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Envisaging future New Zealand dairy farm systems: A scenario analysis approach

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ABSTRACT

Designing future farming systems which are resilient in an increasingly volatile and uncertain environment can be challenging. Scenario planning to inform farm systems design can help address this challenge. In the first phase of this wider scenario planning project, three distinct future world scenarios were developed. In this second phase of the scenario planning project, dairy farm systems for these future scenarios were developed over two workshops: a farmer workshop followed by an industry workshop where participants used mental models to conceptualise the future farm systems for each scenario. In general, the farm systems were most diverse under the consumer-driven Consumer is King (CK) scenario, and least diverse under the Government Dictates (GD) scenario (political chaos with trade dictated by governments). There was considerable overlap between farm systems under the CK and the highly regulatory Regulation Rules (RR) scenarios, but very little farm system overlap between the GD scenario and the other two scenarios. These future farm systems descriptions will play an important role in informing the quantitative modelling phase of this project. The approaches used to identify and describe the conceptual future farm systems were considered to be effective.

KEYWORDS: farm management; dairying; New Zealand; scenario analysis; mental models; World Café

1. Introduction

Farm businesses are complex and operate in increasingly volatile business and natural environments. Farm business owners' and managers' goals and objectives, and the resources available to the business, also evolve over time in response to changing business environments and social norms, and the development of new technologies and knowledge. What is certain is that farm systems will be adapted in future, and will differ from those of today. However, it is uncertain what these future farm systems will be.

Predicting or designing future farming systems which are resilient in an increasingly volatile and uncertain environment can be challenging. Farm systems modelling approaches often extrapolate the future from the current situation, however, this approach is relatively simplistic and not necessarily realistic given the uncertainty and volatility inherent in the industry. A scenario analysis approach (Schoemaker, 1993; 1995), which was developed by Shell to help with their strategic planning because of the inherent future uncertainty (Cornelius, Van de Putte and Romani, 2005), is useful where there is considerable volatility and uncertainty. This approach has been used in an agricultural context both overseas (Demeter, *et al.*, 2009; Forum for the Future, 2012; Dairy Australia, 2013) and in New Zealand (Parminter, Nolan and Bodeker, 2003).

The Centre of Excellence in Farm Business Management (CEFBM) used this approach in their Dairy Farm Systems for the Future project to design and evaluate possible future New Zealand dairy farm systems in 2025 to 2030; and in the process informing farmers, industry and researchers; developing a rigorous approach for evaluating farming systems; and building capability and collaboration in farm system design and analysis, all of which are CEFBM goals.

This research had three phases. In the first phase, scenario analysis was used to develop three possible, plausible futures that dairying operated under, plus a base scenario extrapolated from the present dairy farm business environment. Since most of New Zealand's dairy products are exported, a global perspective was taken. The three scenarios arrived at were: 'Consumer is King' (CK) in which a wide range of dairy products are produced in direct response to consumer demand, 'Regulation Rules' (RR) in which there are considerably greater regulatory requirements on dairy farm businesses,

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and 'Government Dictates' (GD) in which commodity dairy products are produced for a World where global chaos exists and trade is dictated by governments and international organisations. While the scenarios developed were extreme in some aspects, future reality is likely to have aspects of all three scenarios. These scenarios are reported in Shadbolt, *et al*. (2015) and shown in Figure 1.

In the second phase of the project, farmer and industry workshops were held in the Canterbury and Manawatu regions of New Zealand to develop conceptual models of possible farm systems for each region, for each of the scenarios. The diverse dairy industry scenarios resulted in a range of possible, plausible future farm systems being developed in this farm systems description phase. The final project phase will extend these conceptual models, then develop quantitative models to explore farm systems performance and resilience, including across scenarios.

This paper comments on the workshop process, and compares and contrasts the Manawatu farm systems for the three futuristic farm systems scenarios that were developed.

2. Method

Two one-day workshops were held at Massey University (in the Manawatu) mid-2015 to develop future farming systems for the futuristic scenarios described above. The farmer workshop was attended by ten experienced dairy farmers with diverse systems, who were well-informed on dairy farm systems and industry dynamics. Farmers were selected to design the initial future farm systems because they are accustomed to thinking systemically and holistically about farm systems in managing their farming businesses.Cognitive mapping and group model building were used to scope up possible farming system(s) for each scenario.

This workshop was followed by an industry workshop attended by twenty-four industry stakeholders and academics from a range of backgrounds with expertise in various aspects of dairy farm systems. A World Café process was employed in this workshop to critique and extend the farm systems, and describe the system interrelationships within the dairy industry. The academics on the research team and some farmers from the farmer workshop attended, enabling group discussions to link back to the thinking at the farmer workshop.

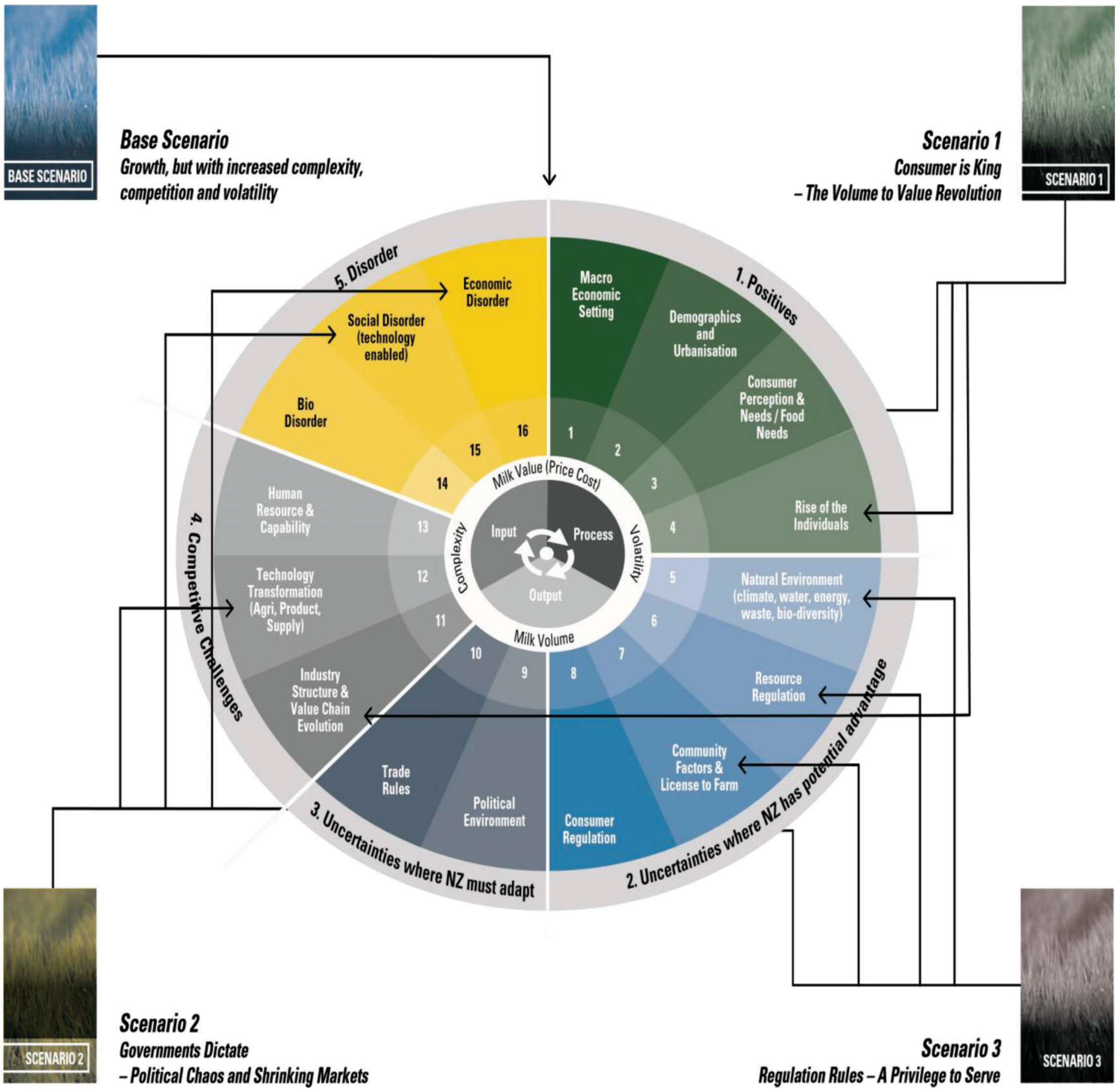

Figure 1: Futuristic dairy industry scenarios developed in the first phase of the project. Adapted from Shadbolt, *et al*. (2015).

Table 1: Massey University Number 1 Dairy Farm description

	Massey Farm	Manawatu Region
System Overview	142.7 ha, 118 ha effective. 2.2 cows/ha (low input farm). 65 paddocks with race access. Farm on bank of Manawatu river. 25% farm irrigated, Flat contour. Free draining alluvial soils, fertile, prone to summer drought. University-owned farm with manager.	141 ha effective. 2.74 cows/ha. 78% dairy farms owner-operated including managed farms, (NZ 70%). 22% farms with sharemilkers. Most farms family owned. Some equity partnerships and corporates.
Animal Production System	256 cows. 70 Friesian (F), 57 Jersey (J), 129 FxJ. Seasonal production, calve in spring (late-July, dry off end of May). 240 days in milk. Once-a-day milking. 2014-2015 season: 90,842 kgMS, 774 kgMS/ha, 354.9 kgMS/cow.	385 cows. 35.4% FxJ, 45.2% Friesian, 11% Jersey, 8.4% other. Just over 50% herds have 100 to 349 cows. 29% have 500+ cows, 12% 750+ cows, 5% 1000+ cows. Majority of NZ farms are seasonal production and twice-a-day milking. 1076 kgMS/ha, 393 kgMS/cow.
Pastures and Feed System	Low input, pasture-based system. Production System 1[3]: self-contained, no purchased supplement. 76 ha ryegrass and clover mix, 10 ha herb-legume mix, 10 ha lucerne, 12 ha summer crop (10T DM/ha). Pasture production 14,146 kg DM/ha (35% spring, 27% summer, 22% autumn, 16% winter).	Most farms run Production Systems 2 to 4 i.e. 4% to 30% purchased feed for milking area and dry cow grazing. Only 5-10% owner-operator farms are System 1.
Technology	24 aside herringbone shed with Westfalia metatrons. 200-cow concrete feed pad. 3-bay calf shed, office, storage room, teaching room. Farm effluent system planned: in 2015 used PN city effluent system.	Predominantly herringbone sheds, with some farms having rotary sheds. Commercial dairy farms have their own farm effluent systems.
People	Employs a manager and a relief milker.	Labour efficiency (peak cows milked per FTE) for NZ is 144. 137 for the North Island, 133 for the lower NI.

The workshops required participants to share their mental models of these future farm systems i.e. cognitive mapping. People use mental models to reflect on their situation, make decisions to behave in certain ways, and consider new experiences and information and store the concepts that are personally salient (Jones, *et al.*, 2011). The process developed for the workshops elicited and consolidated mental models to link peoples' values and management practices to farming outcomes in particular hypothetical situations (Jones, *et al.*, 2011). Individual mental models were submitted to others in small groups and used to build group mental models elicited from the knowledge and experience that the various group members could bring to a situation (Cooke, *et al.*, 2000).[3]

The group model building process used built on the system dynamics approaches pioneered by Vennix (1996), taking individuals' cognitive maps which are not yet well-defined, and consolidating these into substantive interactive systems although these remained qualitative (Forrester, 1975). The group model building process assisted with achieving consensus and aligning mental models so that they can be further applied in problem solving, testing hypotheses and designing simulation software (Andersen, Richardson and Vennix, 1997).

[3] DairyNZ production system category based on level of imported feed for the milking area/ milking herd, including dry cows. System 1 (no imported feed inputs) to System 5 (at last 30% feed imported year around).

Kearney and Kaplan (1997, p. 592) observed that methods for developing cognitive maps from mental models can be constrained by: individual participants' abilities to focus on mental objects and concepts relevant to the presented situation, the concepts contribution to the situation and relationships between concepts; and the efficacy of the group process. To manage these constraints: participants invited were well-informed and expert in their fields; an experienced facilitator helped plan the workshops; techniques suited to eliciting information in a group situation were used; someone in each breakout group understood the rationale and thinking behind the previous project activities and outcomes (i.e. a project team member and/or farmer who attended the farmer workshop); and a World Café process (Brown and Isaacs, 2008) was used in the industry workshop to generate discussion and creativity. This technique is an informal conversational process for groups (Brown and Isaacs, 2008), which Fouche and Light (2010) evaluated and found to be effective for exchanging ideas and information, encouraging creativity through collective discovery and collaborative learning and knowledge creation, and can also be a powerful data collection technique.

Massey University dairy farm description (base farm)

The Massey University No. 1 Dairy Farm was selected to represent a current Manawatu dairy farm as a benchmark in developing scenario farm systems in the workshops.

This farm, which had some atypical attributes, was considered as the base case or status quo farm with respect to its more generic attributes, rather than specifically. Table 1 describes the base farm as at 2015, with some statistics (Massey University, 2015). Information from industry sources for dairy farms in the region at that time (2015) is also provided to provide context (DairyNZ, 2016; LIC and DairyNZ, 2015), particularly where the Massey farm is atypical. Milk price in New Zealand is highly volatile, and in 2014/2015 was low, averaging NZ$4.69[4] per kg milksolids[5] (MS) in 2015 values.

Farmer workshop

The Manawatu farmer workshop was attended by 10 farmers who were pre-allocated to one of three groups, sent information on a futuristic scenario, and asked to consider possible future dairy farm systems for their scenario. A description of the current 'base case' or status quo Massey University dairy farm was provided to farmers (Massey University, 2015), and revisited by the group at the beginning of the workshop to set the scene. Farmers were then asked to work together in their groups to consider their future scenario, and using post-it notes®, to write down the ideas, objects and concepts that could be part of an adapted farm system which could operate viably for their scenario in 2025 to 2030. An academic who had worked on the scenario analysis phase was present with each group to help facilitate, make notes, and explain background as required. The workshop facilitator circulated around the groups. These sessions were recorded.

Farmers were asked for ideas about on-farm production activities, resources, technologies and human capabilities that they expected would be required for their system. Then each group worked together to connect their concepts together into a diagram showing hierarchical dependencies and inter-relationships for their primary system. In addition, they described how the farm system linked to the market and wider industry customers. In doing so, they were asked to consider internal consistency i.e. whether two ideas could co-exist in a system. In the CK and RR groups, farmers could not agree on a single system, so two possible systems differing in size were developed.

At the end of the day, each group presented their dairy farm system and the wider group had the opportunity to provide additional input. This session was video recorded, with the recording later transcribed. The systems for each scenario were written up in table format by theme, and in a narrative form.

Industry workshop

The industry workshop was held a week later and attended by 24 participants (4 dairy farmers from the farmer workshop, 12 academics from different disciplines plus the project team, and 8 dairy industry stakeholders e.g. farm consultants, DairyNZ[6], Landcorp Farming[7] and Fonterra[8] representatives). These participants each had their own strengths: farmers and consultants had a strong understanding of farm systems; academics could offer possibilities particularly in their disciplines, and industry people could identify possibilities from a broader perspective and identify farm and industry interactions required to achieve these. Participants worked in groups of four participants from different backgrounds, with groups moving between the three scenarios. Numbers were sufficient for 6 groups, so two rooms, each with the three scenarios set out were used.

A description of one of each of the farmer-developed farm systems along with some scenario background was provided at each of the three group tables in the room. The system description was in the format of a large table (2xA3 sheets) on flip-chart paper. A narrative of the system and a table summary of all three industry scenarios were available for reference. For each system, groups were asked to provide critical comment, and suggest improvements or new ideas, and supporting services, R&D and technology needed to make this work. Post-it notes® on flip-chart-paper were used to add ideas to the farm system with lines drawn to link ideas. Groups contributed to the systems for all scenarios, spending 40 minutes on each scenario. When moving to the next system, one group member remained behind to link information between groups, sharing and explaining ideas from those who had previously contributed to the system and answering queries (World Café approach).

After lunch, participants had a free hour to consider the systems, adding individual ideas on post-it notes and suggesting new ideas for farm systems. At the workshop conclusion, the last group working with each system scenario presented the final dairy farm system version with research, information, systems and services needed to all participants, followed by group discussion adding further input, ideas and feedback on each dairy farm system. This session was recorded. Results were written up as previously described.

3. Results and Discussion

The farm systems are first compared with an overview of the key points, followed by a description of each of the three systems. The effectiveness of the method is then discussed.

Farm systems comparison

A comparison of the conceptualised farm systems under the three scenarios which integrates farmer and industry feedback is shown in Table 2. There is considerable overlap between the CK and RR systems with respect to the features and attributes of the farm system. In contrast, the GD system features have little commonality with the other two scenario systems. Farm systems are most diverse under the CK scenario, and least diverse under the GD scenario.

There is greater diversity in the animal production system in terms of cow numbers, breed type, production volume and other factors within the CK scenario, followed by the RR scenario. In contrast, the animal production system is largely homogenous under the GD scenario, with a lower milk price driving significant increases in farm size, cow numbers, pasture production (based on GM technology) and milk production, and a

[4] At the time of writing (December 2017), $NZ1 was approximately equivalent to £0.52, €0.59 and $US0.70.

[5] Milksolids (MS) = milkfat plus protein. In NZ, payment is made on these components less a volume charge.

[6] DairyNZ is an industry-good dairy farming R, D and E organisation funded by NZ dairy farmer levies.

[7] Landcorp Farming Ltd is NZ's state-owned farming company and largest farmer with over 141 farms owned and leased. Over 78,000 cows are milked on Landcorp dairy farms.

[8] Fonterra Co-operative Group Ltd, NZ's largest dairy company, is a farmer-owned cooperative supplied by about 85% of NZ dairy farmers.

Table 2: Farm systems description – A comparative view across scenarios

	Consumer is King	Government Dictates	Regulation Rules
System Overview	Farm size polarized, highly flexible and diverse systems, highly automated, diverse ownership structures, significantly increased production costs.	Large farms with high stocking rates, some horizontal integration with beef, high automation, largely corporate-owned or equity partnerships, decreased production costs.	Large farms with low stocking rates in designated dairying areas, highly automated, range of ownership structures, increased production costs.
Animal Production System	May not be seasonal, significant decrease in milk production, focus on milk quality/type, range of cow breeds, close monitoring of animal health and welfare.	Seasonal system, significant increase in milk production, crossbred cows, less importance on animal health and welfare.	Seasonal system, slight decrease in milk production, cows clean and good condition, strong focus on animal health and welfare, no bobby calves, close monitoring.
Pastures and Feed System	Grass-based system (promoted as NZ attribute), may be very specialised feeding systems e.g. feeds to give special attributes to milk, targeted use of nutrients.	Grass-based system with imported grain supplements, high yielding GM pastures, fully irrigated with on-farm water storage, pastures and soils absorb 100% of nutrients applied.	Grass-based system with maize and grain supplements, significant irrigation and drainage investment, water and fertiliser use tightly regulated.
Technology	Significant use of technology and data, complete automation at farm level, technology leasing and IP licencing common.	Increased use of technology and data e.g. drones, robotic milk systems, precision agriculture.	Intensive use of technology and data e.g. drones, robotic milking systems, precision agriculture.
People	Highly educated and trained, technology-savvy staff. Specialist roles on large farms. Public relations function critical to communicate with customers. Good working conditions.	Well trained staff: one highly educated and trained manager, three technology-savvy assistant managers with good farm management skills.	Highly trained, well educated, technology-savvy staff with specialised roles. Specialist administrator for environmental issues, compliance and PR. Staff well treated e.g. 40 hour week.
Auditing for Compliance and Market Guarantees	Significant contractual obligations, strong monitoring and third party auditing for markets and regulation.	Not very important	Strong monitoring systems with tight management control, regular third party audits.

focus on keeping costs low, to increase efficiencies. In contrast, more stringent regulation has resulted in lower cow numbers and stocking rates in the RR scenario. Farm size and cow numbers are variable but tend to be polarised under the CK scenario.

Pasture-based systems are an underlying feature of all three scenarios, but the feed systems and their drivers differ between scenarios: consumer expectations are the drivers for the CK scenario, cost and efficiency the driver for the GD scenario, and regulation the driver for the RR scenario (Table 2). GD and RR systems remain seasonal, however many CK supply chains have changed from seasonal to year-round supply to meet market demand and for greater system flexibility. While milk production per hectare has increased significantly in the GD scenario, this has decreased in the CK and RR scenarios. In the CK scenario, this is primarily due to higher margins and a resulting shift in focus from volume to value. In the RR scenario, greater constraints imposed on the farm systems, specifically around feed supply (water, fertiliser and supplement limits) and cow numbers, restrict production.

Stringent standards and greater compliance needs have caused production costs to increase under the CK and RR scenarios, whereas less regulation and compliance, and a strong focus on keeping costs low because of low milk prices in the GD scenario has meant production costs have decreased. Strong standards imposed by the market (consumers) and regulators (government), and the need to provide credible proof that the standards are being adhered to, mean auditing for compliance and market guarantees is significant in the CK and RR scenarios. A lowering of standards and fewer compliance requirements has meant auditing and compliance are not important features under the GD scenario.

There is increased use of on-farm technology across scenarios, with the use of drones, automatic milking systems, and precision agriculture technologies being common in all scenarios, but highest in the CK scenario where IP licencing and technology leasing occur. Staff are well educated and trained in all the scenarios, but the skills required and levels vary, with demands of both the CK scenario and RR scenario being much higher, requiring more specialist staff, than the GD scenario. CK staff have particular expertise in public relations and communications, and RR staff specialise in managing environmental issues and compliance.

Consumer is King scenario – Volume to value revolution

The defining feature of this system is its flexibility to adapt and deliver to changing international customer needs – or ‘dancing with change’ as one workshop participant aptly described it. The participants at both workshops agreed that a spectrum of farm system types is likely under this scenario due to the diversity of quite specific products and attributes required to meet customer requirements. Some farms are organised as clusters producing specific milk types for the production of specific milk products, hence farm systems within a cluster are similar. Each cluster is operating in an independent and identity preserved value chain, delivering to a distinct high value niche market. Some farms run split systems, and are part of more than one value chain. There is still a market for non-specific milk in which surplus or non-conforming milk can be supplied, although returns are lower.

Economies of size are less important than previously, since farmers have traded volume for value. Across farm types, productivity in terms of milksolids production per cow and per hectare has decreased or remained constant, with the focus being on milk quality or milk attributes. However, MS returns per kilogram have increased considerably. Average farm size (in terms of hectares and cows) has decreased in many cases, however farm size is variable and tends to be polarised. Small farms with 50 to 100 cows supplying high value milk (e.g. with nutraceutical applications) co-exist with larger farms, some of which produce milk for less specialised products. Smaller farms are predominantly owner-operated, with the owner having a high level of control over milk or product quality which is critical in these supply chains. Larger farms producing specialised milk rely on considerable automation to ensure milk quality and other customer specifications are met, hence economies of scale and size are important here. These larger, highly-automated farms often have multiple owners or are equity partnerships, with highly skilled management and employees.

Greater engagement between farmers and consumers has resulted in contracts between farmers and consumers, resulting in groups of consumers investing in farms. Another feature is other supply chain players (i.e. processors, owners of inputs or product/brand IP) share in the on-farm investment, reducing the capital investment required by farmers. This is frequently in the form of a 'toll-processor' who contracts a cluster of farmers, controls what goes in and out of the farming system and specifies production methods to meet market requirements for specialist products.

Often, specific product attributes desired by the consumer are obtained from cow-specific traits or as a result of specific feeding and management regimes, or a combination thereof. This has made genetics and feeding of cows more complex, with farms operating within a value-chain having similar cow genetics or feeding regimes to produce milk with specific attributes desired by the consumer. In some situations, the unique genetics required means stock replacements are bred on specialist breeding farms and supplied as an input.

Farms are largely pasture-based, with irrigation systems in place. Supplements fed, or nutrients used, can affect milk attributes and are implemented to influence the end product being made. Animal health and welfare are a top priority, and cows are in good condition throughout. Intense quality assurance systems to validate product attributes and system claims, along with robust traceability mechanisms are the norm. With significant shrinking of barriers between consumer and farmer, the farm is more visible and exposed. Farmers are proactive on social media and other platforms to remain relevant to their customers. Consequently, people on farms require good communication and public relations skills, in addition to farming skills.

There is significant uptake and adoption of technology at the farm level and this happens along two dimensions: technologies that improve efficiency in feed, pasture and stock management, and monitoring, information management and communication technologies such as various measurement and surveillance tools, including monitoring devices such as on-farm webcams which customers can access. Almost all farms use drones, robotic milking systems, precision agriculture tools and other technologies still currently under development. Data is a core feature of the farm system and integral to decision making, as well as a tool for monitoring and validation of claims. The greater returns generated compensate for the increased costs e.g. labour, compliance, capital. The big risk that farms face is the increasing fickleness of consumers affecting demand for their specialised milk or milk products.

Government Dictates scenario – Political chaos and shrinking markets

The most likely farm system under this scenario was identified as being a large farm of around 260 hectares, having around 1,200 cows and stocked at a high rate of 4.6 cows/ha. Being efficiency driven and subject to less regulation, both cows and pastures are genetically modified. Pastures produce around 25 tonnes DM/ha, and the resulting milk yield is close to 2,200 kgMS/ha. To support this high level of production, most farms are fully irrigated, and precision agriculture ensures efficient and balanced use of fertiliser and related inputs. This has controlled nitrogen leaching to a large extent, and created a carbon-dioxide sink as well. However, grazing of pasture is not as viable as it was previously due to soil damage risk from high stocking rates, and some farms have adopted a cut and carry model. As a result, cropping science and related technology (e.g. harvesting) have become important.

Farms operate either as independent farms, or as part of a larger collective with individual large farms being nested within a larger structure of farms. Farms are either family owned (some with domestic or international equity partners), or corporate owned. Farms are also more horizontally and vertically integrated than before. There has been horizontal integration into beef operations, i.e. dairy farmers operating a beef operation in parallel to their dairy operation to raise surplus calves from the dairy farms. Vertical integration has been downstream with some very large farm businesses or groups of large farm businesses owning processing assets.

For efficiency on the large dairy farms, farm systems operate to a pre-defined set of rules or a 'recipe', with decisions and problems being solved by staff within the scope of this recipe. Each farm is managed by no more than 4 employees, typically consisting of 1 manager and 3 assistant managers, all of whom are highly qualified, and work no more than 40 hours per week. Staff are good problem solvers and have diverse yet complementary skills such as agriculture, IT and engineering. Although traditional skills such as pasture management and stockmanship are still relevant, much of the focus is on more soft analytical work. Farm consultants are still relevant and possess diverse skills.

There is extensive adoption of on-farm technologies (e.g. drones, satellites, milking systems) and farms are highly automated. Milking systems are largely robotic on a rotary platform, but small mobile automated milking machines are also used. Milking frequency is variable, ranging from once- to thrice-a day. Micro-management of herds is common with cows grouped into smaller herds. The predominant breed is kiwi-cross (Friesian x Jersey), but genetic modification has also led to cows with other genetics producing more concentrated milk resulting in lower transportation costs.

Although regulation is not a constraint, the focus on efficiency has generated positive environmental benefits. On the energy front, farmers are able to meet 100% of their energy needs from on-farm renewable energy systems, and sometimes produce a surplus to requirement which is sold. Finally, the dairy industry has a single large dairy processor which could be a co-operative, private investor-owned firm or a state-owned enterprise.

Regulation Rules scenario – A privilege to serve

Under this scenario, significant regulatory limits have been set which farms need to operate within. This has meant most of the farms struggling to comply and remain viable have exited the industry. Regulation has ensured dairying is restricted to designated dairying areas, and there are limits on stocking rate set at about 2 cows/ha. Due to the stringent guidelines and 'boundaries' to farming practices set by regulation, there is less flexibility on how the farm system can operate.

Due to the need for strong monitoring and control mechanisms, farms are polarised into smaller farms with tighter management control, and larger farms with high automation and/or specialist compliance staff. Typically, farm sizes are about 300 cows at the lower end and 800 cows at the higher end. But in general, most farms are at the larger end due to intensification of capital, increasing costs and constraints from regulation.

There is a decrease is MS production per hectare due to the constraints imposed. In parallel, there is a significant increase in production costs, mainly due to the costs of support services such as certification, science and technology R&D, third party audits, and increased costs of animal welfare, food safety and environmental compliance. Farm ownership is diverse, and includes family ownership, equity partnerships, overseas investment, and joint ventures. However, the need for more capital on farm (with equity as a source of capital) has led to many farms being corporate owned.

Farms are almost entirely pasture-based, but also produce maize silage for 'inside' feeding, mainly to ensure pastures are not damaged by pugging, which is unacceptable. To mitigate any risk of damage to the soil and regional system, limits have been imposed on the amount of cropping that can be done. Feed inputs (quantity and feed types) are also regulated with unsustainable feeds such as palm kernel expeller being banned.

Although most farms are irrigated and nutrient application is permitted, there are extremely stringent limits such as a cap on nutrients, and low specified levels of leaching and water allocation per hectare allowed. All waterways are planted to avoid soil erosion and provide shade for stock. Farms also have to manage air pollution to contain unacceptable farming odours. There is a strong impetus on animal health and welfare. Cows look good, are clean, maintain excellent body condition throughout the season and are very healthy.

There is a decrease in labour and an increase in mechanisation. Farm staff are highly educated, especially in IT and environmental issues. Larger farms employ a specialist administrator to manage technology/data, compliance, PR and marketing, while smaller farms have grouped together forming a cooperative to employ a compliance manager, as well as invest in, and share, resources. It is mandatory to provide good working conditions and a healthy work environment for all staff. Retaining staff is important because of the investment in staff training, and to preserve local communities and contribute to the positive image of farming.

Technology use is intense with: drones to check on pasture, stock, effluent and water; robotic milking systems; and GPS and self-driven tractors. Good data is important as well, and is used for decision making and to support monitoring and compliance functions. This data is stored in the cloud and can be accessed from anywhere, including by third parties for compliance.

Farms are also using scientific techniques and on-farm R&D to inform, validate or disprove the rationale for the increased and changing regulation. A large segment of farms under this scenario are 'triple A' rated. These farms have chosen to deliver a product produced in a system which goes above and beyond regulatory requirements, reflecting a 'privilege to serve' attitude. These farms actively promote their 'triple A' status through professional PR and marketing and are successful in achieving comparatively higher returns as a result. Farms also maintain a high degree of connectivity, with both the community (e.g. 'adopt a cow'-programs, public access days) and with regulatory and political bodies (e.g. via Federated Farmers training on political involvement).

Method Evaluation

With research, there is a trade-off between cost and time required, and the ability to explore the research topic. In this research, we also had a small window of opportunity in terms of farmer availability e.g. while cows were dried off, just prior to next season's calving. Hence this work was completed with only two workshops. A third workshop to develop more system specifics would have been beneficial.

One challenge was to develop futuristic systems for the scenarios that were robust in terms of the systems, but were forward thinking. There can be a tendency for people to largely consider current and developing technologies and capabilities and apply these in a futuristic context, as opposed to re-thinking systems envisioning future technologies and capabilities. There was some tendency for this to occur. However, technologies take time to become commonplace, and the timeframe was such that known technologies currently under development require some time to become commonplace so systems were not unrealistic. External factors were largely predetermined by the scenarios.

To develop robust systems, the first workshop was with farmers accustomed to considering farming systems from a systemic viewpoint. Farmers only worked on one scenario and devoted most of the workshop to this.

Pre-allocating farmers to a scenario enabled information on that scenario to be provided in advance. Most farmers had read the material and some farmers had obviously thought about possible systems e.g. turned up with notes. Unfortunately some farmers were unable to attend at short notice, so one farmer worked on a scenario with no prior information. More time than anticipated was required at the beginning of the workshop for groups to discuss their futuristic scenario, with some challenging the scenarios, but once the scenario was established the farmers turned their attention to possible systems.

Participants invited to both workshops were selected on their forward thinking, knowledge of the industry, and future possibilities. Participants at the industry workshop came from various backgrounds and were allocated to groups to create a mix of knowledge and roles. For both workshops, groups were planned to minimise the influence of dominant personalities i.e. stronger personalities together. Most groups worked well due to the manageable group size and mix, however, there were instances where one or two group members dominated and quieter members did not contribute to the extent they could have. Better knowledge of individuals' strengths and personalities in assigning them to groups would have been helpful, but is not always possible, and excluding people would not be productive since they all had expertise to offer and were willing to attend. A trained facilitator for each group could have helped but accessing expertise and extra cost prohibit this possibility.

The short timeframe between the two workshops meant there was no opportunity to write up the farmer workshop and get the information to participants in advance. Few participants read the reading materials supplied at the workshop. More time between workshops would have allowed some reading material to be provided in advance, but limited the availability of some key participants. The 40 minutes of time allocated for each group to discuss and add to a scenario system at the industry workshop was insufficient for some groups because of the time required to understand the future scenarios and farmer developed farm systems. However, providing a session for extra individual contributions which most participated in, followed by a group session at the end allowed people to provide further ideas, and participate in further discussion and debate. Consequently, the impacts of a significant number of the challenges discussed were addressed in this way.

Ideally, it would have been advantageous to have had accessible on-line sharing and wider farmer feedback post-workshop to further develop the systems for those interested as had been planned: there was interest expressed in this. This may have prompted further development of systems as people responded to others' comments and ideas are reflected on. However, suitable technology for this was not readily available at the time.

4. Conclusions

It was identified that the future farm system would be most diverse under the CK scenario and least diverse under the GD scenario. Moreover, farm systems under the CK and RR scenarios showed a fair degree of overlap, while there was very little overlap between the farm system under the GD scenario and the other two scenarios. From a systems design perspective, this suggests that it would be more feasible to adapt farm systems from CK to RR or vice-versa should the future business environment change, than it would be to adapt farm systems from GD to either of the other two scenarios.

The research demonstrated that a scenario planning process that involves developing team mental models can be a robust method to arrive at conceptual models of future farm systems specific to predetermined future scenarios. The conceptual farm systems models were developed to assist in designing future farm systems by informing the development of quantitative models that are needed to further explore farm systems performance and resilience, including across scenarios. In the next stage of this scenario planning project, it is expected that the commonality between systems, how well systems perform across scenarios, and the flexibility to adapt systems between future scenarios will be explored quantitatively.

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