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# Redefining Success

Exploring Artificial Intelligence for Benchmarking in New Zealand's Dairy Industry

Kellogg Rural Leadership Programme
Course 50 2023

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I wish to thank the Kellogg Rural Leadership Programme Investing Partners for their continued support.

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## Executive Summary

The NZ dairy industry is the backbone of NZ's primary sector and is a substantial contributor to the nation's economy through both export earnings and the livelihoods it provides for fifty thousand kiwis. Unfortunately, effective Key Performance Indicators (KPI's) benchmarking between farms is a disjointed, inconsistent process. Business performance measurement is a frustrating undertaking for participants with no standardised metrics nor minimum data quality requirements. The time-consuming process relies on key highly skilled individuals executing a costly assignment full of bias and manual data manipulation.

This project aims to explore the importance of benchmarking with standardised KPIs across the whole NZ dairy industry and investigates Artificial Intelligence (AI) : what it is, and the strengths and weaknesses of implementing AI-driven data management tools, with the potential to enhance KPI performance benchmarking. The outcome of the analytics supporting in depth decision-making with advanced managerial policies.

It is vital that the industry standardises KPIs across the entire commerce model, to drive innovation, and secure its future sustainability but exposing best practice from benchmarking. Ultimately to build more resilient businesses in the sector, we need to automate data management to improve both efficiency and productivity - Artificial Intelligence could be the solution.

The method to investigate the project's research questions involved a comprehensive literature review; a formal survey was conducted of farmers and industry experts, collecting both quantitative and qualitative responses. Lastly, a thematical analysis was undertaken to identify themes which are discussed and analysed to draw conclusions, prior to applying real-time on farm/in office experience to a high-level solution.

Research Question below set the scope for the project:

1. What is the importance of benchmarking and standardisation of KPIs?
2. What technologies are available in the NZ Dairy Industry?
3. What is Artificial Intelligence and its potential in the Dairy Industry?
4. What are successful AI applications in other industries and countries?
5. How can AI build more resilience for the NZ Dairy Industry?

## *Recommendations and next steps for the New Zealand Dairy Industry*

*Develop a Standardised Framework for Benchmarking Best Practices across different areas that contribute to successful farming.*
*Standardised KPIs can foster transparency, enhance communication, and support informed strategies.*
*By focusing on meticulous due diligence in the implementation of Artificial Intelligence (AI) as a Dairy Data Management Tool for predictive modelling, risk assessment, and adaptive strategies, the sector can enhance its resilience and sustainability to secure a positive future.*

In conclusion, this Kellogg project navigates the potential relationship between the convergence of benchmarking and AI-automated data tools. Through exploring the necessity of a standardised framework and lessons from AI adoption in other industries and countries. The NZ dairy sector can fortify its position, ensure long-term viability, and contribute to the nation's economic growth and agricultural excellence by letting our farmers focus on being farmers not data analysts.

## Acknowledgments

I wish to acknowledge the support of the Rural Leaders Trust and the Rural Leaders' programme team: Chris Parsons, Scott Champion, Patrick Aldwell, Lisa Rogers, and Annie Chant for your commitment and dedication in creating an enriching experience have stretched my thinking and expanded my intellectual and social resources. Personal development frequently stems from situations that cause discomfort.

I would like to acknowledge the busy dairy farm managers who took time out of their day to engage with me about how benchmarking improves their performance year on year and share openly their opinions on the future of the industry with an Artificial Intelligence lens. To all the managers, who participated in my survey process, thank you for engaging and providing me with the data I needed, your actual real experience of benchmarking processes was invaluable.

Also, to the experts and further stakeholders who are the living and breathing data management in the NZ dairy industry. Thank you for your willingness to share with me your views on the subject. As mentors, it was inspiring to engage with you all throughout this process and thank you for your participation in the surveys. The depth of knowledge and ideas shared really helped drive further thought for this project.

Thank you to Stu Taylor and Kirstie Lovie (Craigmore Sustainables) for the opportunities you have provided me to grow and learn in this area throughout the last 6 months. The way you both continue to challenge my thinking and provide ongoing advice is hugely appreciated. Furthermore, supporting me on this leadership journey, of personal growth and to help develop my knowledge and networks in the primary sector.

To my 'Fellow Kelloggers' of Cohort 50, thank you for all you contributed to my personal development throughout the course. It was a privilege to watch you all grow as part of your own leadership journeys. It was awesome to have such a diverse group of talented individuals, whose experiences and opinions really expanded my knowledge of our Agriculture industry.

To my parents Ana and Matt, thank you for inspiring me from a young age with the endless opportunity our primary sector offers a keen mind. Without any pressure I'm so grateful to be now adding value in the sector of which you are both so passionate about. Leadership is best learned from following great leaders, and you have both been great role models to me.

Finally, thank you to Craigmore Sustainables for supporting me to undertake this personal growth journey and this research project.

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# 1. Introduction

The NZ Dairy Industry stands as an essential backbone in global agricultural economies, contributing significantly to sustenance, commerce, and the socioeconomic fabric of nations around the world, providing dairy products to consumers across the planet.

The NZ dairy industry, much like numerous other sectors, has undergone a remarkable transformation over the past two decades. Amidst a backdrop of political shifts, global conflicts, trade complexities, and significant world health challenges, this industry has navigated through a series of major events that have shaped its future. Arguably, the most important transformation is in the field of technological advances, where innovations and data-driven strategies shape the trajectory of various sectors; currently the NZ Dairy Industry finds itself at a pivotal juncture.

This project delves into a multifaceted exploration of pivotal themes within NZ's Dairy Sector: the imperative for standardisation of Key Performance Indicators (KPIs), the diverse array of available technologies, the transformative potential of Artificial Intelligence (AI), its cross-industry applications, and its role in future-proofing the New Zealand (NZ) dairy landscape.

# 2. Purpose and Aim of the Research

The aim of this project is to firstly, unravel the intricate interplay between the importance of benchmarking and the necessity to have standardisation of Key Performance Indicators (KPIs) in the New Zealand Dairy Industry.

Secondly, the project investigates the transformative potential of Artificial Intelligence (AI) to explore what efficiency gains are possible by using AI to automate the management of dairy data. A process that could greatly assist the industry with reporting, compliance, and benchmarking performance.

Coupling these concepts together will have the overall effect of accelerating efficiency and productivity.

By delving into the convergence of KPI's and AI, the project seeks to provide readers with a comprehensive understanding of how AI-driven insights and technologies can propel the industry toward an enhanced future, sustainable growth, and resilience (Figure 1).

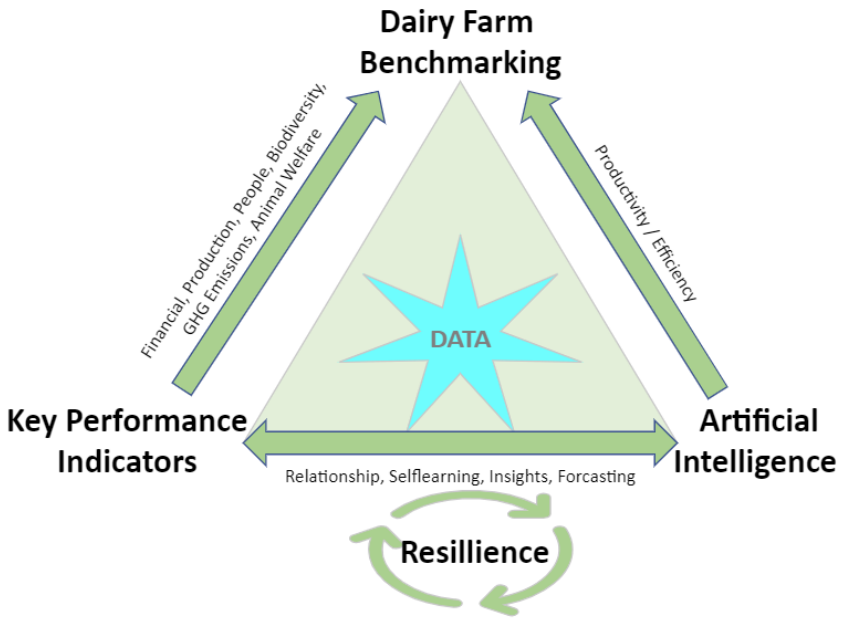


*Figure 1: Diagram exploring the relationship between Benchmarking, KPI's and AI (Joe Ward 2023)*

## 2.1 Research Questions

Through comprehensive exploration, the project aims to shed light on the pivotal role that standardised KPIs and AI-driven innovations can play in reshaping the dairy industry's landscape, fostering sustainable growth, and preparing it for the challenges and opportunities of the future by asking the following questions: Ref 10.1 Appendix One - Question Tree.

- What is the importance of benchmarking and standardisation of KPIs? (ref 7.1)
- What technologies are currently available in the Dairy Industry? (ref 7.2)
- What is Artificial Intelligence and its potential in the NZ Dairy Industry? (ref 7.3)
- What are successful AI applications in other industries and countries? (ref 7.4)
- How can AI build more resilience for the NZ Dairy Industry? (ref 7.5)

Abbreviations, Acronyms and Definitions:

KPI : Key Performance Indicators - measurable metrics for comparison.
AI : Artificial Intelligence - replicating human intelligence in computers or machines.
IoT : Internet of Things - network of interrelated devices that connect.
ML : Machine Learning - a subset of AI that focuses on developing algorithms.
BSC : Balanced Scorecard - performance metric inclusive of non-financial data.
AVC : Agriculture Value Chain - a system of people that work in various stages of agriculture from farm to consumer.
Dairy Data: data captured on farm across all aspects of the business including reports and modelling to help farmers to make the best decisions for their farm
Big Data : larger, more complex data sets, especially from new data sources

# 3. Methodology

The research method was a three-part process that comprised a comprehensive literature review, followed by a formal survey of 15 individuals to gain lived experiences of farmers and industry experts to gather which included both quantitative and qualitative data. Subsequently, a thematic analysis was performed to reveal prevalent themes, allowing a thorough discussion, and drawing conclusive insights.

A literature review was conducted to provide readers with a comprehensive understanding of definitions and concepts and provide a foundation of information across all five sub-questions to help explore key themes and findings. This allows a comparison of contrasting ideas and an evaluation process to draw conclusions against survey results further in the report. The literature review provides an overview of peer-reviewed journals and published research to inform but also highlights gaps for the context of recommendations and next steps for the New Zealand Dairy Industry.

A formal survey was used to gain real-world insights from New Zealand dairy farmers and stakeholder real-life experiences to gather data in both qualitative and quantitative basis using the questions in Appendix One (Ref 10.1) The objective of the surveys was to gather perspectives and opinions from farmers, consultants, and industry experts regarding the importance of benchmarking in the New Zealand dairy sector. These involved questions examining the challenges associated with standardised Key Performance Indicators (KPIs) and dairy data management. Additionally, the survey explored opinions on whether Artificial Intelligence could be leveraged as an opportunity within the industry to enhance efficiency in automatically managing dairy data. The ultimate goal is to assist the industry in effectively measuring and maintaining performance standards to build resilience and future-proof the industry. The importance of this is put into perspective given that the NZ dairy industry contributed $18.6 billion to the New Zealand economy in 2021, representing 5.3% of nominal GDP and 23% of total export value (Te Tai Ohanga, 2022).

The thematical analysis was then used to identify themes from the literature review and patterns from the subjective experiences from the survey. "Thematical analysis is a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006). This supported a comprehensive analysis, scrutinising the importance of benchmarking and the process of standardising KPIs to ensure clarity, consistency, and a meaningful comparability across dairy operations. Secondly, to harness the potential of AI as a catalyst for revolutionising dairy data management, decision-making processes, and overall performance evaluation. The project aims to present a holistic vision of the dairy industry's future landscape through these conceptual explorations.

This investigation then allowed discussion and applied perspective from a corporate dairy analyst exploring the current process of data collected on farms to support decision-making on farm *(Figure 9),* and then a potential future concept process diagram where artificial intelligence automates data management to effectively become a more efficient, accurate tool to support the decision making *(Figure 10)*. Allowing farmers to focus on just being farmers and have all KPI dairy data managed in the cloud, supporting benchmarking and best practice.

Furthermore, exploring a radar chart *(Figure 11)* – a potential tool for improved KPI benchmarking. With the ultimate goal of building a more resilient dairy industry.

## 4. Literature Review

The literature review provides information and context to support the investigation of standardising dairy Key Performance Indicators (KPIs) for benchmarking and the potential of leveraging Artificial Intelligence (AI) to find efficiencies in this process. This is to give readers an overview of key themes and examples of successful AI implementation. A review of existing literature including research, industry reports, articles and opinion pieces was used to evaluate the subject and learn why and how benchmarking and sharing information is so crucial for the NZ Dairy Industry moving forward.

Dairy is a unique industry in which the farm systems are replicated across many different properties across the country, all with one thing in common; they produce milk. Every day farmers milk their cows they receive milk data, and the farm management teams also have access to a vast range of complicated information across many aspects of their businesses. Where this would imply simplicity, for all farmers there is still a struggle to compare apples with apples across their dairy businesses. This tends to be due to the lack of standardised measurements across different equity structures, different gearing scenarios, different reporting methods, and different stakeholders requiring different focus outcomes.

The report investigates the opportunities and limitations of how AI could possibly be used to find efficiencies in this process also by removing bias and errors that comes unintentionally from humans processing and reporting data, ultimately this could lead to building resilience in the dynamic dairy industry landscape.

## 4.1 What is the importance of benchmarking and standardisation of KPIs?

### 4.1.1 Understanding the Basics of Benchmarking, KPI's and Balanced Scorecards (BSC)

#### Benchmarking

The Benchmarking concept aims to provide businesses with valuable insights into their own operations by measuring themselves against best practices and industry standards. It is often stated that those who benchmark do not have to reinvent the wheel (Parker, 1996). By following others, one can make improvements and not focus on stale ideas. Benchmarking is a strategic process that involves measuring an organisation's performance against the best in the same or different industry. With the aim of improving existing ideas and practices. It is a misconception that benchmarking is merely copying or adopting others' strategies. Instead, it's about learning from and leveraging the knowledge and experience of other organisations to enhance one's own performance. Benchmarking involves assessing strengths and weaknesses, identifying critical processes, and making improvements based on the gathered insights. (Lankford, 2002).

Bogan and English state (Bogan, 1994) there are three primary forms of benchmarking: process benchmarking, which enhances daily operations; performance benchmarking, which evaluates goods and services in comparison to those of rivals; and strategic benchmarking, which concentrates on long-term competitive strategy.

Other types of benchmarking can also include;

a) co-operative and collaborative benchmarking, which entail knowledge-sharing across firms.
b) competitive benchmarking, which gathers data from direct competitors.
c) internal benchmarking, which discovers best practices within the organisation; and
d) external benchmarking, which compares different operational best practices, by purchasing industry reports or examining public financial filings.

Although organisations must use benchmarking with some caution, it can be a very powerful tool depending on the industry, for example, in the New Zealand Dairy Industry with 80% of farms supplying Fonterra as a co-operative, it can be a very insightful, informative process of learning best practices from NZ's industry leaders. However, that said, to get the most value, farmers must foster a spirit of openness and co-operation from indirect competitors.

#### Key Performance Indicators (KPIs)

KPI's are measurable metrics employed to assess a company's overarching long-term performance. These indicators play a crucial role in evaluating a company's strategic, financial, and operational accomplishments, offering valuable insights into its comparative standing within the same industry when compared to other businesses. (TWIN, 2023)

At the core of KPIs lies the process of collecting, storing, cleaning, and producing data. The primary objective of KPIs is to convey results concisely, enabling management to make well-informed strategic decisions, across different sectors with similar aims. Along with benchmarking with industry peers standardising KPI metrics is crucial, so businesses can ensure their KPI's are comparable and sound while remaining relevant to various departments or divisions throughout any business.

## The Balanced Scorecard (BSC)

Similar to KPI's, The Balanced Scorecard is a strategic management performance metric designed to identify and enhance internal business functions, the BSC is a way of including non-financial information and their subsequent external outcomes, balancing it with the quantitative financial information. The concept of BSCs was first introduced in 1992 by David Norton and Robert Kaplan, who took previous metric performance measures and adapted them to include qualitative information (Tarver, What Is a Balanced Scorecard (BSC), How Is It Used in Business?, 2023).

Widely adopted in the United States, the United Kingdom, Japan, and Europe, balanced scorecards serve as another powerful tool for measuring and offering "quick check-in feedback" (Tarver, 2023) to organisations in a single report. The process involves critical data collection, enabling managers and executives to gather and interpret measures to address the goals and results of the organisation. This information empowers company personnel to make more informed decisions for the future success of their organisations. . by carefully balancing all aspects of the business.

In the analysis, a hybrid of KPI and a balance scorecard is explored to determine if it is possible to be a suitable method for measuring dairy performance across many different modern farming spectrums.

*Information empowers company personnel to make more informed decisions for the future success of their organisations.*

### 4.1.2 The Importance of Benchmarking and Standardisation of Key Performance Indicators (KPIs)

Through an analysis of scholarly works and case studies, this review aims to provide concise insights into the transformative impact of benchmarking and standardised KPIs, empowering stakeholders to drive continual improvement and resilience in their evolving businesses.

Benchmarking and standardised KPIs are important for stakeholders to enhance operational efficiency and foster sustainability, they are a tool that delves into how to identify best practices and establish a common language for communication across the business supply chains facilitating performance comparison.


*Figure 2: The benefits of benchmarking (ACCE, 2021)*

Dairy farming is where the anomalies and irregularities of nature meets the ever-changing demands of modern export markets. It is also an industry where farmers are continuously adapting farm systems to improve decision-making processes. Benchmarking has emerged as a crucial tool empowering these agricultural enterprises to strategically compare and evaluate businesses' processes, practices, and results against those of its' peers or industry leaders to identify areas of improvement and set KPIs. Figure 2 illustrates the many benefits of benchmarking.

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*"Benchmarking focuses best practices to identify next practices".*

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### 4.1.3 Basic Benchmarking and KPI's in the NZ Dairy Industry

Performance benchmarking is well suited to NZ's Dairy Industry and the standardisation of KPI's could allow farmers to compare 'apples with apples' as a powerful tool to assess and enhance their performance by learning from others and adapting best practices. It is not about replication but about improving and staying competitive in a rapidly changing global business landscape.

Dairy farming industries worldwide, along with individual farmers, must consistently assess their business performance and production methods to safeguard a healthy level of profitability - benchmarking, and standardisation of Key Performance Indicators (KPIs) are proven to be a very powerful tool to achieve this. The practice is essential for these sectors and the farmers within them to sustain a competitive edge within their respective regions and to uphold their international competitiveness compared to other dairy industries in other competing nations.

A study on the relationship between frequent use of financial benchmarking and farm performance found that through the abolition of the European Union (EU) Milk Quota in 2015 it triggered significant changes in the EU dairy sector, with varying impacts across differing countries. Notably, milk production surged in countries like Ireland, Poland, and the Netherlands due to their comparative advantage in pasture-based systems.

Across a period of profound change within the Irish Dairy Industry, the results of this study clearly indicate the existence of a strong positive relationship between frequency of financial benchmarking and greater technical and financial efficiency. "Our findings also indicate that financial benchmarking is positively associated with environmental

sustainability and more efficient use of resources". (G. Ramsbottom, 2020)

Irish milk production, reliant on cost-effective grazed grass, spiked by 73% between 2009 and 2023, This increase in production was complemented by a 39% (Ritchie, Rosado, & Roser, 2019) expansion of the Irish dairy herd during the same period. Benchmarking of dairy farms' financial performance is crucial in this context, particularly for pasture-based systems exposed to global market price fluctuations. Ireland's success in maintaining low production costs stems from its seasonal calving pasture-based model.

In NZ, a Balanced Score Card could allow dairy companies to pool information to help improve efficiencies by providing more information about non-quantitative measures, for example staff engagement and wellness, training and skills, or perspectives on biodiversity and animal welfare. This inclusion of non-financial information, as standardised key metrics, is essential for the NZ Dairy Industry because it is an integral part of agriculture today and the social licence to farm.

### 4.1.4 How Do Dairy Farmers Currently Track KPI's, and What are the Challenges in Comparing this Data Across Farms?

There is a range of extensive literature written on supply chain performance and measurement systems across the world, covering hundreds of different industries (Balfaqih, Nopiah, Saibani, & Al-Nory, 2016). This poses a challenge in achieving a comprehensive understanding. Given the shear number of performance indicators used in a particular business, there is a risk that researchers may lose sight of the correct evaluation criteria required to assess existing performance measurement frameworks (Moazzam, Akhtar, Garnevska, & E. Marr, 2018). For example, (Van Der Spiegel, Luning, Ziggers, & W.M.F., 2005). Introduced a criteria-based approach to the selection of measurement frameworks for food quality systems. This new method measured frameworks across six key quality dimensions: product quality, availability, costs, flexibility, reliability, and service. The study also employs five specific criteria including: financial and non-financial indicators, comprehensive coverage of entire supply chains, an emphasis on food quality, risk assessments, and environmental sustainability. Aiming to appraise existing performance measurement frameworks and identify those suitable for agri-food supply chains. These criteria are briefly discussed, followed by a review of generic performance criteria and a focus on significant performance measurement frameworks and models. The paper concludes by proposing an analytical framework for agri-food supply chains, achieved by combining various indicators and models.

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*This framework is well suited to address the specific needs of the dairy industry, and the uniqueness of financial performance measures.*

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It emphasises the importance of balancing both financial and non-financial indicators to gain a holistic view of supply chain performance, acknowledging the challenges posed by the diversity of dairy farms.

Comparing financial KPIs across dairy farms is challenging due to variations in farm size, production methods, location, and available resources. Milk supply to process often includes retrospective payments which can further complicate cost structures, revenue streams, and risk management. Consequently, meaningful benchmarking requires tailored approaches.

In summary, this literature review highlights the importance of measuring diverse KPIs in agri-food supply chains. The unique characteristics of dairy farms, including their diversity in size

and methods, make it crucial to adopt a balanced approach that incorporates both financial and non-financial indicators for comprehensive performance assessment in this sector.

## 4.2 What Data Capture Technologies are Currently Available in the Dairy Industry?

In the rapidly evolving dairy industry, there is a complete spectrum of available technologies shaping the landscape of milk production and processing. From Precision Farming to robotic milking systems, and more being developed each day, there are differing functionalities, applications, and practical implications of a multitude of technologies. Through an examination of academic workings and case studies, this review aims to offer a concise yet comprehensive understanding of how these tools are redefining traditional practices and contributing to the sustainability and efficiency of the dairy sector.

### 4.2.1 What are the latest technologies used in the NZ Dairy Industry for data collection, analysis, and monitoring?

The adoption of sophisticated management technologies is on the rise in pasture-based dairy systems, a progression commonly referred to as precision dairying. 'Precision Dairy Farming is the use of technologies to measure physiological, behavioural, and production indicators on individual animals to improve management strategies and farm performance' (Bewley, 2018)

*Figure 3: Automated dairy shed / technology assisted milking (Landsend Dairy, Culverden NZ)*

Precision Dairy Farming technologies offer various benefits, including increased efficiency, cost reduction, enhanced product quality, minimised environmental impacts, and improved animal health and well-being.

The technologies are expected to have a significant impact on health, reproduction, and quality control within dairy farming. Larger herds stand to gain more from data summarisation and exception reporting due to the challenges of individually observing animals. As dairy operations scale up, Precision Dairy Farming becomes more feasible, leveraging less skilled labour and economies of size related to technology adoption.

Technology assists the modern dairy farmer to make timely and informed decisions, leading to improved productivity and profitability. Real-time data monitoring and exception reporting allow for the identification of deviations from normal patterns. Automation of dairy management activities is possible, and system output may offer managerial recommendations. The effectiveness of information derived from Precision Dairy Farming relies on interpretation and integration into computerised information systems (Bewley, 2018). This is a building block for the next step in exploring the possibilities of Artificial

Intelligence to further enhance the technologies capabilities.

The evolving scale and complexity of pasture-based dairying poses challenges for farm system management in workforce, sustainability, efficiency, and profitability. In the Australian and New Zealand Dairy Industries, the traditional model of small family farms with 'experience-based' management is transitioning to larger operations employing predominantly non-family workforces (Alvarez & Nuthall , 2006). This transition, coupled with diverse farming environments, necessitates various farm system approaches for both small and large farms. Consequently, there is an increasing demand for enhanced management capabilities, focusing on animals, feed base, and personnel, facilitated by efficient information collection for decision-making.

Traditionally, dairy producers relied on experience and judgment to identify unusual/exceptional animals, but this approach has limitations. Precision Dairy Farming, by monitoring physiological parameters, enables the early identification of changes not visible to the human eye, allowing for timely intervention. This is particularly important as more cows are managed by fewer less-skilled workers. Overall, the technology has the potential to complement the observations of skilled stock manger or milking assistant, contributing to more effective and proactive dairy management.

### 4.2.2 Current Technology and Automation Available

There is a large variety of different technologies available on modern dairy farms that have revolutionised both efficiencies and productivities through automation and data capture technologies.

| Automation Technologies: | Data capture technologies: |
|---|---|
| • Plant wash<br>• Vat wash<br>• Yard washing<br>• Teat spraying<br>• Drafting systems<br>• Cluster removal<br>• In-bail feeding<br>• Feeding systems<br>• Robotic milking | • Electronic milk meters<br>• Mastitis detection<br>• Heat detection<br>• Walk-over weighing<br>• Electronic ID<br>• Wearables<br>• Pasture management<br>• Weather stations<br>• Herd management |

*Figure 4: Examples of available technologies (Joe Ward 2023)*

These technologies assist farmers in many different areas such as production, decision making, labour savings, animal welfare, environmental sustainability, milk quality, traceability, future proofing and waste reduction.

In a study conducted by Cullum Eastwood (Eastwood, Jago, Edwards, & Burke, 2016) found that farmers in the study highlighted improved profitability and labour savings with the adoption of Precision Dairy Farming technology.

The overall productivity improvements in milk production has greatly increased, as seen in

the Dairy NZ graph shown in Figure 5. Over the past thirty years through the influence of precision farming production output has nearly doubled per cow and per hectare.


*Figure 5: Graph Milksolids production per cow and per effective hectare since 1992/93* (DairyNZ, 2022)

Facilitating peer-to-peer learning among farmers is identified as a potent method for knowledge transfer. Dairy industry organisations are urged to play a role in guiding skill development among farmers and service providers by proactively offering learning opportunities at various levels of dairy training.

The study also highlights the necessity for independent information on considerations before investing in precision dairy technologies, guidance on selecting appropriate technologies, and best practices for maximising technology benefits. Additionally, the collection of on-farm data is recognised as a significant opportunity for individual farmers and the industry, as a whole, in managing performance and responding swiftly to farm system changes. Industry organisations are urged to take a leadership role in guiding the development of new technologies that align with farmer needs and reduce uncertainty surrounding precision dairy innovations.

This highlights the increasing role of technology, particularly precision dairy farming, in modernising and streamlining dairy farm management in response to evolving challenges and opportunities in the dairy industry.

### 4.2.3 What Challenges are Involved with Precision Farming and why isn't Everyone using the Technologies Available?

To gain deeper insights into the impact of Precision Dairy Farming, a study (Yule & Eastwood, 2008) was conducted with objectives such as assessing Precision Dairy Farming influence on farm performance and management practices, understanding the challenges faced by precision dairy farmers, and examining the role of various players in the innovation network related to precision dairy farming. The focus of the study was on farm management opportunities rather than the development of new technologies. The study employed a qualitative research approach to gather information and develop a research agenda for the Precision Dairy Farming sector.

The study concluded two key themes:

a) Confidence is key for acceptance and

b) Strategic planning and implementation are critical to success.

Farmers' confidence in technology is crucial for its adoption, particularly as dependency on technology grows. The increased automation level amplifies dependency, where a failure in one component can disrupt the entire system. Manufacturers and service providers also face challenges in adequately supporting these products in a price-competitive market. Remoteness must also be considered for customer support. Additionally, negative experiences can make farmers hesitant about further technology adoption.

The success of precision dairy farming relies heavily on the planning, management, and review capabilities of the farm management team. Effective planning is essential for realising the purpose of adopting new technologies. In the emergent phase of precision dairy farming, challenges include issues related to technology and management adaptation, ICT skills and engagement, uncertainty about unlocking benefits, staff-technology interactions, and a lack of capability in the service sector. Therefore, the design of information systems becomes crucial, and management systems should utilise data to provide clear and efficient information to time-constrained farmers or herd managers.

Similarly, Cullum Eastwood (Eastwood, Jago, Edwards, & Burke, 2016) also found there are lingering questions for farmers regarding optimising the use of technologies and data. These uncertainties include understanding the potential value of in-bail individual feeding, integrating various technologies and data sources, and determining an appropriate level of support. The Eastwood (and co) study emphasises the need for technology suppliers to shift focus towards after-sales service, tailoring support programmes to different learning stages, and creating compelling value propositions for farmers to invest in such services.

The strong correlation of effective precision farming and the confidence of farmers with the technology adoption is also found in another study Technology Adoption Factors: "The technology acceptance model and use of technology in New Zealand Dairy Farming" (Flett, et al., 2003).

*"Consistent with psychological variables New Zealand dairy farmers are influenced not only by economic considerations when adopting and using a new technology but are also influenced by the ease of understanding and ease of use of that technology".*

## 4.3 What is Artificial Intelligence and its Potential in the NZ Dairy Industry?

In the evolving landscape of agriculture, Artificial Intelligence (AI) holds significant promise for transforming the NZ Dairy Industry. This literature review explores AI applications in dairy farming, investigating its potential to enhance efficiency, sustainability, and productivity. Through real-world case studies and realistic findings, we delve into the impact of AI on aspects such as precision livestock management and milk quality assurance. Ethical considerations, regulatory frameworks, and societal implications will also be scrutinised, providing a comprehensive overview of AI's role in reshaping the future of the dairy industry.

### 4.3.1 What is Artificial Intelligence (AI)

Artificial Intelligence (AI) involves replicating human intelligence in computers or machines. AI enables machines to learn from past experiences, autonomously acquire new skills, and exhibit different behaviours. Through AI, computers can be trained for specific tasks by processing large datasets (Big Data) and identifying patterns within the data. (Sarabi, 2020)

Artificial Intelligence is a branch of science and technology that creates intelligent machines and computer programmes to perform various tasks which requires human intelligence. (ANJILA, 2021)It is a system that mimic various functions which a human can do. AI uses external data like the big data to achieve excellent performance for the given tasks. These include learning, reasoning, problem-solving, perception, and language understanding. AI systems are designed to mimic, replicate, or augment human-like cognitive functions. There are various approaches to implementing AI, and the choice of method depends on the specific task and goals.

Here are some key components and techniques commonly associated with AI:

#### Machine Learning (ML):

Machine learning is a subset of AI that focuses on developing algorithms and models that enable computers to learn from data. Instead of being explicitly programmed to perform a task, a machine learning model is trained on a dataset to make predictions or decisions. There are different types of machine learning, including supervised learning, unsupervised learning, and reinforcement learning.

#### Data:

Data is a critical component of AI systems. Machine learning algorithms learn patterns and make predictions based on the data they are trained on. The quality and quantity of data significantly impact the performance of AI models.

#### Algorithms:

AI algorithms are the mathematical instructions that define how a system should learn from data or make decisions. The choice of algorithm depends on the nature of the task. For example, neural networks are commonly used in deep learning for tasks like image and speech recognition.

#### Neural Networks:

Neural networks are a type of machine learning model inspired by the structure of the human brain. Deep learning, a subset of machine learning, involves neural networks with many layers (deep neural networks). These networks can automatically learn hierarchical representations of data.

### Natural Language Processing (NLP):

NLP is a branch of AI that focuses on enabling computers to understand, interpret, and generate human language. It is crucial for applications like language translation, chatbots, and sentiment analysis.

### Computer Vision:

Computer vision involves the development of AI systems that can interpret and understand visual information from the world. This is used in tasks such as image and video recognition.

The general process of how AI works can be summarized as follows:

**Data Collection**: Relevant data is collected for the specific task the AI system is designed to perform.

**Data Preprocessing**: Raw data is cleaned, organized, and prepared for training.

**Model Training**: The AI model is trained on the prepared data using machine learning algorithms. During training, the model learns patterns and relationships within the data.

**Inference**: Once trained, the AI model can make predictions or decisions when presented with new, unseen data.

It's important to note that AI is a rapidly evolving field, and ongoing research is focused on improving the capabilities, efficiency, and ethical considerations of AI systems.

### 4.3.2 What is the Internet of Things (IoT)?

In (Morgan, 2014) journal explaining IoT, he states the Internet of Things (IoT) is the idea of connecting any device with a power switch to the Internet or to each other. This encompasses a wide range of items such as computers, cell phones, household appliances and a range of industrial machines. Essentially, if a device has an on/off switch, it can likely be integrated into the IoT. It presents countless possibilities and connections that extend beyond our current imagination or comprehension. The widespread interest in IoT is evident, as it introduces numerous opportunities and challenges. Companies must develop strategies to handle the extensive data generated by IoT, involving storage, tracking, analysis, and interpretation.

### 4.3.3 The Relationship between IoT and AI

(Sarabi, 2020) describes the relationship as (IoT) enables device connectivity and generates substantial data while Artificial Intelligence (AI) analyses IoT data, extracting patterns and behaviours to make informed decisions. Together, IoT and AI address real-world issues and drive innovation, as seen with connected cars and self-driving vehicles.

The relationship between AI and IoT is pivotal. IoT's true value lies in deriving meaningful insights from data and making predictions, a task made possible through AI-driven Big Data processing. Without AI, IoT remains a static technology for device connectivity and data collection automation. Combining AI with IoT creates smart devices capable of learning, self-improvement, and decision-making.

Overall, the integration of machine learning and IoT (as shown by Figure 6) promises to unlock the potential of IoT data for various applications, from predictive maintenance to optimising business outcomes. This synergy will continue to drive advancements in both fields, leading to smarter, more efficient, and data-driven solutions. (Adi, Anwar, Baig, & Zeadally , 2020)

The paper classifies IoT analytics techniques into descriptive analytics, predictive analytics, prescriptive analytics, and adaptive analytics.

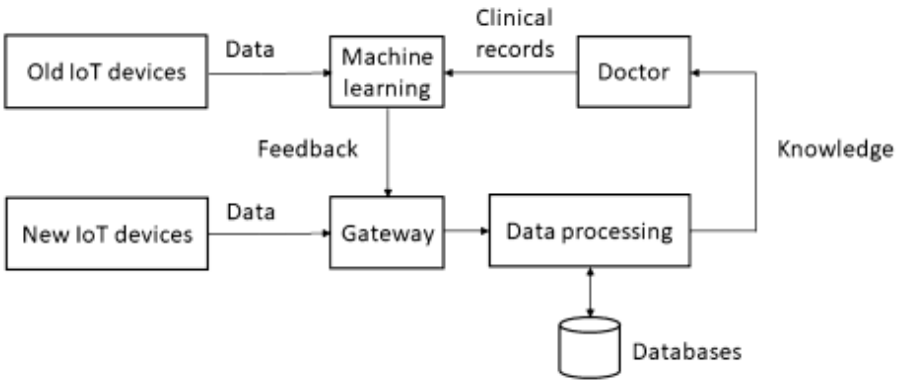


*Figure 6: Gateways adapt heterogeneous data from different devices (Adi, Anwar, Baig, & Zeadally, 2020)*

Descriptive analytics summarises historical data. Predictive analytics forecasts future trends. Prescriptive analytics suggests responses to future events. Finally, Adaptive analytics adjust outcomes based on real-time data. These techniques are essential for processing and making sense of the vast amount of data generated by IoT devices.

This relationship could provide an opportunity to establish AI and machine learning technologies to process data captured by on farm, to help forecast and assist farmers manage KPI / BSC performance and make decisions.

### 4.3.4 Getting value from Artificial Intelligence (AI) in agriculture

In M. Smiths research on getting value from AI in agriculture (Smith, 2018) he found, Artificial Intelligence is rapidly evolving as a very powerful tool in agriculture industries with recent advancements in data, computation, and algorithms. This paper explores the value AI brings to agriculture in the next decade. Immediate applications include enhancing precision information on farm activities, leading to more accurate alerts for farmers. AI aids in understanding, the reasons behind phenomena in farm systems, thereby improving management. Improved data and understanding lead to better predictions, facilitating optimal decision-making in farm systems, and encouraging the development of decision support and sustainable recommendation systems.

AI is experiencing global widespread adoption and is bringing significant advancements to various industries. The purpose of AI implementation varies between businesses but is most commonly providing actionable insights, streamlining data management, and innovative solutions like chatbots, a computer programme that simulates conversation with human end users.

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*Agriculture sector is not exempt from the AI revolution, and it is becoming popular for remote monitoring and decision support tools due to its large geographical scope and complete production systems with variable weather and challenging environments.*

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Smith explores the potential benefits of AI in agriculture, focusing on data acquisition, information extraction from imagery, language translation, and AI-assisted data capture, all of which enhance precision farming and data-driven decision-making. It also

acknowledges challenges such as job disruption, the need for proper AI interpretation training, and the risk of over-reliance on AI alerts must be addressed to ensure responsible AI integration.

The integration of AI into agriculture systems and potential challenges.

While it promises to revolutionize the industry by providing valuable insights and automating tasks, careful integration with human oversight is crucial for responsible and effective use. The article encourages a proactive approach to AI adoption in agriculture, recognising that challenges may uncover new opportunities for value creation. It emphasises the indispensable role of AI in addressing sustainability challenges in agriculture while also highlighting the importance of studying and mitigating any potential adverse effects to ensure a balanced and successful AI-driven transformation in the industry.

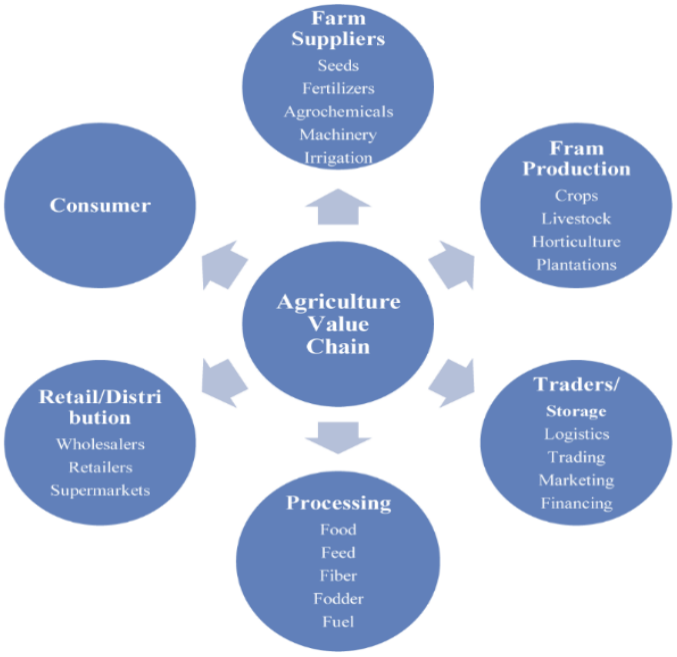


*Figure 7: This diagram from (Ganeshkumar, Jena, Sivakumar, & Nambirajan , 2023) shows areas in the AVC where AI could be applied, for the purpose of this research paper I will only be exploring the Farm related data points and some interaction with Farm suppliers.*

This is similar to (Ganeshkumar, Jena, Sivakumar, & Nambirajan , 2023) study that explores the application of Artificial Intelligence (AI) in agriculture (refer to Figure 7) and its potential benefits. It emphasises the transition from traditional to modern agriculture in emerging economies and how AI can facilitate this transformation. The paper explores: AI's role in Precision Farming crucial in managing unpredictable growing conditions and improving the quality and efficiency of agricultural yields, with a lot of focus on sustainability and protecting the environment, with less chemicals and fertiliser, whilst looking after the soil and water. Furthermore, AI assisting food produces in navigating an ever-changing agriculture landscape looking to future farming practices, and ultimately solving global food production challenges where there is a need to increase global food production by 60-70% by 2050 to meet rising demand.

The comprehensive literature review of 88 research studies spanning from 1994 to 2020 reveals that while AI adoption in agriculture has shown promise, there remains a significant research gap, particularly in stages like processing, distribution, and retail within the Agricultural Value Chain (AVC).

The paper concludes AI is seen as a critical tool to achieve this goal while considering economic growth, changing food consumption patterns, and income levels in developing countries. Underscoring the challenges of feeding, an expected 2 billion increase in the global population, by 2050, and highlighting the pivotal role that Artificial Intelligence can play in addressing this, while emphasising the importance of government involvement in identifying and prioritising AI implementation areas within the Agriculture Value Chain (AVC). It further highlights the potential of AI-driven technologies to enhance agricultural efficiency and tackle issues such as crop yield and soil health, especially in the context of a globalised marketplace and growing e-commerce in agriculture. Ultimately, the paper calls for continued research to bridge these gaps and extend AI adoption, particularly in underdeveloped and developing countries, as a critical step toward addressing the impending global food security challenge.

There is common themes emerging from these literature reviews:

The paper from (Eli-Chukwu, 2019) highlights the recent application of Artificial Intelligence (AI) in the agricultural sector, addressing challenges such as improper soil treatment, disease and pest infestation, big data requirements, low output, and the knowledge gap between farmers and technology. Emphasising the flexibility, high performance, accuracy, and cost-effectiveness of AI, the paper reviews its applications in soil management, crop management, weed management, and disease management. Special attention is given to the strengths and limitations of these applications and the utilisation of expert systems for achieving higher productivity in agriculture.

Agriculture plays a crucial role in livelihoods, GDP growth, national trade, employment, and overall economic development. To meet the challenges of a rapidly growing global population, innovative solutions are essential. The integration of Artificial Intelligence (AI) into agriculture, facilitated by technological advancements like Big Data analytics, robotics, the Internet of Things (IoT), sensors, drones, and widespread internet coverage, offers predictive insights for optimal crop management. AI has the potential to enhance crop yields, reduce resource usage, mitigate environmental impact, improve worker safety, stabilise food prices, and align food production with population growth. Despite its promise, challenges such as response time, accuracy, data requirements, implementation methods, data costs, and flexibility all exist. The future of AI in agriculture is optimistic, especially in addressing the challenge of feeding a growing global population, with robotics and autonomous systems expected to play a significant transformative role in the future of agri-food industry.

### 4.3.5 Opportunities for Artificial Intelligence (AI) in the Dairy Industry

(Alami , Barramou, & Dakir, 2021) study shows: Precision agriculture has leveraged emerging technologies such as the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI). The abundance of high-resolution remotely sensed data, along with the evolution of frameworks and Machine Learning (ML) algorithms, has elevated the sophistication and precision of raw data analysis. Artificial Intelligence has introduced an innovative perspective, enabling the resolution of intricate challenges in agriculture.

A similar study (Araújo, Peres, Barata , Lidon, & Ramalho, 2021) that investigated how investing in technological research is vital for sustainable solutions in agriculture. Araujo and colleagues identified that the key drivers of Agriculture 4.0 (the next revolutionary trends) are advances in IoT, sensors, robotics, AI, Big Data, and cloud computing. They viewed these drivers as a solution for global food needs. The research characterises the current landscape, identifies trends, and discusses challenges and opportunities for future research. It presents a high-level cloud based IoT architecture for smart agricultural systems, aiming to guide a successful transition towards sector digitalisation. This passage highlights the pivotal role of agriculture in sustaining human life, especially with the anticipated global population growth.

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Facing challenges like climate change and resource scarcity, the emergence of Agriculture 4.0, integrating IoT, Cloud Computing, Big Data, and Artificial Intelligence, is emphasised for improved productivity and sustainability.

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This reoccurring theme of AI potentially enhancing both efficiency and productivity in food production systems was also found in I. Kumar's and colleague's research. The study

presented the various facts which demonstrate the advantages and implementation opportunities of AI for a range of unique food production businesses. In the current scenario, food production industries globally are beginning to utilise a basic level of AI. Every day the role of AI is becoming more and more evident in areas like hygiene, food protection, and waste management systems. In the future, AI is going to transform the food processing industry because it has so much potential to generate reasonable and healthier productivity, for farmers, consumers and employees, alike.

The implementation of AI and ML in food production and eatery businesses is already taking the business to a new level by minimising human mistakes in manufacturing and manages copious product minimising wastage. It enables low costs for packing as well as conveyance, increment in customer pleasing, rapid services, voice searching, and more personalised orders. These business advantages can also be benefited for big food factories which will bring an obvious benefit in the long run (Kumar, Rawat, Mohd, & Husain, 2021).

### 4.3.6 Limitations of Artificial Intelligence (AI) in the Dairy Industry?

There are limitations and risk associated with relying on AI and IOT:

A study conducted by Asaf Tzachor and colleagues exploring responsible implementation of AI acknowledged the rapid advancement of AI's potential to enhance many aspects of agriculture such as crop management, productivity, and disease diagnosis for example. However, the implications of machine learning (ML), expert systems, and autonomous machines in farming are not yet well-understood. This paper discusses systemic risk factors, including issues with inter-operability, reliability, and relevance of agricultural data, unintended socio-ecological consequences from ML models, and safety concerns associated with large-scale deployment. To address these risks, the authors propose mitigation measures such as involving anthropologists and ecologists in technology design, adopting frameworks for responsible and human-centred innovation, establishing data co-operatives for transparency, ownership rights, and deploying agricultural AI in controlled digital environments (Tzachor, Devare, King, Shahar, & O hEigeartaigh, 2022).

The study investigated 3 main risks associated with agricultural AI and categorised into three main areas:

1) Data-Related Risks, 2) Optimisation and Adoption Risks, and 3) Deployment Risks.

Data challenges include issues of accessibility, quality, and trust, with concerns about bias and relevance, particularly for smallholders and Indigenous farmers. Optimisation for yield may lead to ecological problems and exacerbate socioeconomic inequalities. The adoption of AI may widen the digital divide, affecting small-scale farmers' work, identity, and ownership rights. Deployment risks involve potential centralisation, cyber vulnerabilities, and system failures, impacting agrifood supply chains. To mitigate these risks, proposed measures include FAIR data (Findable, Accessible, Interoperable, Reusable) frameworks, transparent standards, data cooperatives, and responsible innovation practices (Tzachor, Devare, King, Shahar, & O hEigeartaigh, 2022). Addressing these challenges is crucial to ensuring the benefits of agricultural AI are distributed equitably and do not harm the environment or worsen existing inequalities.

*Understanding and acknowledging the limitations of AI are crucial for the responsible and beneficial integration of AI into food production.*

AI, while showing considerable progress, has inherent limitations. These constraints include the inability to grasp context like humans, reliance on biased data, lack of common-sense reasoning, and ethical concerns regarding privacy and accountability.

In an interview on the McKinsey Podcast (Chui & Manyika, 2018), McKinsey Global Institute partner Michael Chui and MGI chairman and director James Manyika speak with McKinsey Publishing's David Schwartz about the cutting edge of AI. When asked what are the big limitations of AI today? James Manyika responded that the limitations need to be separated into technical limitations: "can we explain what the algorithm is doing? And can we interpret why it is making the choices and outcomes and predictions that its' making?" then with practical limitations: "is the data actually available and is it labelled?" The third limitation has been the use of the AI: "how transparent are the algorithms? And what bias is in the data and the way in which the data was collected".

This means that when implementing AI into a business system users must, not only, carry out due diligence to ensure that AI is fit for purpose, but also be aware that there are limitations are both in data sets and the actual algorithm written and being used by the technology. Therefore the 'machine learning aspect of AI is crucial to ensure successful algorithms are used for the data processing. As Manyika states "the holy-grail question, which is: How do you build generalisable systems that can learn anything? Humans are remarkable in the sense that we can take things we've learned over here and apply them to totally different problems that we may be seeing for the first time." So how can we transfer that to machine learning to ensure our systems are flexible and adaptable to different problem-solving situations? This is called transfer learning and is a real focus for AI developers to ensure systems are manipulatable to be best suited for user applications.

This is theme of bias and algorithm transparency was evident in a research paper: Limitations of AI (Sultan, 2021) quoting "The problem is that AI is emotionally immature since it is incapable of classifying individual emotions and mindsets into unique data points or profiles. In any case, things will begin to improve within the next few years" this aligns with the concept above of transfer learning. AI technologies improve efficiency and accelerate workflows, leading to increased profits through increased efficiency and productivity. However, as the paper concludes: other concerns include transparency, bias, and legal issues. While AI offers advantages like reduced errors and fatigue, its implementation requires careful consideration of procedures and policies. Long-term planning is crucial before undertaking resource-intensive AI initiatives.

### 4.3.7 Solutions to the Artificial Intelligence (AI) Limitations

There are many ways that businesses can solve some of these limitations an ensure fit for purpose implementation of AI technology.

The Turing test also known as the imitation game by Alan Turing 1950 is a surprisingly simple method of determining whether a machine can demonstrate human intelligence. The test has recently become a new standard of evaluating modern AI. (Bansal, 2023) states "Despite its limitations, the Turing Test remains an important reference point in the field of AI and continues to inspire new research and development in this area." Bansal explores Turing Test in AI and concludes the advantages are that it can be used to: a) evaluate machine intelligence, b) set a benchmark (for AI and is a minimum goal for researchers to strive for), c) inspire research (developing machines that can past the test has driven progress of AI) and d) its simple to administer (anyone can use the test when evaluating AI).

Paul Walton's paper: Artificial Intelligence and the Limitations of Information concludes that there are some important implementation principles that should be followed as best practice when analysing the use of AI in a business setting. (Walton, 2018)

#### Fitness in AI

Organisations must thoroughly understand the problem they are trying to solve when looking at AI implementation as a solution. Comprehensive information analysis is essential.

#### Integration Challenges

Businesses should explore a range of challenges posed by the vast array of different AI solutions. They also need high quality, coherent information for each AI component. Ensure they address discrimination issues during data interrogation. And that there is no overlap with human processing.

#### Ecosystem boundaries

While the Turing Test focused on the human/computer ecosystem boundary, businesses should also understand how AI collaborates with employees and supports other ecosystem boundaries is crucial in its particular business setting.

#### Assurance in AI

Businesses must manage and understand impacts and risk, with an emphasis on cyber security and safe data. Also acknowledge limitations of the technology for any big decisions.

#### Artificial General Intelligence (AGI) theoretical difficulties

How is AGI determined and can it handle future integration to adapt to new ecosystems over time. Can AGI process and relate abstractions while avoiding the pitfalls humans face in connecting abstractions and information quality?

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*AI is revolutionary and there is a lot of successful examples of AI being used positively and effectively in a vast range of different industries, NZ Dairy Industry could also benefit from AI's capabilities.*

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## 4.4 What are Successful AI Applications in Other industries and Countries?

In the dynamic landscape of contemporary industries, Artificial Intelligence (AI) stands as a transformative force, reshaping global business operations. This part of the literature review explores successful AI applications across diverse sectors worldwide. Through case studies and empirical research, we aim to uncover strategies, challenges, and technological interventions that have driven tangible advancements. Beyond promises, we delve into real-world benefits, ethical considerations, and societal impacts. This review contributes to a deeper understanding of how AI is revolutionising industries and shaping our daily lives globally.

### 4.4.1 Manufacturing Industry success story

The study (Jianjun, Yao, Hameed, Kamran, & Nawaz, 2021) investigates the growing organisational trend of examining both artificial and non-artificial intelligence's impact on innovation and the success of new products. Focused on manufacturing organisations in China, the research employs quantitative methods, utilising questionnaires and smart-PLS analysis. The study's findings indicate that three dimensions of artificial intelligence—technical infrastructure, management capabilities, and personnel expertise—contribute to gaining competitive advantages for new products. These dimensions lead to enhancements in operational, production, and marketing strategies, as well as improvements in technology and procedures. Ultimately, these advancements enable organisations to effectively adapt to changing market trends, ensuring the success of their new products in competition with market rivals.

### 4.4.2 Healthcare industry success story

The National Academy of Medicine report (Johnson, et al., 2020) highlights the significant potential of artificial intelligence (AI) in healthcare, emphasising its ability to enhance specialist care and address human limitations. Key principles for successful AI adoption include data transparency, analytics supporting human activities, and collaborative expertise. Challenges include data integration, security, and bias.

The digitisation of health data, coupled with technological advancements, is driving AI development (Sima, Gheorghe, Subic, & Nancu, 2020) Wearables (e.g. activity and fitness trackers, blood pressure monitors, skin patches and embedded biosensors) and medical devices generate vast amounts of personal data, offering insights for a healthier life. Big Data plays a crucial role in healthcare analytics and AI applications across various sectors.

AI applications in healthcare include fraud detection, clinical decision support, predicting readmissions, and supporting government efforts in disease control. Precision medicine, driven by extensive data, all working in tandem with AI.

Quoting conclusions "The synergy between these two forces and their impact on the healthcare system aligns with the ultimate goal of prevention and early detection of diseases affecting the individual, which could ultimately decrease the disease burden for the public at large, and, therefore, the cost of preventable health care for all." (Johnson, et al., 2020).

### 4.4.3 Agricultural success story

A study carried out by (Gehlot, Malik, Singh, Shaik, & Alsuwian, 2022) underscores the importance of establishing an intelligent ecosystem in the dairy industry through the incorporation of emerging technologies. It delves into a hybrid architecture, employing machine learning-based edge devices for the comprehensive monitoring of both the physical and mental health of dairy cattle. Furthermore, the study explores the integration of drones and long-range communication systems to enable real-time tracking of animals. In addition to this, the implementation of Internet of Things (IoT)-based devices and blockchain technology is discussed, particularly focusing on their role in enhancing milk quality monitoring and streamlining supply chain processes within the dairy industry. In the report they state "Emerging technologies such as IoT, AI, ML, robots, drones, and blockchain will play a key role in improving the productivity and sustainability of dairy cattle." (Gehlot, Malik, Singh, Shaik, & Alsuwian, 2022)

Another study carried out by (San Emeterio de la Parte, Martínez-Ortega, Hernández Díaz, & Martínez, 2023) This paper focuses on precision agriculture within the Internet of Things (IoT) context, where data from various farm sensors are collected. These data are characterised by spatial, temporal, and semantic attributes, which pose challenges in managing and implementing models and databases efficiently. The lack of standards leads to limited inter-operability between management solutions and other non-native services.

To address these issues, the paper presents an innovative system for spatio-temporal semantic data management. This system includes a data query system that enables farmers and users to address daily queries and supports decision-making, monitoring, and task automation. The proposed solution ensures service inter-operability and is validated using two European smart farming platforms, AFarCloud and DEMETER.

## 4.5 How can AI Build More Resilience for the NZ Dairy Industry?

Artificial intelligence (AI) can future-proof businesses and enhance resilience across various industries in several ways:

In our modern digital world that's defined by rapid technological advancement, AI has emerged as a pivotal force in future-proofing industries and been an incredibly powerful tool to help organisations against both internal and external drivers. If businesses are able

to effectively implement AI technology not only will they be able to streamline operations and enhance efficiency, but also proactively address challenges and uncertainties. It's a transformative technology that's taking the world by storm, redefining the way in which industries can navigate increasingly complex and dynamic landscapes. AI offers a solution to a vast array of applications, from predictive analytics for risk management, to the optimisation of supply chain processes and adaptive cybersecurity measures. Most importantly AI supports better informed decision making. AI builds more resilient and agile industries, fosters innovation, and fortifies against unforeseen disruptions (Strawser, 2023).

The COVID-19 pandemic was the most sever global supply disruption in our history. With unprecedented challenges the world faced, it emphasised the need to enhance the resilience of supply chains, to face sudden risks and uncertainties. The study (Naz, Kumar, Majumdar, & Agrawal, 2022) explores the role of Artificial Intelligence (AI) in improving Supply Chain Resilience (SCR) post-COVID-19. The study found that the integration of advanced technologies and AI can strengthen supply chain resilience and improve overall supply chain performance. However, it found a gap in the literature in designing optimisation models using Big Data analytics for Supply Chain Management related problems. Examples of optimisation models, such as a two-stage supply chain distribution model using Modified Particle Swarm Optimisation (MPSO), are discussed. "The technological innovations and AI applications will help in creating a resilient supply chain and further facilitate risk mitigation, supplier selection, decision modelling, technology management, network design, data-driven and optimisation algorithm in the supply chain." (Naz, Kumar, Majumdar, & Agrawal, 2022). With further development of AI it does appear to be the best tool industries can equip themselves with to face adversity.

With the world population growing to 9.7 billion in 2050 and 10.4 billion by 2100 with increasing life expectancy (United Nations, 2022). An example of an industry embracing AI resilience in agriculture is the Netherlands, who are the second biggest exporter of agricultural goods in the world. These exports are estimated to have increased by 9.4% to a record €104.7bn (£90bn; $114bn) in 2021, according to Wageningen Economic Research (WUR) and Statistics Netherlands (CBS). A recent article on The Farm of the Future, located in Lelystad, Netherlands, reports that precision farming technologies and AI are essential for increased efficiency, production and sustainability (Bearne, 2023). Furthermore, Jacob van den Borne farming potatoes in southwest Netherlands, says he is investing in AI to help provide the answers in the future. "For example, asking questions like if there's an issue in the field, we can try and figure it out with AI." "For me, the farm of the future is all about data, Artificial Intelligence and learning." (Bearne, 2023)

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*This reinforces that AI is transformational technology and is essential to building a more resilient industries globally.*

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# 5. Analysis

"Thematical analysis is a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006). The use of the thematical analysis (Figure 8) is used extracted key themes from an extensive literature review with findings from a thorough in-depth survey that includes 15 responses from stakeholders. By analysing findings from established research in the literature review with real-world perspectives, the aim is to uncover similarities and disparities between existing knowledge and lived experiences. Through thematic analysis, this study seeks to identify recurring patterns, divergences, and correlations, ultimately offering a comprehensive understanding of importance of benchmarking the potential opportunity to use AI to manage data, within the context of both theoretical constructs and practical applications.

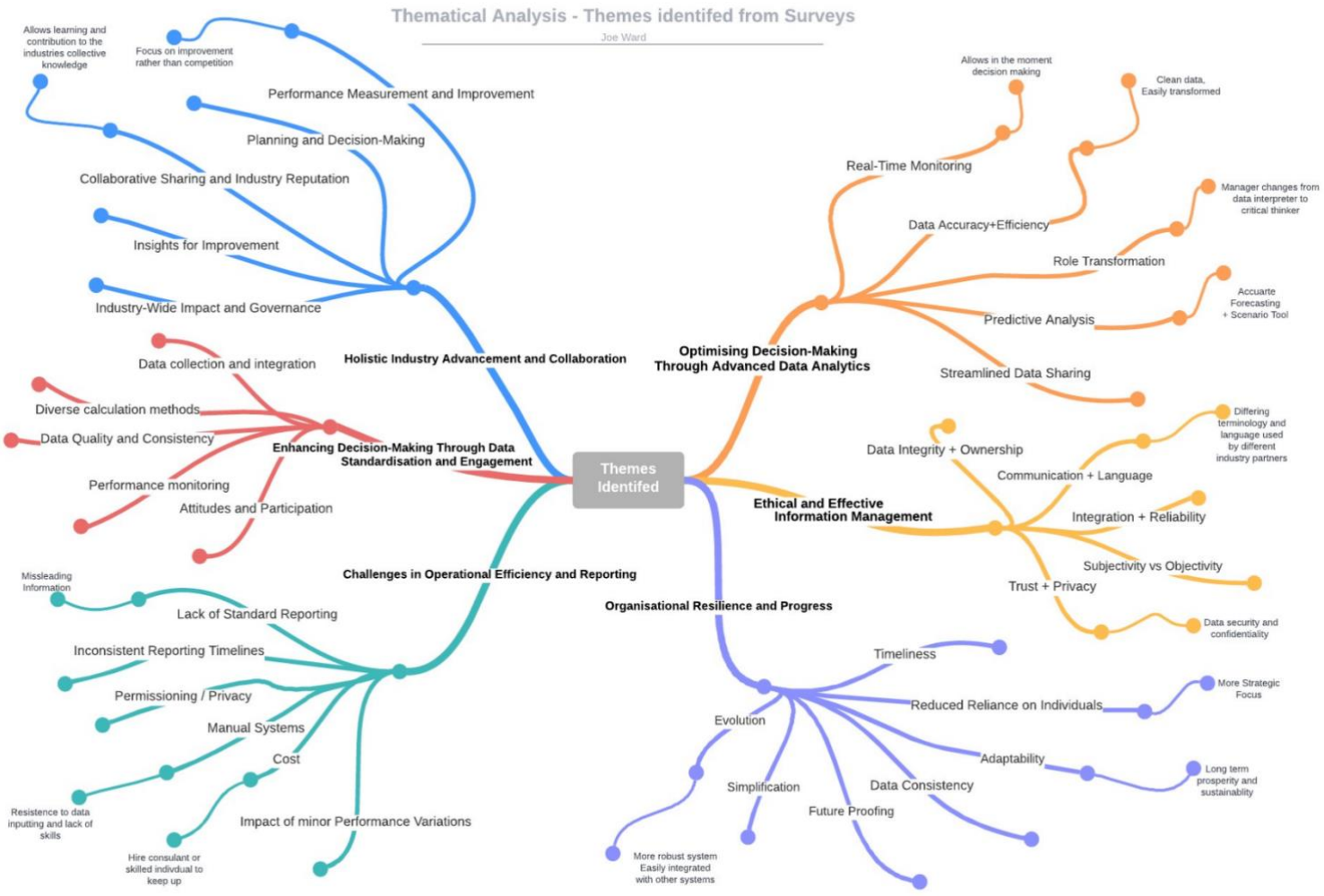



*Figure 8: A mind map exploring distillation of survey responses into key themes and sub themes as per (Braun & Clarke, 2006) method (Joe Ward 2023)*

The participants were asked 10 questions to investigate the importance of KPI performance benchmarking and exploring Artificial Intelligence as a potential solution to data management to build resilience in New Zealand's Dairy Industry. Participants answered anonymously to allow transparency in confidence. They were made up of seven dairy farm managers from both the North and South Island, eight industry experts included participants from consultancy, industry-body organisations and corporate management.

## 5.1 Holistic Industry Advancement and Collaboration

This theme was very evident through most of participants' responses when they were firstly asked:

## Q1. How and why is KPI performance benchmarking important for the dairy industry?

*"The collaborative aspect is unique to the dairy industry, as other farmers are not competitors but a source of a wealth of knowledge. It would be easy to get caught with tunnel vision if not benchmarking or comparing performance to other farms".*

There was a real sense of working towards the greater good from both the farm mangers and the industry experts. This reinforces findings in 7.2 of the literature review where it was acknowledged that benchmarking was deemed a crucial tool empowering farms to strategically compare and evaluate best practices to lift both farm and industry performance. This also makes a significant difference to enhancing industry reputation which is essential as an exporting country.

"Crucial to show where we are doing well an where we can improve compared to others. Not about competing, about improving".

The idea of not competing with other farmers, is an important point to make where dairy is a unique industry whereby farmers are mostly supply milk solids as a collective. This allows them to foster a spirit of openness to ensure effective cooperation and collaboration. This concept emerged as an essential aspect of value-add benchmarking.

*"Driving performance and development through data. Understanding which anecdotal or assumed points of view are fact or false. Underlaying strategic decisions with clear information".*

Performance measurement and improvement was the most common response across participants and highlights how crucial KPI benchmarking is to the dairy industry to provide users accurate insights for planning and decision making. Which was an evident aspect throughout the literature review.

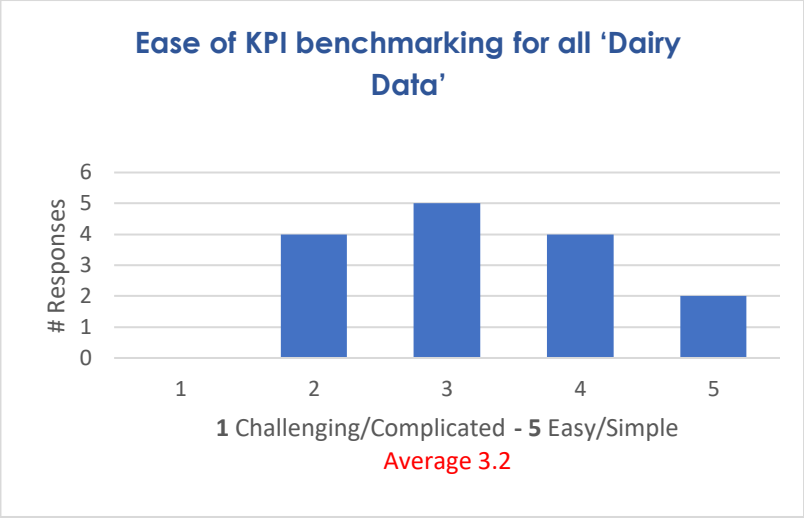
*"KPI benchmarking is essential for the dairy industry both from a governance perspective for individual businesses and an industry perspective of being able to get all farms on a journey of improvement. Individual businesses need a way of standardising and measuring their performances against previous seasons, within groups or across the industry. From an entire industry perspective, KPI data can be used to highlight opportunities to those poorer performing businesses by showing what is possible".*

This response touches on a lot of the sub themes, the idea to get all farms on an improvement journey is a great concept and one that is missing currently in the industry. The standardising is a reoccurring theme in which is a fundamental aspect of this research paper, so is great to see that emerging from stakeholders survey responses.

The governance perspective was not covered in depth in the literature review but is an extremely relevant angle to consider when exploring the importance of benchmarking in the dairy industry.

## Q2 Currently how easy do you think the process of KPI benchmarking of dairy farms is, including all 'Dairy Data'?

Stakeholders were asked how easily do they think the KPI benchmarking process of dairy farms currently is, of which respondents answered 50/50 between challenging and easy (average response 3.2). This probably reflects different biases of willingness to benchmark. i.e. for example a recent frustration/gratification with the current KPI benchmarking process may swing results. Therefore, data was further split into farmers, and industry experts.




This was done to drill down and see if either group skewed either way, due to the nature of their roles in the industry. However, surprisingly there was a very similar average between both groups of participants. Concluding that there are many other factors that are driving 'experience' of KPI benchmarking, for example how tech savvy participants are.

It highlights a range of different abilities in industries in so reinforces perspectives that emerged in 7.2.2 including the need for a standardised framework. There was even the need for automation that was further explored in 7.4.5.

## 5.2 Enhancing Decision-Making with Data Standardisation and Engagement

Improving decision making process is a fundamental driver for this research and is essentially driven by effective standardised KPI performance benchmarking.

## Q3. What are the challenges of managing this 'Dairy Data' and Performance KPI's ?

*"If overcomplicated, or too many things to look at then the real critical important factors can't be focused on".*

Simplicity and consistency emerged in a lot of responses, especially from the farm mangers. There was nearly a sense of frustration throughout. It was intriguing to explore this from the real-world perspectives and it cements the fact that 'Confidence is key for acceptance', explored in 7.3.2. Farmers are dependent on this dairy data for all decision making on farm.

*"Often getting information from multiple sources are challenging. Somethings from year to year can skew results. Especially in a commodity-based business with weather variations affecting operations. Multi-year views are sometimes required. Getting relevant KPI's can also be challenging. Different goals tend to mean companies have different focuses and different (not relevant) KPI's".*

Data quality is a foundation for successful performance benchmarking and was evident throughout nearly all responses received. Similarly, the experts across all areas of research, in the literature review, also emphasised the importance this.

*"Attitudes and enthusiasm from the farmers, accuracy in data recording, "close enough is good enough".*

This is a key point to make that was common throughout industry experts' responses so must be a common occurrence they deal with in their professions. At the end of the day the farm managers own the data therefore engagement factor is essential for effective data management.

*"The wide range of systems and ways it is calculated. Many companies will not use industry standard benchmarks as they have their own a benchmark as a point of difference".*

*"Ego's of companies on willingness to share data. Many will talk about sharing it on one platform but only if it is their platform!".*

This a very valid perspective from a participant and is becoming a common frustration with farmers especially in areas like compliance. This can feel like an endless process for dairy farmers as is seemingly all year process whether it is consents or catchment groups there is no 'one stop shop' for standard data benchmarks. There is a gap of research to acknowledge, although there are vast amounts of data capture technologies explored in 7.3.1 there is not a lot of research, not yet available, exploring how these technology's and software's will link together throughout a farm system is required. There is communication between technology in some areas, but for the most part the new startups competing in the Agri-tech space hold their cards close.

## 5.3 Challenges in Operational Efficiency and Reporting

Gaining industry perspective on challenges with data collection was crucial to investigate the opportunities and potential solution further in the report.

### Q4. Why is data collection process challenging?

*"Can be time consuming. You need to understand why things have happened. Record keeping can sometimes be a limiting factor. You also need to be comparing apples with apples. Land values and ROA's also need to be considered".*

*"Over lapping data causes time to be lost and cross over of information".*

Inconsistent timelines and lack of standard reporting was one of the most commented challenges with all participants. This theme also surfaced in 7.2.2 literature review and is an important note due to the diversity of dairy farms including geographic location but also the seasonality of weather and other variables that show consistent timelines is a complicated.

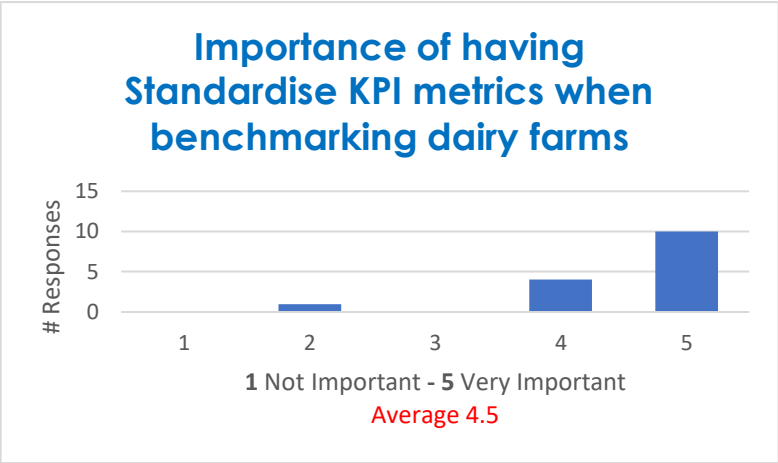
*"Every farm, farmer and system is different. And, more importantly systems are not automated. There are also issues with farmers own data often being of poor quality, which requires significant review.".*

Manual systems and the cost of consultants to 'play catch up' is a massive challenge for a lot of managers, for example, many don't have the support of a corporate behind them for their data analysis. This process of outsourcing revels some permission and privacy issues, which can be very hard to navigate if you do not know what you are doing.

This is a continuous theme through the project as data moves between users and software and back again. This is explored in an AI context in 7.4.6 but is an ongoing issue in the industry as a whole.

## Q5. How important is having to standardise KPI metrics when benchmarking your farms?

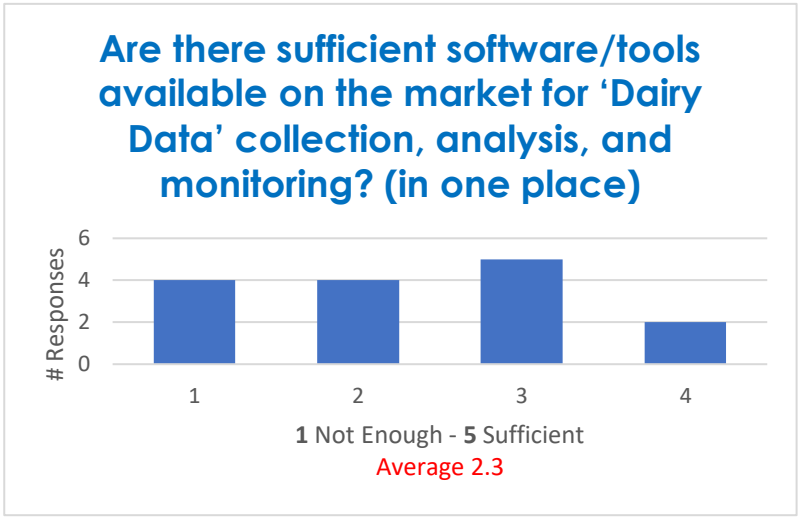
Participants were asked how important standardised KPI metrics is when benchmarking farms, the result revealed that this extremely important with significant confidence.




This reinforces the lit review 7.2.2/3 reemphasising the primary objective of KPIs, which is to convey results concisely, enabling management to make well-informed strategic decisions. This is why standardised metrics is so crucial to ensure that benchmarking adds the most value possible to businesses and they all have their part to play in collecting, storing, cleaning, and producing data.

## Q6. Do you feel like there is sufficient software/tools available on the market for 'Dairy Data' collection, analysis, and monitoring? (in one place)

This question was gauging how industry feel for having sufficient software and tools available for data collection analysis and monitoring as part of the benchmarking process.




Results showed a range of satisfaction which reflects probably the mix of competence and systems in which participants are using in their operations, however there was an average of 2.3 inferring there are not sufficient tools on the market for the average stakeholder in the dairy industry.

7.2 of Literature Review explores available technologies in the industry looking at both farm system automation and some data capture.

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*It is clear from the survey results, currently available software technologies in the NZ Dairy Industry may not be providing users the service they require.*

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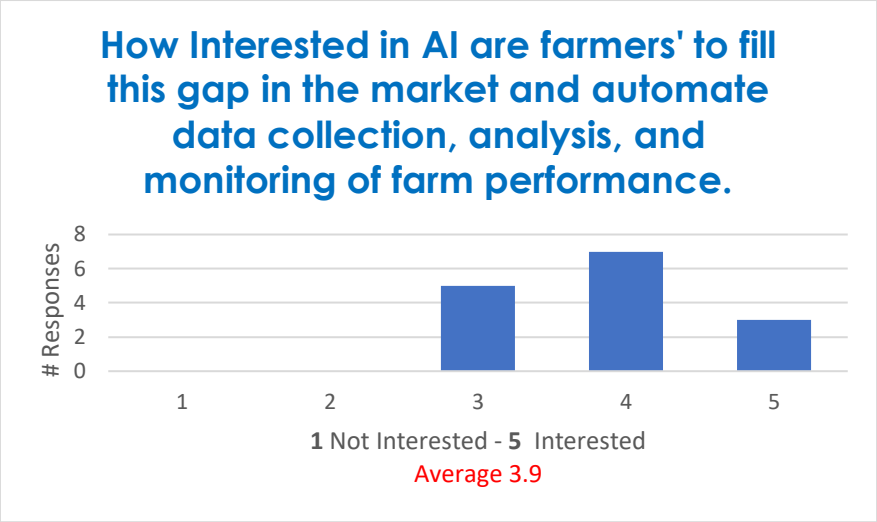
## Q7. If Artificial intelligence were to fill this gap in the market and automate data collection, analysis, and monitoring of farm performance. How interested in this concept would you be?

This question delved into responses of participants regarding interest in the potential of AI to support data management, monitor farm performance and benchmarking.




The findings, with an average rating of 3.9, revealed a robust interest among both farmers and industry experts in looking to innovative AI-driven solution. This reinforces the conclusions drawn from the literature review. The review highlighted that researchers had previously determined AI's potential to substantially improve the efficiency and productivity of food production systems.

The amalgamation of these findings presents a crucial point: should the industry wish to adopt such technology there exists a considerable opportunity for such advancements. This underscores the importance of further exploration and implementation of AI in agricultural practices, signifying a potential pathway for significant enhancements in the industry's operational efficiency and productivity.

### 5.4 Optimising Decision-Making Through Advanced Data Analytics

The emergence of advanced AI data analytics has signalled a new era in decision-making across various industries. This theme shows areas outlined below in which the industry must focus on to optimise decision-making through the lens of advanced data analytics, to ultimately support benchmarking through providing insights and trends that illuminate the transformative potential of leveraging data in strategic decision processes.

## Q8. If interested: How would this revolutionise/transform your business performance/management?

*"If you could get real time tracking and data analysis which you can make 'in the moment' decisions to improve productivity then you suddenly change the game. A lot of data collection is in the past. And while you can learn from mistakes, you can't solve a problem that has already happened."*

Real time monitoring is something the agriculture industry has also struggled with as is so hard to navigate working with biological production (animals) all data results are past tense. An important note when implementing AI – ensure timeliness.

*"I think it would change the role of a manager. Less time and focus spend on amalgamating and interpreting data from different platforms, more focus on and room for positively using the data and critical thinking. Possibly would even reduce the talent required on farm, allowing a more satellite management style provided the data inputs are accurate. This would potentially allow for speedier uptake of technology as better use can be made from data points and ROI could be maximised."*

Role transformation and automation is the way all industries who are adopting AI are moving. The success stories in the Literature Review 7.5 supports this. New Zealand has a negative connotation around job security with AI disruption, but for the dairy industry where imported labour is currently the only solution it urgently needs to be exploring alternatives. This technology has a substantial ability to transform labour efficiency.

*"Difficulty of storing data across different platforms has always been a challenge so potential opportunity for AI to collect this from different areas? It would certainly transform processes if it was able to report to the relevant authorities/third parties needing information."*

In findings/discussion below the report will outline a theory of data warehouse / data lake maybe live in the cloud. This is acknowledged as a crucial factor of implementing a potential AI solution.

*"You would have to change the attitude of most farmers. If possible, then yes production would increase in terms of profitability. Risk is that AI gets it wrong all farms using it go down."*

A very relevant response, this project does not have scope to evaluate risk of AI solutions and whether there are excessive amounts of risks associated with AI, but the limitations have been explored in the Literature Review: refer to 7.3.6.

The survey responses revealed lots of areas that advanced AI data analytics would revolutionise businesses. Real-time monitoring, role transformation, streamlined data sharing, predictive analysis were prominently highlighted. Embracing these insights could transform decision-making by enabling proactive, data-driven actions while necessitating a balanced approach to manage the risks associated with AI adoption. This reinforces the critical need for industries to harness AI's potential for optimised decision-making while navigating and mitigating the accompanying challenges.

## 5.5 Ethical and Effective Information Management

The fifth theme, ethical and effective information management, brought to light from the responses, helps explore the intricate interplay between responsible data practices and operational effectiveness.

### Q9. If any, what concerns would you have as a stakeholder having AI manage your KPI - dairy data?

*"Data integrity. Ultimately any software-based tool relies on the information that goes in."*

This is fundamental sub theme that has become apparent throughout the whole document as data integrity is arguably the most important part of data management.

*"Initially, AI not truly understanding the data. Data security and confidentiality. It would take time to build trust on an individual and industry level."*

7.3.6 in the Literature Review looks into AI limitations.

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*Businesses must manage and understand impacts and risk, with an emphasis on cyber security and safe data.*

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*"Covering the what if's and because of's when reporting leading to not fully understanding the position of a farm and making decisions without fully knowing the background to the calculations. Missing the gold of*

*working through the KPI's and the conversations had to gain knowledge."*

The integration of an AI driven benchmarking in the dairy industry would require an extensive education piece but as we learned from the research the implementation phase is critical adoption. Arguably the AI driven benchmarking would provider users to have more accurate and standardised KPI's to add more value to those "gold conversations".

*"Farmers will have concerns with data integrity/confidentiality".*

*"Often, specific less commonly used KPI's may be relevant to a specific business, this would need to be available through an AI system."*

The possibilities to which the extent of an AI driven data management system are completely up to the user. From the scope of this project using standardised metrics for benchmarking but that's not to say unique KPI performance monitoring is not possible with this system.

## 5.6 Organisational Resilience and Progress.

An automated AI 'Dairy Data' management system promises to streamline benchmarking process and decision-making. Ultimately though to future proof the New Zealand Dairy Industry and support more resilient businesses that can compete sustainably on a world scale. With reduced reliance on individual, adaptability, data consistency, future proofing, simplification, and evolution. These are all ideas from participants responses in identifying areas for improvement in their eyes, fostering long-term profitable resilient businesses.

### Q10. If you had an automated AI 'Dairy Data' management system, that was continuously standardising KPI metrics across every aspect of your business, to support benchmarking, reporting, and operational management, how would this build resilience in your business?

*"It would reduce reliance on key people or accurate people. Potential for focus on strategy or opportunities to take place instead. It would still need to be simple and clean, focusing on the key factors at play versus trying to serve and complete every focus point. Less is more and channelling focus is crucial."*

This reinforces the idea of transformation opportunity in the labour market. To eliminate key person risk in benchmarking is essentially ensuring accurate data is represented year on year to expose trends. Simplification is also an extremely important point to make a potential system as ergonomic as possible.

*"Timeliness of information and having triggers based on pre-set information would enable businesses, particularly multi farm businesses, to know where to direct their attention. However, this AI based information will help, people are still required for planning and execution of any strategy. It could also help to rationalise some management costs which would make a business more financially resilient. "*

Again, timely information and trigger-based AI alerts are crucial for dynamic farming businesses, guiding attention efficiently. While AI aids decision-making, human involvement remains vital for strategy and execution, offering potential cost rationalisation and resilience.

*"It would clearly and concisely identify areas for improvement or focus across any business to ensure long term profitability, productivity and environmental performance."*

This is the ultimate goal of the project and is encouraging to see this emerge as a survey response from a potential stakeholder.

*" Having access to more and centric data with less time invested leads to more frequent, and better-informed*

*decisions with less time creating and collating data. Identifying inefficiencies and areas of opportunity enables an information/critical mind to build a more robust system. Being able to query historic scenarios would be a great addition."*

This analysis, drawing insights from dairy farm managers and industry experts in New Zealand, explored their perception on the possible role of AI in enhancing data integrity and simplifying benchmarking with standardised KPIs to support the decision-making processes within the dairy industry.

Emphasising that the industry must focus on collaboration, data standardisation, challenges in operational efficiency, optimising decision making, ethical data practices, and business resilience.

## The discussions underscored through the thematical process:

An opportunity for AI in building robust and efficient dairy data management systems, with standardised KPI's to support benchmarking paving the way for enhanced industry practices and sustainable progress.

# 6. Findings and Discussion

In summary, the research project juggled the importance of benchmarking standardised KPI's in the dairy industry and investigating how AI empowers businesses to adapt to change, mitigate risks, and build resilience.

Nevertheless, it is essential to explain that an AI dairy data management system has the potential to not only support a benchmarking process but can leverage data-driven insights, automation, and predictive capabilities across various operational aspects. However, the scope for the report is to propose the use of benchmarking as an environment to analyse such a solution as it is perceived as an area where AI could add the most value currently.

Through the process of the thematical analysis, across the key sub questions discussed in the paper, including benchmarking and available technology in the dairy industry, the definition of AI and opportunities applications, with successful case studies and its role in building a more resilient dairy industry were addressed.

The themes uncovered through the process, stand as a framework for the industry to consider when implementing an AI system in a benchmarking scenario. That said, the sub themes provide a more granular and comprehensive view of the complexities of benchmarking and most importantly areas of consideration necessary for successful implementation of an AI system.

## 6.1 An Innovative Approach: Contextual Case Study

The importance of a streamlined benchmarking process is essential for the New Zealand's Dairy Industry, as illustrated throughout the report. A range of challenges that stakeholders face in the process, especially in terms of standardising KPIs were investigated. The vast amount of variability in metrics and methods currently used is believed to hinder effective benchmarking and best practice decision-making on farm, as a result.

Through the concepts presented, the point to emphasise – is the importance of standardising KPIs for benchmarking purposes. Standardisation enables consistent measurement, comparison, and evaluation across different dairy operations, fostering a more comprehensive understanding of industry performance. Introducing the idea that AI can play a pivotal role in addressing the challenges of standardising KPIs.

*The following diagrams, Figure 9 and Figure 10, illustrate how AI technologies, can streamline the benchmarking process through advanced analytics and machine learning to enhance the process of defining, collecting, and analysing standardised KPIs.*

**Current Data Flow** an interpretation of how data flows from on farm data capture cources to the user's end decision-making process. Data is collected from any source on farm which is uploaded via the ETL process, to a system or software that is connected or driven by the internet, this manipulates or visualises data to present to the user, for them to analyse. Furthermore, farm consultant, neighbour, owner, industry expert or anyone that is providing information, or advice, for a user to make a well-informed decision. This is an outdated process in which is over reliant on the decision maker's intellect, skills, ability and bias to make the best decisions for the farm system based on how they interpret data from farm.

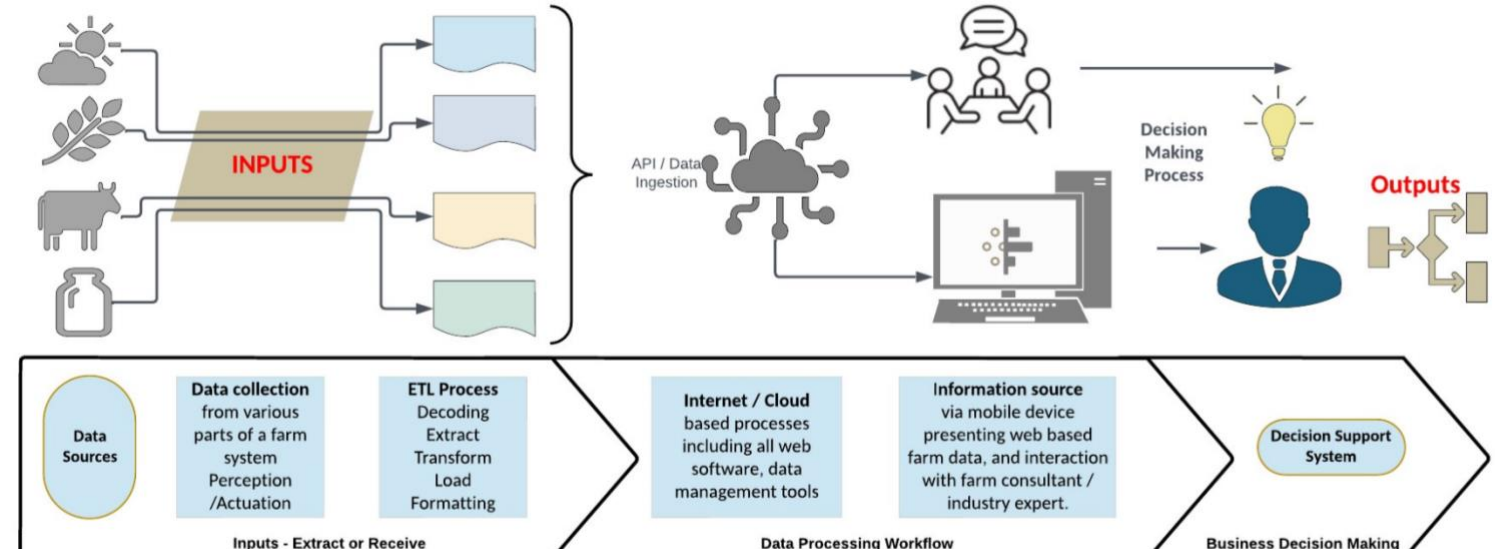



*Figure 9: Current Data Flow Process, Joe Ward 2023*

**Future Data Flow Process** an interpretation of how data might be able to flow with a potential AI data management solution. Data will still be captured on farm conventionally, but post ETL process, data will go through a gating process with minimum quality standards. It will be uploaded to a server in the cloud and stored in a data warehouse where it will be continuously maintained, tidied and sorted by AI. The artificial intelligence will continuously provide the user

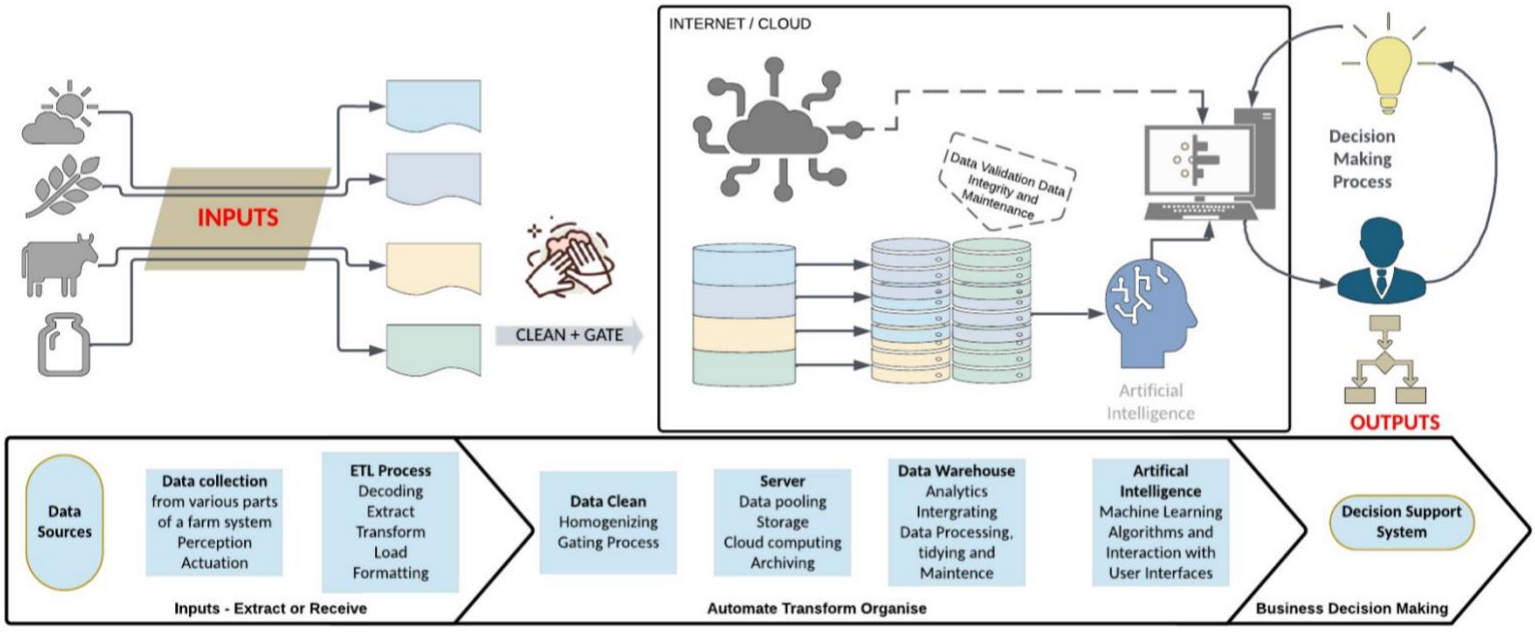



*Figure 10: Future Possible Data Flow Process, Joe Ward 2023*

with advanced analytics required via the users interface. This new process providers better quality data that is organised and simple to understand. Along with forecasting and analysis soft ware farmers wont nesseciary need to rely on experience or 'tech savviness' to extract the most value from data captured on farm.

## 6.2 Possibility of Standardising KPI's by using a Radar Chart

This is a concept of a tool where AI can facilitate automated data collection through the future state process. It could integrate with any data source from farm systems, processing plants, and supply chain logistics. AI algorithms can then process this diverse data to generate standardised KPIs as set by industry standards (similar to accounting standards, by which everyone must abide). The Radar Chart proposed could be represented live and is accessible for any application.

Dynamic KPI Adjustments: The AI in this radar chart would be adapt and adjust KPIs based on industry trends, evolving best practices, and changing regulatory requirements. This ensures that the standardised benchmarks remain relevant and reflective of the current state of the dairy industry.

Enhanced Decision Support: With an automated AI benchmarking tool would provide a more solid foundation for decision-making. Businesses can compare their performance against industry norms, identify areas for improvement, and make informed decisions to enhance overall efficiency and resilience.

Future Directions: The potential benefits of standardising KPI benchmarking with AI would future proof the industry by overcoming challenges illustrated throughout the report. This approach not only addresses current challenges but also sets the stage for ongoing improvements and innovation within NZ's Dairy Industry.

The topic of standardising dairy KPIs for benchmarking is one of the initial inspirations which led to a Kellogg research project – the chance to do a deep dive into the subject and learn why and how this is so crucial for the industry moving forward. Dairy is a unique industry, in which the farm systems are replicated across many different properties in the country, simply put, all with one thing in common; they produce milk. Farm management teams have access to a range of data that is captured every day on farm. Yet, for some various reasons, still struggle to compare 'apples with apple's across dairy businesses. One challenge is the shear amount of capital required to get "skin in the game" in a dairy farm and as direct result, a vast range of equity arrangements exist, from corporate, to mum and dad entities, as well as contracts, share milkers, 50/50 milkers and everything in between. Therefore, it is merely impossible to accurately line up financial reporting standards in a benchmarking setting without some form of manipulation from someone's bias that they deem 'the correct way'.

Accountability and consistency of reporting is currently a roadblock in the benchmarking process, which as stemmed from decades of farms being solely farm focused.

There is a real change in perception of a dairy farm in today's world and our social license to farm is more important than ever. High performing dairy farms need to be doing more than the conventional high production with a good cashflow.

In today's climate businesses need to be doing better in more areas than just being profit focused.

The radar chart, in Figure 11, equally weights eight pillars of a modern dairy farm. This concept reflects a model in which, to score the farm well overall, you need to be achieving

high KPI's across people, production, financial, GHG emissions, water, biodiversity, animal welfare and the environment. As we can see on the graph "Farm X" has scored 52/80 overall. Achieved through scoring the below across standardised KPI's in the pillars below

- 7 Financial
- 10 Animal Welfare
- 7 GHG Emissions
- 1 People
- 8 Water
- 7 Environmental
- 4 Biodiversity
- 8 Production

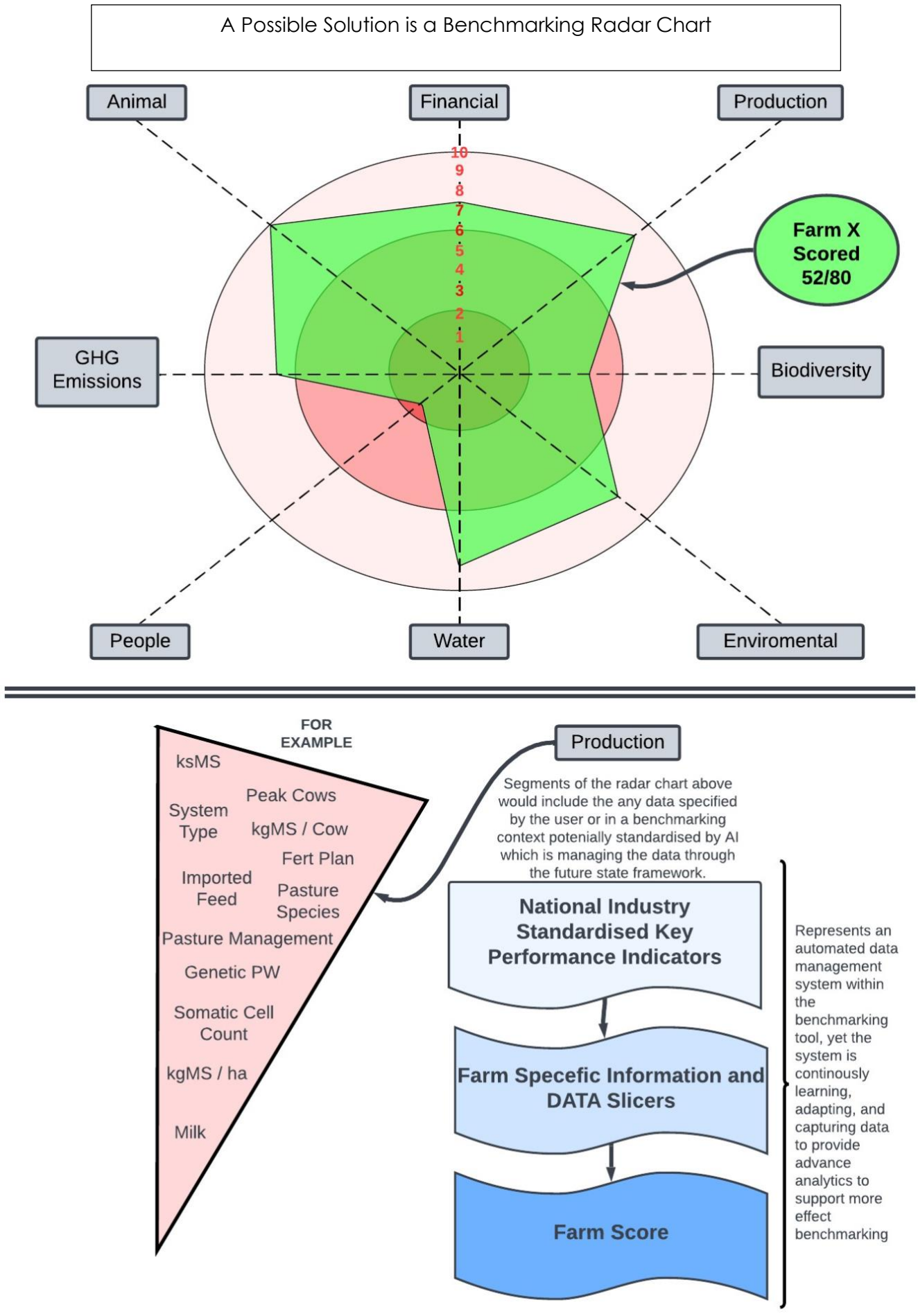
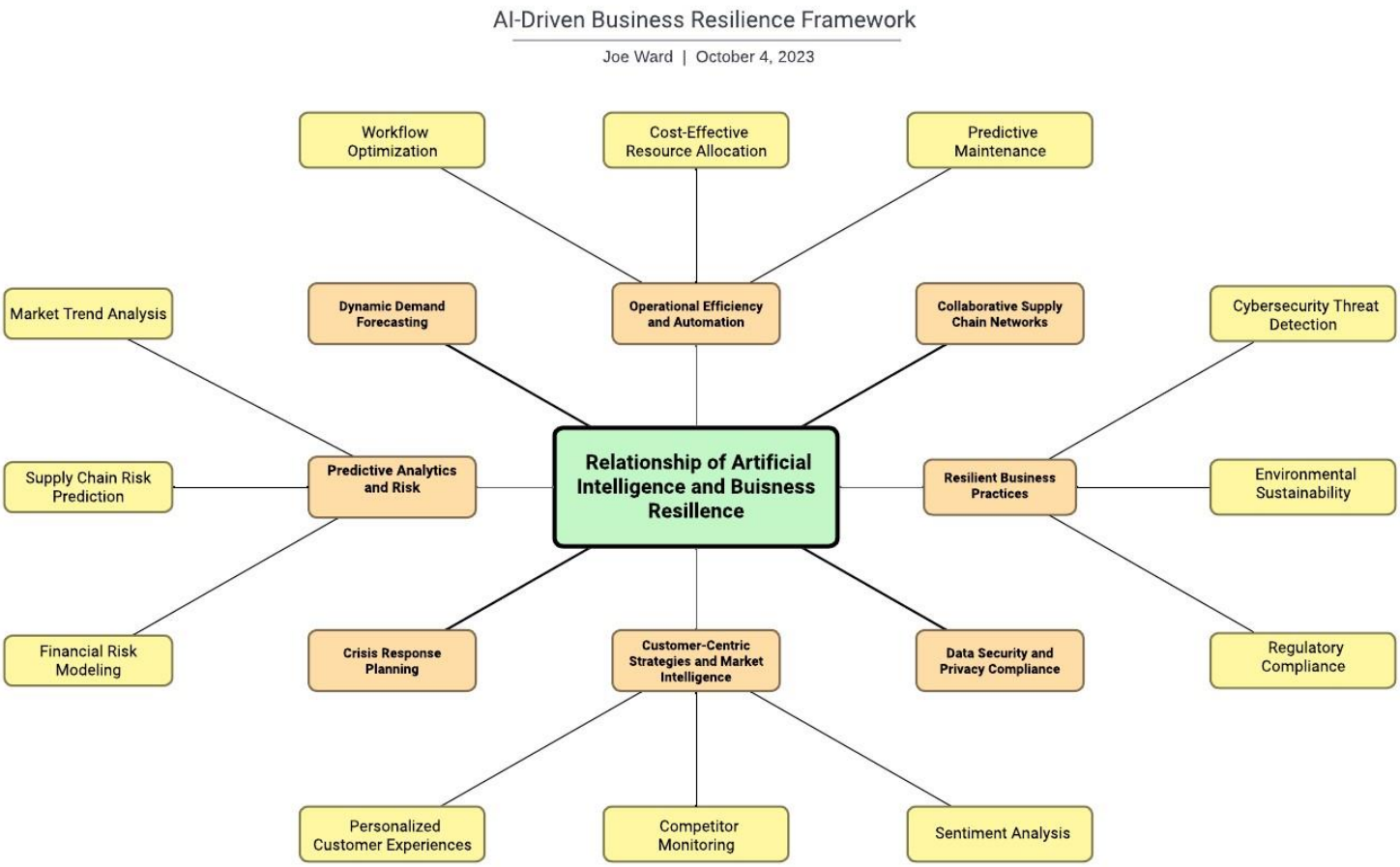



*Figure 11: Benchmarking Radar Chart (Joe Ward 2023)*

This is a concept the industry should adopt whereby a set of industry standard KPI's are set and held in each pillar, and a potential future state AI managed model would ensure that the data feeding KPI's is material, measurable, verifiable, credible, consistent, timely, ambitious, and adaptable – a solution to challenge users having the current benchmarking process.

## 6.3 AI Resilience Framework

The below The framework shows an example where AI is currently supporting businesses in a range of different industries to highlight the capabilities of the technology to help us explore potential use cases in the dairy industry.




(Joe Ward 2023)

## 6.4 "VUCA" Resilience Analysis

The VUCA resilience framework is designed to address the challenges posed by a volatile, uncertain, complex, and ambiguous business environment. It involves cultivating skills and strategies for Volatility by staying adaptable, embracing Uncertainty through scenario planning, navigating Complexity by fostering collaboration and learning, and addressing Ambiguity by promoting clarity in decision-making. This framework enables organisations to build resilience and thrive in unpredictable and rapidly changing conditions (Taskan, Junça-Silva, & Caetano, 2022).

### Volatility:

Identifying Rapid Changes: The dairy industry is experiencing significant external pressures from:

- Market Price Volatility
- Climate and Environmental Factors
- Trade and Geopolitical Risks
- Continuous technological advancements and innovation
- Consumer behaviour and preferences
-

These forces are changing benchmarking from focusing solely on production and financial KPI's towards a more holistic view, including areas such as environmental sustainability, animal welfare, people and social impact to ensure resilience in perpetuity.

### Uncertainty

Challenges in Standardising KPIs: in relation to uncertainty requires a flexible and adaptable approach that considers potential changes and risks.

- Regulatory Changes
- Compliance and Consenting Requirements
- Data Variability
- Industry Standards
- Reporting Bias and Manipulation

Despite the abundance of data, there's uncertainty in comparing different dairy farms due to the absence of standardised KPIs. A robust benchmarking tool like the radar chart will provide a resilient solution that would not be impacted by the uncertainty in the industry.

### Complexity:

Addressing complexities in the New Zealand Dairy industry requires a nuanced approach that considers the interdependencies among various factors such as

- Diverse Farming Systems
- Interconnected Stakeholders
- Environmental and Production Interdependencies
- Technology Integration
- Equity Structures

The AI automated benchmarking process will require a implementation strategy that acknowledges the diversity in the industry to ensure that a solution will support more resilient businesses.

## **A**mbiguity:

In the New Zealand Dairy Industry, ambiguity arises from several factors that introduce uncertainties and subjective interpretation, leading to potential risks:

- Subjectivity in Data Interpretation
- Differing Reporting Standards
- Lack of Clear Industry Standards
- Challenges and Defining Best Practices
- Interpretation of Holistic Performance

There's ambiguity and subjectivity in current reporting standards due to the absence of standardised benchmarks. This subjectivity could lead to bias and manipulation in portraying 'correct' reporting hence the need of a robust framework as set out above to ensure resilience.

The dairy industry consists of numerous farm systems with the common goal of milk production, but the complexity lies in their diversity and replication across different properties. Which lead me to establishing Interconnected Pillars of Dairy Farming: Through the radar chart, with its eight pillars for assessing a modern dairy farm, represents the complexity of integrating various aspects like people, production, finance, sustainability, and animal welfare into a single evaluation model.

Through applying VUCA analysis to this model by acknowledging and accommodating the dynamic, uncertain, complex, and ambiguous nature of the dairy industry to create a robust and adaptable benchmarking framework that will ultimately support and more resilient industry.

# 7. Conclusion

The purpose of this research was to illustrate the crucial role of benchmarking standardised KPIs in the dairy industry and highlight the opportunity of an AI driven data management tool that would support decision making (in a benchmarking context). The impact of AI technology in building more resilient businesses whilst enhancing performance. Investigating existing literature on the importance of benchmarking with a balanced scored card, along with technology that's currently available in the dairy industry set a foundation to analyse findings against real-world perspectives from the survey of stakeholders. Matched with exploring the fundamentals of an AI driven solution to data management drew out 6 key themes.

These themes stand as essential points to scrutinise for the potential adoption of an AI-driven dairy data management system that unveils essential pathways for industry benchmarking advancement, and standardisation of KPI's.

The integration of AI into benchmarking practices presents an opportunity for a complete transformation to industry advancements and collaboration within the dairy industry, thereby aligning businesses to a greater good as a collective with more resilient farms continuously improving and adapting.

There is a range of challenges identified in current benchmarking efficiency and reporting standards in the dairy industry. Which can be effectively addressed through the integration of AI-driven systems, supporting the recommendation to focus on a standardised benchmarking framework. Achieving best practice data management, enhanced decision-making and hopefully lifting engagement throughout the industry.

AI's advanced data analytics capabilities are pivotal for informed, data-driven decisions, aligning with the emphasis on improved decision-making through meticulous AI integration. However, AI must align with ethical principles, ensuring transparent and responsible handling of sensitive data. This echoes the necessity for the dairy industry to focus on developing a standardised framework for benchmarking, promoting ethical and effective information management.

The successful adoption of AI-driven systems in this context is yet to be seen. Adopters of such technology will benefit the most as avenues for system adaptability and efficiency enable them to navigate dynamic changes, thereby fostering progress and viability. Ultimately turning a good farm into a great farm.

The alternative to investing in automation, is to continue to be reliant on manual labour which has a lot of external risks. That said, the barrier to this standardise benchmarking framework and AI-driven technology will be industry adoption; it cannot be government led as previous initiatives have proven these are not successfully adopted as industry advocates might have hoped.

The aim of this research is to pave the way for a redefinition of benchmarking, transforming it into an easily comprehensible, automated process with the potential to use AI insights and drive industry-wide advancements and have a positive impact on farm performance and future resilience of NZ's Dairy Industry.

# 8. Recommendations and next steps

The recommendations for the New Zealand Dairy Industry are three fold:

1. **The New Zealand Dairy Industry should Develop a Standardised Framework for Benchmarking Best Practices**

Given the importance of benchmarking for the dairy industry's advancement illustrated throughout this project, there is a clear need for a standardised KPI framework for benchmarking best practices. Industry-wide collaboration is essential for the proposed standardised benchmarking framework. This would involve creating a common ground for data collection, analysis, and reporting (Incorporating AI technology in the development). The solution should address the concerns regarding varied data sources, different KPIs, and the lack of sufficient tools available for data collection and analysis. This framework should focus on simplicity, consistency, and user-friendly interfaces to encourage wider adoption.

2. **Dairy Farm Stakeholders (owners, managers, advisors) need to Focus on Meticulous due diligence in the Implementation of Artificial Intelligence as a Dairy Data Management Tool**

AI offers a significant opportunity to transform data management and advance analytics in the New Zealand Dairy Industry. In the scope of this project, context of an AI solution focused on benchmarking best practices and supporting users decision-making processes. Given the complexities and challenges outlined regarding benchmarking, data collection, and analysis, introducing AI technologies can streamline and enhance these practices. However, the industry needs to undertake thorough due diligence of implementation, ensuring fit-for-purpose tailored and Flexible AI Systems are adopted with ethical AI Solutions, ensuring a robust, adaptable system and the risks to data integrity and confidentiality.

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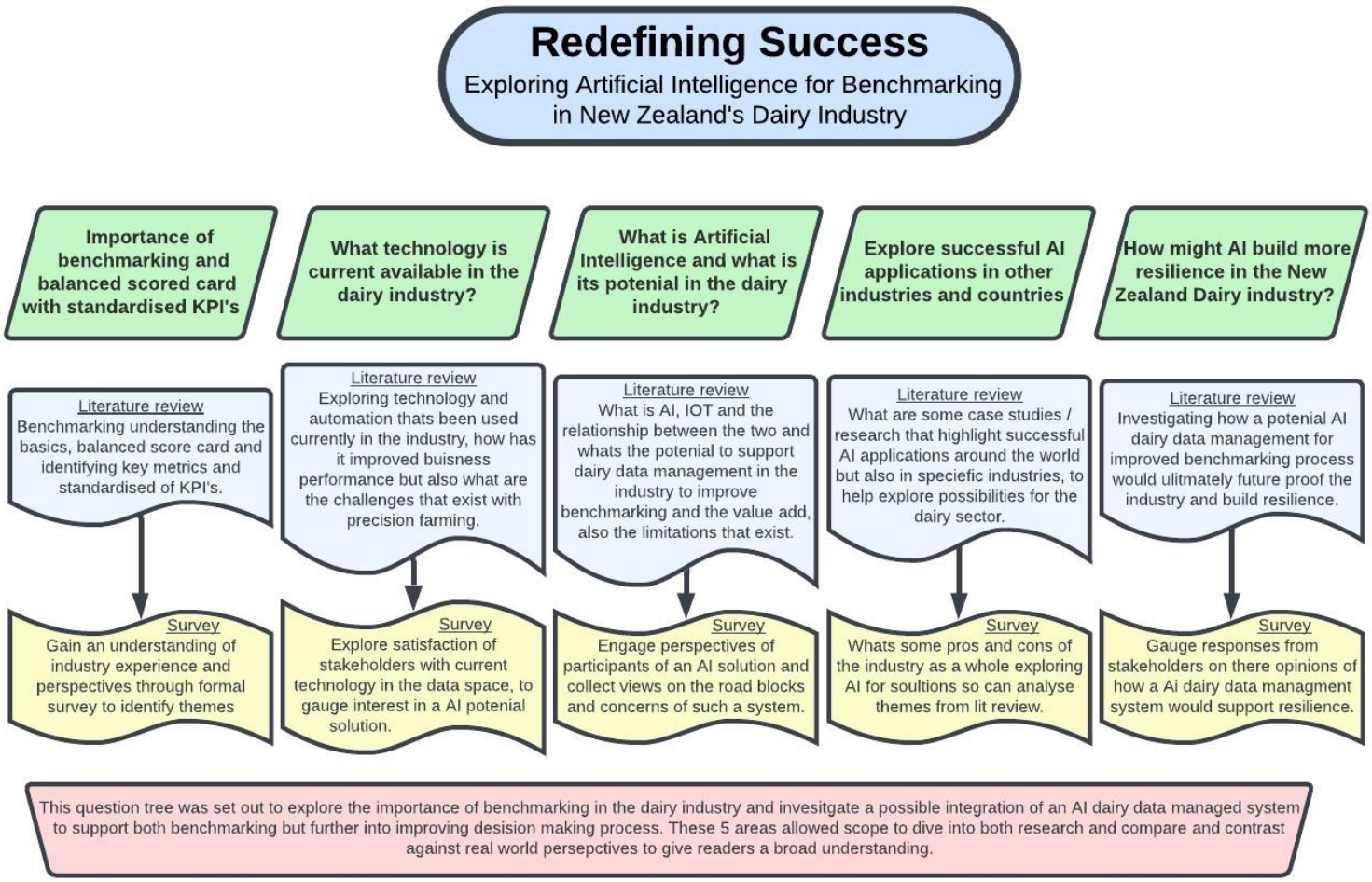
# 10. Appendices

## 10.1 Appendix One - Question Tree



## 10.2 Appendix Two - Survey Questions for stakeholders

Definitions

**'AI': Artificial Intelligence (AI)** refers to the development of computer systems that can perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and understanding natural language. AI aims to create machines or software that can emulate cognitive functions, enabling them to adapt and improve performance over time.

**'Dairy Data'**: refers to all data points on farm and traditional metrics across production, financial, people, emissions, water, animal health, etc

| Dairy Farm Managers | Dairy industry experts and stakeholders |
|---|---|
| 1. How and why is KPI performance benchmarking important for the dairy industry? | 1.How and why is KPI performance benchmarking important for the dairy industry? |
| 2. *Regardless of equity structure (corporate / owner operator / contract milker/share milker etc) and assuming no support from consultant/office or admin staff.*<br><br>As a Farm manager, how easily would you be able to prepare and manage 'Dairy Data' and KPIs of your business? *(1 Challenging - 5 Easy)* | 2.Currently how easy do you think the process of KPI benchmarking of dairy farms is, including all 'Dairy Data'? *(1 Challenging - 5 Easy)* |
| 3. What are the challenges of managing this 'Dairy Data' and performance KPI's ? | 3. What are the challenges of managing this 'Dairy Data' and performance KPI's? |
| 4. Why is data collection process challenging? | 4.Why is data collection process challenging? |
| 5. How important is having to standardise KPI metrics when benchmarking your farms? *(1 Not important - 5 Important)* | 5.How important is having standardised KPI metrics when benchmarking farms in the New Zealand Dairy Industry ? *(1 Not important - 5 Important)* |
| 6. Do you feel like there is sufficient software/tools available on the market for 'Dairy Data' collection, analysis, and monitoring? (in one place) *(1 Not enough - 5 Enough)* | 6.Do you feel like there is sufficient software/tools available on the market for both farmers and admin/consultants to collect/manage/analyse all 'Dairy Data'? (in one place) *(1 Not enough - 5 Enough)* |
| 7. If Artificial intelligence were to fill this gap in the market and automate data collection, analysis, and monitoring of farm performance.<br><br>How interested in this concept would you be? *(1 Not Interested - 5 Interested)* | 7.If Artificial intelligence were to fill this gap in the market and automate 'Dairy Data' collection, analysis, and monitoring of farm performance.<br><br>How interested in this concept would you be? *(1 Not Interested - 5 Interested)* |
| 8. If interested: How would this revolutionize/transform your business performance / management? | 8.If interested: How would this revolutionize/transform the industry in terms of business performance / management? |
| 9. If any, What concerns would you have as a stakeholder having AI manage your KPI - dairy data? | 9.If any, What concerns would you have as a stakeholder having AI manage your KPI - 'Dairy Data'? |
| *10. If you had an automated AI 'Dairy Data' management system, that was continuously standardising KPI metrics across every aspect of your business, to support benchmarking, reporting, and operational management.*<br><br>How would this build resilience for your business? | *10.If you had an automated AI 'Dairy Data' management system, that was continuously standardising KPI metrics across every aspect of dairy farms, to support benchmarking, reporting, and operational management.*<br><br>How would this build resilience for your interests / business? |