production (KgMS/cow)</td>
<td>406</td>
<td>485</td>
<td>457-550</td>
</tr>
<tr>
<td>Milksolid production (KgMS/ha)</td>
<td>1421</td>
<td>1892</td>
<td>1600-2182</td>
</tr>
</tbody>
</table>

All the case study farms had a high level of supplementary feed (600-1200kg/cow). The farms were feeding between two and five kilograms of supplements per cow daily (mostly grains). This means the case studies fit into systems three to five of the DairyNZ Five Production Systems. Sinclair (2011) found that the ability to source good quality supplements at a low price was a significant factor in the success of system five farms. The case study crop farms do not subsidise the cost of feed for the dairy platform but information sharing allowed the appropriate quantity and quality of feed to be supplied to the dairy farm with reduced transaction costs.
5.3 Application of integration through land use change in Mid-Canterbury

Industry informants put forward two rival hypotheses (section 3.1.1, p. 37) on the drivers of land use change and where the Mid-Canterbury crop-dairy was heading in the future. Informant A suggested integration was actually a process of transition from mixed cropping to a dairy platform. However, Informant B suggested integrated systems would exist as a method of risk management, enabling farmers to better prepare against volatile markets.

One of the case study farmers is in the process of transitioning to full dairy and there may be a number of Canterbury crop farmers who have transitioned from crop to dairy using integration. However, six of the seven case study farmers in this study have not, and do not currently intend to fully transition into dairy. Risk management is a strong driver for them to remain with both enterprises, as suggested by Informant B.

This highlights the continuation of integration and shows that these farmers have different drivers than Pangborn’s (2012) wave 3 crop farmers who were driven by profitability and converted completely to dairying.

5.4 What were the drivers of conversion?

5.4.1 Search for increased profitability

Six of the seven case study farmers named profitability and/or income spread as a driver for adopting a dairy platform. However, none of the case study farmers saw profitability as a sole driver for this change. Farmer A said at the time of his conversion (1999) he saw both systems as having equal profitability but the potential future profitability would be higher for dairy. At the time of their conversions, Farmers B and D saw dairy as more profitable relative to the time and stress they were putting into crop. Farmer F said he had no profitability drivers and Farmer C said he was driven by improved income spread rather than profitability. However Farmer C said the security from dairy income allowed him to grow higher risk crops on his cropping farm, potentially increasing the profitability of the crop farm.

5.4.2 Lifestyle improvement and the social factor

Four of the six farmers that identified profitability as one of their motives, also talked about lifestyle improvements as a reason for converting. These farmers recognized dairy as being a
simple system in comparison to crop, with less stress and workload for the owner. These farmers partially converted to dairy to recapture the enjoyment of farming and to increase their recreational time. Yet, these same farmers did not want to fully convert because they have a personal preference for cropping and consequently wanted to continue to work on the cropping farm.

As outlined in chapter 2.3.2 (p. 20), researchers McGackian and Rickards (2011) found that social factors predominately influence land use change. For all of the farmers in this report, ‘social factors’ were important in their decision making. The four social factors outlined by McGackian and Rickards (2011) were hassle reduction, labour, recreational time and personal influence. Personal influence was defined as a farmers desire for a system which includes the enterprises he enjoyed. Although they all maintained partial cropping, and it continued to be their personal preference, in all the case studies the idea of making ‘change’ was itself, a motivating factor.

The ‘labour factor’ was outlined by McGackian and Rickards (2011) as ‘the desire to use labour more efficiently’. However, in the circumstances of the case study farmers when they converted to dairy they were intensifying their labour to reduce their personal workload. All the case study farmers employed a system which removed them from the role of managing and hiring labour thus allowing them to meet their personal work preference, reduce hassle and increase recreational time.

All the case study farmers employed either a lower-order sharemilker or a manager on the milking platform. In all cases, the primary reason for this structure was so the case study farmers did not have to manage staff. However, some farmers also wanted to avoid the milking process. Additionally, this management strategy removed some land from the case study farmer’s direct care thus further reducing workload. In all cases the cropping area was reduced. Farmers continued their involvement with cropping, their preferred enterprise but on a smaller scale.

This management strategy meant that the case study farmers did not need to upskill or acquire new knowledge (in both the areas of dairy and labour management) with any urgency.
5.4.3 Risk Management

Risk management was an important driver for partly converting to dairy. Spreading risk through diversification of income was regarded as an important factor in six case studies. In these cases, a dairy conversion was seen to reduce the climatic, market and price risks associated with cropping. Market volatility is apparent in both the milk pay-out, arable and small seed return however partial conversion drivers were mostly associated with risks within the arable system.

The perceived security of the dairy diversification further encouraged a number of the case study farmers to change their personal risk position within the cropping enterprise. They substituted their perceived low risk crops for higher paying crops (which they regarded as higher risk) because they had income security through the dairy farm.

Risk management was also a primary reason the case study farmers chose not to fully convert to dairy. Risk will be further explained as a synergy in section 5.5.1.

5.4.4 Other drivers of partial conversion

A number of other reasons were offered for conversion from an individual farmer’s perspective. Farmer E and Farmer G both converted as a method of making the farm more easily divisible for succession. Additionally, Farmer A said the irrigation scheme and scattered trees made his property better suited to dairy than crop and this helped his decision to convert. Farmer G initially decided to convert purely to obtain additional water rights, but then decided to convert further for reasons relating to profitability, succession and the simplicity of management. Farmer C said a driver of the conversion was the excitement of entering a new industry and learning new skills.

5.4.5 Summary

Improved lifestyle, the search for improved profitability and risk spreading were the main drivers of partial conversion recognised by the majority of the case study farmers. Improved lifestyle included reduced workload, less stress and preferred on-farm roles. Succession and physical attributes of the land created unique drivers for some of the case study farmers.
5.5 What synergies exist between crop and dairy?

5.5.1 Cost and risk sharing

Farmer E was the only case study farmer who mentioned creating a synergistic relationship (with adjoining enterprises) as a driver for partially converting to dairy. All the other case studies needed prompting into a discussion on the synergies on their properties.

However, when asked about their plans for the future, a number of farmers noted the benefits of synergism namely through risk management. Risk management was not only a driver for conversion but also a driver for not converting any further and continuing to crop part of their farm system.

Cost and risk sharing has been defined in Chapter 2.4.6 by Villano et al. (2010) as a form of synergy. When spreading risk through diversification, the greater the diversification, the better the ability the system has, to adapt to change at a lower cost (Villano et al., 2010). The case study farmers said they changed crops in their rotations to avoid lower paying crops, but they never suggested increasing cow numbers if crop prices fell. Nor did they suggest that they would decrease cows to increase cropping if milk prices fell below $5.50 (the price suggested by Farmer A and Farmer C where cropping would be more profitable than dairy).

5.5.2 Sharing of machinery resources

Four of the seven case study farmers named the sharing of machinery as a synergistic relationship. Cropping machinery and cropping staff were used on the dairy farms for regrassing, fixing laneways and spreading fertiliser. This reduced the farmer’s reliance on contractors and allowed projects to be completed when it best suited the dairy platform.

5.5.3 Land use synergies

Farmer C was the only farmer without a fully fixed area selected for the dairy platform. Instead paddocks could be switched between crop and dairy, usually with crop being incorporated into the dairy platform when regrassing was required. This allows for more rapid pasture renewal on the dairy farm. Further, having crop and dairy adjoining without fixed boundaries often allowed Farmer C’s milking platform to be expanded when additional grazing was required.
All the case study farmers had full or partial dairy herd wintering on their crop farms. Farmers D, E and F (all with adjoining crop and dairy farms) used their crop farms for grazing at the ends of the season. They could practice individual drying off of cows in autumn so that they could milk cows longer. They could also keep cows on the crop/winter grazing longer in spring, bringing them onto the milking platform in small groups at calving. Moving cows across to the crop farm to graze ryegrass seed crops was also a popular occurrence across the case study farms. These management practices may explain how the case study farmers achieve above average milk solid production per cow and greater stocking rates. Anecdotal evidence suggests that grazing ryegrass seed crops in spring improves yields.

The farmers felt they had more control of the cow’s well-being and feed intake when wintering the cows on their own farms compared to external grazing contracts. Farmer B said wintering cows was more profitable than fattening lambs because the grazing price is set at a guaranteed price but the schedule for lambs is volatile. Farmer B stated that if he felt there was a better land use for his wintering paddocks, then he would send the cows off-farm for winter grazing.

Farmer C said wintering provides security and guaranteed the cropping profit. Farmer A said wintering cows fitted into and allowed for a six year intensive rotation for crops. He also noted that the maize which followed winter feed in the rotation benefited from the manure and reduced the fertiliser applied to the maize crop. Farmer D mentioned that the closeness of winter grazing (on his adjacent crop farm) made the dairy workers job easier – as they didn’t have to travel far to set feed breaks.

5.5.4 Supplementary feed
All the case study farmers had synergies involving supplementary feed. Farmer A and Farmer E only bought supplements for cows from their cropping farm. Farm C and Farmer D bought the majority of their feed from their cropping farm but would make their decision based on the comparative costs of other feeds. These farmers all mentioned the benefit of reduced transaction costs when they traded feed internally. Farmer B grew grain on his crop farm but did not sell it to his dairy platform as the land was not adjoining and he could buy grain from neighbours (neighbouring the dairy platform) at a lower cost. Farmer F did not grow any
supplements (other than waste products and silage) for the dairy platform because he could get better prices elsewhere (lower than what his crop farm sells it for) for his cows.

All of the case study farmers sold silage or baleage (made on their cropping farm) to their dairy farms. Other products the farmers sold to the dairy platform included pea and barley straw. Those farmers with adjoining crop and dairy farms also grazed their seed crops (ryegrass and clover) with cows, which could be considered a supplement.

### 5.5.5 Information sharing and farmer knowledge

Information and farmer knowledge was another important synergy. The case study farmers felt they had greater knowledge (and suggested their knowledge was comparatively better than pure dairy farmers) on crop markets and the value of feed. The case study farmers generally felt this enabled them to make more informed decisions about feed costs.

### 5.5.6 Environmental synergies

A synergistic relationship which arose in the literature was the use of animal effluent on crops. Farmer A noted this benefit when growing maize. Farmer A's cows wintering on fodder crops provided enough nitrogen from urine to grow a subsequent maize crop without further nitrogen fertiliser. Farmer E applied dairy effluent onto his crop land. He noted that he expects to see an increase in fertility on this land in the future. When the cropping land was used for dairy and then planted back into crop, Farmer C noted that these paddocks produced better yields. Spreading effluent over a greater area (cropping land) could reduce nutrient loading and growing crops which ‘mine’ nutrients could reduce negative environmental effects.

Farmer F noted that spreading effluent on his cropping farm could be possible. This would be beneficial to decreasing the environmental footprint of the dairy farm.

### 5.5.7 Summary

The ability to share risk was an important synergy across the case studies. Risk reduction was an important synergy because it was also a driver of conversion and a reason for maintaining a partial crop system. Land sharing between the milking platform and the crop farm was another important synergy. Land sharing provided easy expansion of the dairy platform in crucial times while increasing the value of crop through the grazing of waste products. It can
be suggested that this additional grazing may be a factor in the above industry-average production reached by all the case study farms. Buying supplementary feed from the crop farm created synergistic benefits including reduced transaction costs and reliable crop markets. The case study farmers noted potential environmental synergies but the advantages of these synergies are yet to be determined.

5.6 What was the process of adoption and development? How did the physical attributes of the properties influence farm development and the available synergies?

5.6.1 The process of dairy adoption
The process of dairy adoption for all the case studies was the movement from intensive crop to dairy. Previously, most of the case study farmers had moved from sheep systems to dairy support or intensified cropping before converting to dairy.

None of the case study farmers were existing dairy farmers when they converted to dairy. Farmer B has been categorised in this thesis as a crop farmer rather than a dairy farmer, although he has a history in both crop and dairy. This is because prior to his final conversion, Farmer B had been cropping for a number of years. Based on this assumption, all the case study farmers converted to partial dairy from a crop background, thus with a specialist skill-set in cropping. These existing skills allowed the case study farmers to maintain cropping within their operations. There may be implications as to whether these skills will pass through to the next generation if they become more involved in the dairy portion of the business.

Most the farms were irrigated prior to the conversion and a number of farms already had appropriate laneways and fencing from previous dairy support. Some of the farms chose average shed sizes with automation for ease of labour (50-60 bale rotaries). Choosing smaller shed sizes may highlight a lack of urgency to further convert land to dairy.

Consultants and discussion groups influenced and led the case study farmers through the conversion process. Farmer E was influenced by another farmer who had converted successfully and had found dairying a more profitable enterprise.
Some of the case study farmers utilised equity partners to grow their businesses. An experienced manager or lower order sharemilker who was passionate about dairy was highlighted as important by some of the case study farmers.

### 5.6.2 Farm physical attributes influencing synergies and development

The biggest physical attribute which affected the availability of synergies within some case study farms was the non-adjoining nature of land parcels. Farmer A said he would have liked adjoining crop and dairy farms for greater synergistic benefits, however he had not had the opportunity to purchase more land around his dairy farm. The adjoining nature of some of the case study properties will be further explained in section 5.7.3.

Different soil types separated what Farmer F could use for crop and dairy, while Farmer E noted high DDT levels limited the area available for the dairy platform. Farmer A chose to convert his farm to dairy because the scattered trees made the land better suited to dairy (with sprinkler irrigation) than crop.

### 5.6.3 Summary

The case study farmers moved from intensive crop to dairy, this gave the farmers a specialist skill set in cropping. There are implications as to whether the complementarities will pass through to the next generation as the skill-set may not be passed on especially if succession divides the business. The greatest cost in the conversion process was the dairy shed as the farms contained sufficient existing infrastructure. Farmers utilised a range of information sources in completing the conversion process.

### 5.7 What were the challenges and successes of partial conversion? What are the future plans and proposed developments?

All the farmers were asked about problems and challenges with the dairy system including negative lifestyle changes. The case study farmers showed little negativity towards both the dairy and crop in their new mixed systems. Therefore, it can be theorized that the challenges of running a mixed system were no greater than operating a pure cropping system. A reason for their positive outlook may have been due to the ‘newness’ of their conversions and the novelty value. Most of the case study farmers converted post-2000, and five of the seven farmers undertook conversions after 2005. The success from improved income spread and
reduced work load were such powerful outcomes that it could be suggested that farmer attention was diverted from any negatives.

None of the case study farmers had immediate plans to further convert to dairy in the short term. In nearly all cases (with the exception of Farmer G) the successful elements of the system were risk management, reduced workload and the creation of a dependable market for crops. The increased risk spread allowed by cropping and dairy enterprises was more attractive than fully converting to dairy. However, two farmers foresaw future succession planning as a circumstance where further dairy conversion may need to be reconsidered.

Farmer G was the exception because he converted the majority of his land, no longer grows crop for sale, and can provide only minimal supplements. Farmer G acknowledged that increasing the size of his runoff (through purchasing land) was attractive for dairy feed security.

5.7.1 Summary
The case study farmers saw their mixed systems as successful and were optimistic about the future of their systems. The successes included improved income spread and reduced workload. None of the case studies had short-term plans to convert further but in some cases farmers acknowledged that future conversions may need to be considered in succession plans.

5.8 How do the identified complementarities fit relative to prior theoretical frameworks on farm system complementarities?

To define and categorize levels of complementarity in the case studies, the case studies will be compared to the integrated farm frameworks taken from literature. Complementary systems or ‘systems operating with complementariness’ are umbrella terms in this thesis used to describe farm systems under different levels of integration. Synergies are the cooperative effects which arise from these complementary systems. Section 5.8.1 uses the framework of Villano et al. (2010) to define the synergistic relationships recognised in the case studies. Section 5.8.2 uses further frameworks to categorise and define the overarching complementary systems.
5.8.1 Villano’s synergistic relationships applied to the case studies

The synergistic relations outlined by Villano et al. (2010) reduce competition between two enterprises and accentuate the economic advantages. The case studies incorporated most of the synergies defined by Villano et al (2010).

Villano’s synergy of ‘combining farm resources’ was applicable to land, machinery and management in the case studies. Hired labour was not shared as the differing nature of the work required between dairy and other farm systems and the attitudes of the workers to the types of work did not mix. Therefore, the labour force on crop and dairy farms could not be combined. Further Farmer E noted animosity from cropping workers towards dairy workers, and suggested it was a response to feeling threatened by job loss from the rise in conversions. Although some of the crop farms did contract work for the dairy farms (fertiliser spreading, lane maintenance) none of the case studies shared their workers across their different enterprises.

Information-sharing, joint decision-making and risk sharing were seen as crucial synergies in the system (section 5.2). Augmentation within the case studies can also been seen as a form as vertical integration. Augmentation was crop and residuals fed into the dairy system, and manure as a waste product used in the crop system. Augmentation is constantly changing depending on the price of feed in the market. Using effluent as a form of augmentation has been recognised by some farmers and may be seen as an economic and/or an environmental benefit.

Of Villanos’ five synergies there is only one synergy not easily distinguishable within the case studies, this is ‘functional complementarities’. New functional characteristics often comes about through research and development (Villano et al., 2010). The example used by Villano et al. (2010) for functional complementarity was crop breeding research resulting in a crop variety which has more nutritious stubble for winter feed. This synergy was not apparent; however it may exist in the case studies without intention. Due to the ‘newness’ of these systems there is unlikely to be research and extension which creates intentional functional complementarities between crop and dairy.
5.8.2 Classification of system complementarities
Classifying the case studies into different levels of complementarity can be achieved through comparisons to international frameworks. This application of the frameworks to the case studies will be achieved by using three steps or levels of complementarity. These can be divided into organisational, space and time as proposed by Bell and Moore’s (2012) model (section 2.4.5, p.30, figure 11). Each step is outlined in this section with application to the appropriate models and theories.

Step 1: System complementarities

- Sumner and Wolf (2002)
- Villano et al. (2008)
- Villano et al. (2010)
- Bell and Moore (2012)

Step 2: Type of system complementarities (in physical space)

- Endz et al. (2005)
- Russelle et al. (2007)
- Hendrickson et al. (2008)
- Hilimare et al. (2011)
- Bell and Moore (2012)

Step 3: Types of system complementarities as effected by time

- Hendrickson et al. (2008)
- Hilimare et al. (2011)
- Bell and Moore (2012)

5.8.2.1 Organisation: Applying system complementarities
Within the case studies, complementary systems were apparent and arose in two ways; vertical integration and diversification. Although vertical integration and diversification were
apparent, none of the case studies had only diversified or only vertically integrated. Rather they had used both to meet their key drivers.

According to Sumner and Wolf (2002), diversification mitigates risk through having more than one distinctly marketed output. The case studies highlighted that the spreading of risk was a driver of conversion. The case studies diversified by having milk production and crops for external markets. This included seed crops, vegetable crops, milling wheat, crops sold to other farms for feed and in some cases meat animals such as sheep and steers.

Vertical integration controls risk through ensuring a market (for crops) and ensuring the quality and quantity of fixed inputs (dairy feed). A number of case study farms integrated supplementary feed with the dairy platform so the system did not have to purchase any external feed. Reduced transactions costs arising from this complementarity reflected the existence of scope economies (Villano et al., 2008). The result of economies of scope is greater output at a lower cost per unit of output. Reduced transaction costs according to the case study famers included cartage and commission to agents.

A further driver of conversion was less management stress and increased free time. It can also be suggested that management time is a transaction cost which was reduced through integration; because the farmer no longer had to communicate with the external market.

Bell and Moore (2012) described Australian farm business practices in relation to integration. Their model (figure 11, p. 30) splits the ‘farm business’ into two categories; specialisation and diversification. This categorisation was developed based on the number of farm enterprises in the farm business. For application to the crop-dairy system in Canterbury the model has been revised to include not only the number of enterprises but also the number of final products. This means the ‘farm business’ splits into three categories; specialisation, diversification and vertical integration. A proposed model for Canterbury crop-dairy is outlined in figure 12.
Figure 12: A nested categorisation to describe practices that involve interaction of crop and dairy enterprises.
5.8.2.2 Space: Types of system complementarities
Russelle et al. (2007) described two types of integration within a farm business in the scope of space 1) within-farm integration and 2) among-farm integration. What arises from this simplistic differentiation is that complementarity can arise without adjoining or overlapping enterprises in space. The proposed model (figure 12) shows ‘space’ divided into co-location and segregation. Co-location is within-farm integration and segregation includes both adjoining and separate land parcels when land rotation does not occur. Farmers A and B are examples of segregated farms with no opportunities for rotation due to separate land parcels. However, Farmer A and B still have synergistic relationships through integrated management and knowledge sharing which reduce transaction costs.

5.8.2.3 Time: Type of synergies
Hendrickson et al. (2008a) defined integrated production systems as systems that interact in space and time. The case studies provide evidence which emphasises that to achieve complementarity the level of interaction can vary and space and time do not have to be synchronised.

Case study farmers C, D, E and F have adjoining crop and dairy properties with some levels of spatial separation, rotational integration and fully combined integration as defined by Hilimare et al. (2011). However, none of the farms undertake full rotational or fully combined integration. Within the Canterbury crop-dairy systems, the most applicable definition of ‘fully- combined’ or “synchronised” is when animals come onto crops post-harvest to graze on a residual. By comparison, rotation integration is when crops and cows occupy the same paddock but at different times. Farmer C notes that the greater returns from dairy are too significant to rotate dairy land for crop. However Farmer C will use rotation by including a crop-cycle in his dairy pasture renewal platform and because his enterprises are adjoining he can then replace the lost dairy area or adapt the size of the dairy platform by taking more land around the outer edges from the crop farm. Farmer D undertook rotational land use by growing 20ha of crop on his 420ha dairy farm but has since increased his herd size and dropped the crop from the dairy platform. Farmer B who does not operate adjoining land parcels grows 20ha of kale on his milking platform for winter feed, an example of rotational integration.
Farmers who winter cows on their cropping land undertake rotational integration. Farmer A commented that this rotation is advantageous to his cropping system as animal excrement can reduce fertiliser application.

Farmers C, D, E and F see an ‘advantage’ in their systems gained from the adjoining nature of their enterprises. A reflection of this advantage is their above industry-average milk solid production. These farms all have the ability to expand their milking platforms by grazing pasture or residuals (fully-combined integration) on their cropping farms. Further, using this integration exercise, the farms practice individual drying off and the staggered return of dairy cows to the platform in spring. This reserves the platform for lactating cows only.

5.8.3 Creating an applicable framework

Hilimare et al. (2011) divided integration further into three categories and Bell and Moore (2012) divided integration into three similar categories using space and time. The case studies cannot easily be categorised into these models (table 8).

Table 8: Application of two integration categorisation models to the case studies

<table>
<thead>
<tr>
<th>Definitions</th>
<th>Hilimare et al. (2011)</th>
<th>Bell and Moore (2012)</th>
<th>Case study farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPACE</td>
<td>separate land areas for each enterprise</td>
<td>Spatially separated</td>
<td>Segregated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>crop and dairy: in same paddock, different time</td>
<td>Rotational</td>
<td>Rotated (co-located)</td>
</tr>
<tr>
<td>TIME</td>
<td>crop and dairy: same paddock, same time</td>
<td>Fully Combined</td>
<td>Synchronised (co-located)</td>
</tr>
</tbody>
</table>
However, the case studies do not easily fit into these frameworks. Therefore it is proposed that the case studies fall into three clear categories.

The three groups recognised from the case studies:

1. **Complementary – spatially separated**: two separate land parcels operating different land uses. Includes: Farmers A and B.

2. **Integrated – amalgamation**: one land parcel operating both land uses (the enterprises may be different entities but a level of land integration applies). Includes: Farmers C, D, E and F

3. **In transition** – seen to be moving from crop into dairy. In transition to specialisation. Includes: Farmer G

Farms included in 1. *complementary* and 2. *integrated* all operate different ratios of vertical integration and diversification.

Figure 13 documents the history of development of the seven case studies over time as they have intensified, converted to dairy and moved into different levels of integration and utilises the concept of waves (Pangborn, 2012). This figure visually shows integration through space. The green arrows in the diagram represent mixed farms with the inclusion of sheep. The dark blue arrow shows the intensification to crop and dairy support. The red arrows represent the milking platform and the pale blue arrow represents a dairy support system without crop for external sale.

Farmer A and Farmer B have been categorised as complementary with spatial separation. These farms run individual parcels of land with individual day to day management.

Farmer C, D, E and F have been categorised as integrating through amalgamation. These farms have adjoining land parcels and/or land that has moved from one enterprise to the other, consequently allowing for greater synergies. Farmer C is unique in that he does not have a defined area within a season dedicated to crop, rather his crop and dairy enterprises share space.

Farmer G has been categorised as ‘in-transition’ as he is moving away from diversification and into specialisation. His crop block has become wintering land with no crops for external
consumption and no defined supplements from his cropping land entering the milking platform. Winter crop is his main form of integration.

5.8.4 Summary

The case studies all operated two or more enterprises with the application of both diversification and vertical integration. Between these operations complementarities were apparent. The complementarity which appeared to have the most synergistic benefit was land sharing, however this synergy was only feasible for the case studies with adjoining crop and dairy farms.

The case studies provided evidence suggesting that to achieve complementarity, the level of interaction can vary, and space and time do not have to be synchronised. For example, Farmers A and B have no synchronisation due to spatial separation but they had synergistic relationships reducing transaction costs. The synergistic relationships defined by Villano (2010) incorporated all the synergies found in the case studies, however function complementarity was not apparent.

The frameworks investigated in the literature review were not easily applied to the case studies; however the case studies could be divided into three groups: complementary due to spatial separation, integration through amalgamation and in-transition where the case study farming was transitioning away from diversification and reducing integration to specialise in milk harvesting (figure 13).
Figure 13: Case Study farms development since 1980 and the systems adaption to complementary approaches.
5.9 Conclusion

This thesis analyses seven case studies farmers which moved from intensive crop farms to partial dairy conversions with retained crop. The case studies all operated two or more enterprises with the application of both diversification and vertical integration.

In the seven case studies, the drivers of land-use change were a combination of profitability, personal lifestyle needs and risk management through diversification of income. Dairy farming was attractive because it was a simple system with a reduced workload compared to the case studies cropping systems.

[Diagram: Reasons for Partial Conversion]

- Profitability
- Risk Management
- Lifestyle
- Diversification
- Vertical Integration
- Succession Environment Simplicity

Complementary, Integrated, In-transition

- Specialisation
- Sharing Land
- Sharing Knowledge
- Sharing Machinery and Resources

Outcomes
- Reduced day to day workload
- Reduced transaction costs
- Access to dairy feed
- Assured crop market
- Milk production above district averages

Figure 14: Conclusion of Theory
The farms operated complementary systems. To define the complementarities in the case studies, a framework was developed to categorize them into three groups: complementary due to spatial separation, integration through amalgamation and in-transition where the case study farm was transitioning away from diversification, decreasing vertical integration and moving towards specialisation. Six of the seven case study farmers plan to keep cropping as part of their operation as it is their preferred on-farm role. The case study farmers all have a special skill-set in crop. There may be implications as to whether these skills will pass through to the next generation if they become more involved in the dairy portion of the business.

The synergistic relationships between crop and dairy including shared land, risk management and supplementary feed which created synergistic benefits. These benefits included; reduced transaction costs, reliable crop markets and reliable access to supplementary feed. The synergistic relationships defined by Villano et al. (2010) incorporated the synergies found in the case studies.

5.10 Limitations of research

A limitation of this thesis is the lack of quantitative data to back up the farmer’s spoken word. Profitability indicators would have allowed for a greater comparison between the case studies and industry averages. Further this data may have allowed a monetary value to be calculated for different synergies. In most cases the farmers had not divided their expenses between their two enterprises (enterprise accounting). Case study farmers were also unwilling to share profitability data due to the ‘newness’ of their systems. In some of the cases this meant the farmers did not have three years of comparable data and in other cases the farmers felt financial data would not fairly indicate the capabilities of their systems due to recent investment and developments. Lastly, due to the newness of the industry and the limitation of time, only seven case studies (with at least one season of dairy production and retaining crops) were discovered in the Ashburton District, however industry informants indicate that other newer conversions will potentially be available for future research.
5.11 Future research

Future research arising from this thesis would be to determine how many of these partially converted systems exist and if the frameworks developed in this thesis would remain applicable with the incorporation of more farms. There was evidence from industry informants to suggest that at the time of data collection there were a number of other farms considering partial conversion.

There was a lack of recorded data (at an industry level) around the size, productivity and profitability of cropping systems across New Zealand. All the farms in this thesis seem like large enterprises. If there were opportunities to collect regional arable data sets, further research could be undertaken to determine the comparable size of these farms and if scale was important in their success.

It was apparent that the case study farms obtained above average milk solid production and fed supplements throughout the milking season. To apply the crop and dairy systems to the DairyNZ five systems model further research on supplement usage would be of interest.

Research on farm profitability including key KPI’s between crop-dairy farms in Canterbury and industry averages would help determine the productivity and profitability of the systems, including the monetary value of key synergies. Further, the inability to collect qualitative data from the case study farms suggests that arable farms may not be undertaking any forms of production and financial analysis, it would be interesting to find out why they do not have this information readily available and if this impacts their day to day management.

Potential environmental benefits were discussed; however evidence of the sustainability of these farms from a whole-system approach is a gap requiring further research to determine environmental footprints. The ability to reduce the potential environmental issues surrounding dairy farming by incorporating cropping land has important implications for industry growth.
REFERENCES


APPENDIX 1

DairyNZ Five Production Systems

New Zealand pastoral farm is about efficiently balancing feed supply and demand. The five production systems are a way to group dairy farm systems by the allocation of imported feed. The 5 systems are classified on the basis of when imported feed is fed to dry and lactating cows during the season and by the amount of imported feed and/or off farm grazing. The definitions do not include feed or grazing for young stock.

System 1: All grass, self-contained

No feed is imported. No supplements fed to the herd except supplements harvested off the effective milking area. No cows grazing off the milking area.

System 2: Feed imported, either supplement or grazing off, fed to dry cows.

Approximately 4-14% of total feed in imported. Large variation % as in high rainfall areas and cold climates, most of the cows are wintered off.

Systems 3: Feed imported to extend lactation (typically autumn feed) and for dry cows

Approximately 10-20% of the total feed is imported. 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

Approximately 20-30% of total feed is imported onto the farm.

System 5: Imported feed used all year. Feed used during lactation and for dry cows.

Approximately 25-40% (but can be up to 55%) of total feed is imported onto the farm.

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

Interview guide for case study farmers

*Main questions in bold with possible prompts in italics.

1) **What was your original farm system before the dairy conversion?**
   *Effective hectares, land use including crop grown, livestock, how it operated, lifestyle, employees*

2) **How long ago did you partially convert to dairy?**

3) **What were the drivers and key factors for converting (part of the farm) to dairy?**
   *Who influenced you to convert?*

4) **Why did you only partially convert?**

5) **Over what period of time did you convert?**

6) **Did the ownership structure (due to or as a result of the conversion) of the farm change?**
   *Did your debt structure change? (Equity partners) Did you intend for it to change? E.g. reasons of succession*

7) **How did you ‘skill up’ for this change? Did you use managers, contractors, sharemilker?**

8) **What was the cost of converting/ what were your biggest costs to convert?**

9) **How does the farm run now? Is the effective area still the same? How does the dairy farm operate? Cow numbers, milk production. How does the crop farm operate? Crops grown are in crop, crop markets, and labour units.**

10) **What supplementary feed is used? What percentage is made on farm? What percentage is imported?**

11) **What are the interrelationships between crop and dairy? What resources are shared?**
   *Crop rotation policy, reduced transaction costs, increased labour flexibility, spreading risks.*

12) **Did the physical attributes of the farm effect how it was integrated? Soil type, water, landscape features?**

13) **Has the integration of dairy increased the profitability of crop?**

14) **Looking back what were the key features of its success? (if you think it was successful)**
15) What were the problems and what were the surprises of the conversion?
16) Do you face any challenges with the current system?
17) What are the goals, future plans and developments of this system?
APPENDIX 3

Interview guide for key industry informants

1. **What is your background?** How did you get into your position? What is your field of interest? And involvement in the Canterbury dairy/crop industry?

2. When did you become interested in integrated farming?

3. Why the interest in this farming method?

4. What do you know about the development of current integrated farms in Canterbury? Are there many of these systems that you are aware of?

5. What are the different integrated dairy systems which exist in Canterbury and which system do you think has more potential in Canterbury? E.g. rotational land use or separate systems with synergies.

6. When did integrated farms appear as an ‘alternative system’? Why do you think this system is being implemented?

7. Where do you think integrated farming is going in the future?

8. Is there an interest among farmers for this system? If so, what sorts of farmers are interested? E.g. Crop farmers with dairy support already. Farmers who still have capital stock – breeding ewes etc.