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Overcoming Barriers to Data Interoperability within New Zealand's Wine Industry

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Zac Howell

I wish to thank the Kellogg Programme Investing Partners
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Executive Summary

New Zealand (NZ) wine is a premium, export-led success story, within the food and fibre sector, with exports totalling ~$2.4b in 2024 (New Zealand Winegrowers, 2024). Yet, despite steady historic growth, today's operating environment is tougher than ever; wine-buyers are increasingly cost-conscious, inventory cycles are more volatile, and producers face rising input and compliance costs. To remain competitive in the global marketplace, the industry must look to drive greater efficiency across all operations, while leveraging market insights to meet price-quality expectations.

The future success of the industry will be underpinned by data and insights that enable sharper, faster decision-making. While NZ wine has been inherently innovative and collaborative throughout its history, and the tools to collect, store, and analyse data are widely adopted, data interoperability remains a critical gap. Moving high-value data securely and reliably across vendors and organisations is still difficult, mirroring a broader agri-tech challenge (Dyckhoff, 2020; Loder, 2023; Skinner, 2023).

This study draws on two main sources of evidence; a targeted review of international and New Zealand literature on data interoperability in agri-tech and the wine sector, and semi-structured interviews with stakeholders across the New Zealand wine value chain, and broader agri-tech sector, with thematic analysis to link key ideas. Importantly, the findings from this report indicate that the limiting factors are not inherently technical in nature. APIs, cloud platforms, and open specifications are all viable solutions to the technical challenges posed by data interoperability, in theory. The real barriers lie in governance, trust, and commercial alignment (Douma, 2023; Dyckhoff, 2020; Noura et al., 2018). Encouragingly, few seem to oppose interoperability in principle, though the challenge remains making it work in practice.

This report sets out practical recommendations to bridge software vendors and software users, enabling connected data that improves traceability, strengthens market-access claims, and lays a sound foundation for emerging tools. AI can deliver advanced analytics when data is clean, portable, and well-governed; blockchain can anchor integrity and auditability across organisational boundaries but does not solve data quality, semantics, or ownership; those remain governance challenges. Accordingly, blockchain is an optional enabler to consider only after interoperable identifiers and profiles are established (Bellavista et al., 2021; de Lange et al., 2025).

The recommendations of this report aim to focus less on inventing new technical solutions, and more on aligning incentives, rules, and capability to make the existing technology work at scale, with three key action points:

1. **Intentional, pragmatic, iterative standardisation:** Start small with minimum-viable interoperability and reuse what already exists; harden profiles collaboratively.
2. **Review data-ownership and incentive models:** Clarify rights over raw vs derived data; make portability the default; align pricing and value flows.
3. **Build sector digital capability:** Role-based training, named data stewards, and simple how-to patterns that lift everyday practice.

Together, these actions prioritise governance, incentives, and capability, rather than new technical standards to unlock safe, reliable data flow that improves efficiency, de-risks compliance, and strengthens market access, and through the enablement and use of interoperable data, serves to support continued industry growth and prosperity.

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1.0 Introduction

Behind every bottle of New Zealand wine sits a complex web of decisions, which taken together, have shaped the scale, marketability and success of the NZ wine sector. However, despite the industry's global success, its data remains siloed and underutilized, and the sector is too often finding itself "rich in data, but poor in insights", limiting the opportunity to leverage data capture efforts into effective decision-making. For context, NZ wine is a $2.4 billion industry spanning over 42,500 hectares of vineyard area and exporting to over 100 countries (New Zealand Winegrowers, 2024). In an increasingly dynamic operating environment, leveraging real-time data capture, and historical insights into data-driven decisions is essential for promoting operational efficiency, and with customer-driven compliance on the rise, may be pivotal for market access, two critical areas where today's data remains highly fragmented.

Interestingly, the challenges are not unique to the wine industry. Across much of the agri-tech sector, the ability to connect data across otherwise disparate systems is missing, with persistent and highly interdependent barrier to data interoperability limiting progress (Douma, 2023; Dyckhoff, 2020). Technically speaking, the challenges driving limitations to data sharing are perpetuated where data lives in heterogeneous formats across proprietary platforms; to complicate things further, these non-standard identifiers can shift with vineyard blocks being split, merge, or being renamed (Skinner, 2023), causing issues as the practical implications of these changes to master data plays through downstream systems. Where standards do exist, they are often not adopted by consensus, which leads to uneven implementation, and low proliferation, which in turn limits the value of adoption (Dyckhoff, 2020; Iftikhar & Pedersen, 2010). Economically, refactoring legacy systems or building durable integrations rarely stacks up under current commercial models, especially for vendors managing technical debt and thin margins (Skinner, 2023). Organisationally, fragmented responsibilities and capability gaps slow change (de Lange et al., 2025; Douma, 2023). And in governance, ambiguity about rights over raw versus derived data erodes trust, inviting contract-by-contract workarounds rather than shared solutions (Loder, 2023; Carbonell, 2016). These frictions feed each other, turning a solvable technical problem into a sector-wide coordination challenge. Interestingly, as a number of interviewees noted, "we don't actually have a technical problem, we have a people problem".

The true barriers to interoperability are more likely to be seated in the ambiguity of data ownership, governance, and trust. Moreover, with significant advances in technology, the wine sector risks finding itself lacking in the capability required to take advantage of emergent and transformative technologies, as the next wave of analytics and AI depends on consistent, portable, high-quality data. If done well, from a governance and trust perspective, data interoperability can be seen as an enabler to unlocking insights and trends which were previously buried in large datasets, all while reducing administrative overheads. If done poorly, it risks things such as "checkbox APIs" that satisfy policy on paper but deliver little in practice, or worse may serve to disincentivize participation from software vendors, limiting future innovation. The industry has an opportunity now to continue the conversation around data interoperability to enable streamlined sharing of data and insights, which promises to enable greater data-driven decision making, and is made even more promising by the emergence of data-driven technologies such as blockchain and AI (Bellavista et al., 2021; Marzougui et al., 2024).

This report takes the position that interoperability is not an abstract ideal, but a near-term enabler of productivity, compliance and sustainability reporting, and ultimately, global

competitiveness. What follows sets out a compelling case for constructive change, the barriers as they are described in the literature, and as they are experienced and observed from within the industry and the enablers most likely to shift the system. Ultimately, the aim is not to suggest or outline another abstract standard; but rather point to some potential enablers of Interoperability within the NZ wine sector, which is by all accounts, a "wicked problem" but not an impossible one to solve. As described by the literature, and semi-structured interviews; the challenges which are posed by interoperability under current frameworks centre on the three classes (1) technical barriers (e.g., data heterogeneity, lack of common identifiers, legacy systems), (2) organisational and cultural resistance (e.g., capability gaps, adoption challenges, entrenched ways of working), (3) governance and data ownership (e.g., trust, stewardship, open data vs open standards), which are all heavily underpinned by economic and resource constraints (e.g., ROI, funding, commercial models).

The semi-vertically integrated nature of the NZ wine industry, which has a rich history of innovation and collaboration see the sector well-positioned to solve the barriers to data interoperability. In essence, what remains is aligning incentives, governance, and minimum-viable specifications to enable interoperability in a way that delivers tangible value to growers, wineries, technology providers, and sector bodies alike.

2.0 Aim

Considerable opportunity exists for the NZ wine sector if data interoperability can be achieved. Moreover, the insights this might unlock, through the enablement of freer data sharing, may become a precondition for protecting the long-term sustainability of the industry from and operational standpoint, and as an enabler for market access from a compliance and regulations perspective. For instance, this might include the ability of the sector to benchmark, understand and act on insights derived from vineyard and winery performance, seasonal quality risks and opportunities, environmental sustainability and compliance, and market data. By highlighting these opportunities, this project seeks to steer the conversation toward solving some of the longstanding issues relating to data interoperability in the wine-tech sector, with the intention of building greater interest towards unlocking insights and value for all stakeholders.

3.0 Literature Review

This literature review covers some of the recent work on data interoperability in the agri-tech sector, outlining key challenges, and establishing a platform for discussing how these barriers to interoperability might be overcome to unlock the transformative potential of connected data and insights.

3.1 Technical barriers to interoperability

Fragmentation and heterogeneity of datasets

At a fundamental level, technical barriers to data interoperability in agriculture might be seen to stem from fragmented systems and the heterogeneous nature of datasets therein. Drawing on Henriyadi (2021) and Zeng (2019), Douma (2023) identifies four key forms of data heterogeneity that limit interoperability, along with potential technical solutions (Table 1)

Table 1: Showcasing where data interoperability challenges may result as a consequence of heterogeneity of data, as well as potential solutions (Douma, 2023).

Data Interoperability Challenge	Definition of Challenge	Potential Solution
Heterogeneities of the Schema	Differences in the reference frameworks and data source	To overcome schema heterogeneities ontology matching can used to identify the semantic relation between two objects so they are connected
Granularity of Data	Is related to how the data is presented	Data granularity can be overcome through data integration or data warehousing
Mismatch entity naming and data unit	Differences in the naming or data unit for the same thing	Ontology mapping is a method used to overcome the mismatch with entity naming and data unit issues. An ontology map describes the data structure transformation process from one schema into a different schema by transposing the data
Inconsistency of Data	Data that comes from several external data sources provide a different value for the same thing	To overcome this challenge, the best external data source should be used.

In practice, Kharel et al. (2020) note that misalignment across datasets which is caused by heterogenous data makes integration difficult and leads to suboptimal insight generation, particularly where geospatial data is concerned. Skinner (2023) demonstrates how common specifications for the geospatial elements of row/block identifiers could reduce issues pertaining to data heterogeneity and subsequently allow growers to enter agrochemical data once and share it across platforms, which would then serve to reduce the chances of mistakes being made in data entry, and streamline process, reducing administrative overheads. Dyckhoff (2020) notes that the issue of heterogeneity in datasets is compounded by poor data practices, which can see farm information stored in notebooks or locked within proprietary systems that lack integration capabilities. In practice, this manifests as inconsistent naming conventions, duplicated records, and fragmented datasets (Loder, 2023; Skinner, 2023). Ultimately, undermining traceability across seasons and leading to data loss or underutilisation both of which serve as a cause and consequence of weak interoperability (Skinner, 2023). This goes to show that while technical fixes exist, standards alone are insufficient; broad, well-governed adoption and aligned incentives are needed to reduce bespoke integrations and realise value (Skinner, 2023; Dyckhoff, 2020).

Absence of widely adopted standards

A major contributor to data heterogeneity is the absence of widely adopted data standards. Data standards provide common vocabularies or data dictionaries which serve as the foundation for agricultural data interoperability (Dyckhoff, 2020). Interestingly, although detailed frameworks like the Collabriculture Vineyard Data Model (Figure 1) exist, promoting FAIR (Findable, Accessible, Interoperable, Reusable) vineyard data (Douma 2023; Loder, 2023;

Skinner,2023).

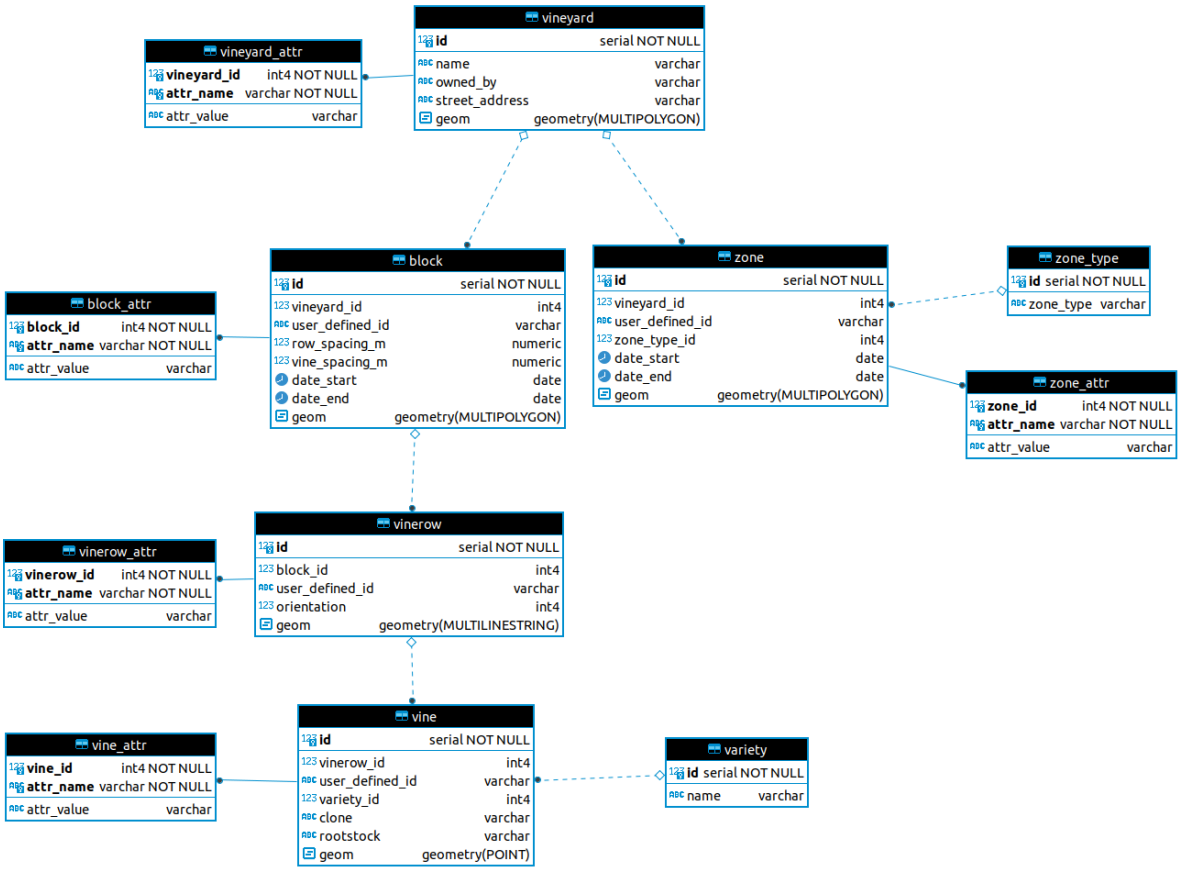

Figure 1: Showing Collabriculture Vineyard Data Model Schema (Collabriculture, 2021)

In practice, standards such as these often fail to proliferate to the point of delivering widespread value to stakeholders (Dyckhoff, 2020). Interestingly, across the broader agri-food sector, it is suggested that end-to-end interoperable traceability standards remain rare, with persistent gaps (Tagarakis et al., 2021), while Iftikhar and Pedersen (2010) point to frameworks such as ISOBUS, which standardises electronic communication between tractors and implements, and AgroXML, an XML-based system-to-system data exchange standard; which is in principle not unlike Collabriculture, as integration pathways for agri-data, while suggesting their high implementation and maintenance costs highlight the economic constraints that continue to limit widespread adoption despite technical feasibility. Dyckhoff (2020) goes on to suggest that the reason standards tend not to find adoption across industry, to sufficiently deliver commercial value, or widespread implementation may be down to a number of factors which lead to a perceived lack of cost–benefit for stakeholders; adopting standards often requires costly upgrades, such as system refactoring, and without broad industry alignment, there is little to be gained by adoption; in other words, vendors may be left wondering "what's in it for me?". Skinner (2023) supports this view, noting that commercial software models remain misaligned with open standards, where differentiation is sometimes rewarded, serving to discourage investment in interoperability, and further constraining adoption. Ultimately, while the solutions presented here (Table 1) are technically feasible, they do not address the root causes of data interoperability.

Economic and resource constraints

Economic pressures present a significant barrier to data interoperability in the NZ wine sector, in practical terms, integrating dispersed climate/IoT and operational data into decision support tools requires sustained investment in tooling and data engineering, which is often too difficult under thin margins and seasonal cashflows (Simeunović et al., 2025; Naigeon et al., 2023), and subsequently serves serves as to continue many of the technical barriers the sector faces. Naigeon et al. (2023) goes on to warn that winegrowers may fail to identify emerging risks or develop adaptive practices, potentially leading to escalating costs or even the long-term unsustainability of viticultural activities. Interestingly, even when businesses value data, lean teams and constrained budgets can mean integration is de-prioritised (Loder, 2023). Moreover, from an NZ wine industry standpoint, New Zealand Winegrowers (2024) further highlight how inflation, supply chain volatility, and rising compliance costs are eroding producers' capacity to invest in digital tools and infrastructure.

A practical example might be seen where Skinner (2023) finds that common specifications for row/block identification and spray-diary records are foundational enablers for compliance, biosecurity, and traceability. However, adoption has been slow because some stakeholders do not yet see the value and current commercial models for interoperability are misaligned issues, which are compounded by low digital adoption across the sector. Implementing interoperable frameworks also requires sustained investment in human and technical capacity, which is challenging in industries operating on tight margins and seasonal cashflows (Douma, 2023). Loder (2023) also notes that without custodians' data standards are unlikely to be maintained, and evolve overtime, and subsequently their value may become diminished, further constraining adoption.

Collectively, these challenges highlight that the persistence of data interoperability issues in agriculture is not inherently due to a lack of technical solutions, but rather the complexity of implementing them in real-world contexts. While Douma (2023) and others identify technically feasible pathways to address data heterogeneity, these are consistently undermined by inconsistent practices, limited standard adoption, and economic disincentives. Lefebvre et al, (2025) adds to this, confusion around regulations, misaligned incentives, lack of trust, and concerns around data quality, security and utilization of data, as well as the potential for unforeseen societal impacts, which may also prevent shifts towards technical solutions which would enable data sharing through improvements to data interoperability. In practice this might be reflected where we see the failed implementation of a number of technically feasible frameworks which also serves to showcase a broader misalignment between technical capability and commercial incentive within the agri-tech sector. Taken together, this starts to paint a picture which reflects the interdependency of barriers to interoperability, whereby they are as much organisational, political and economic as they are technically rooted.

3.2 Organisational and Cultural Resistance

Workplace culture and resistance to change

Organisational resistance to data interoperability often reflects workplace culture and habits aimed at protecting a perceived competitive edge. In New Zealand's primary sector, Dyckhoff (2020) frames progress in this space as a "trust & ownership" problem and observes that articulating change requires clear "what's in it for me?" benefits and structured change-management backed by sector leadership. This can extend across the value chain as well as along it; where horizontal data sharing frameworks ask firms to collaborate "even at times with

their competitors," which can serve to heighten concerns about ceding control over information due to concerns about how that information may be used (Lefebvre et al., 2025). Across agri-food value chains, de Lange, et al (2025) similarly point to technological *and* organisational barriers, such as perceived effort and trust, also pointing out that uneven readiness or infrastructure across organisations can act as key factors for shaping the conditions that compound cultural resistance to interoperable data sharing. In practice, Douma (2023) identifies organisational resistance as one of the most significant barriers to implementing interoperability, also noting that trust is essential to fostering cultural acceptance. This is corroborated by Dyckhoff (2020) who shares that trust also plays a critical role in addressing concerns that data sharing might erode autonomy, compromise competitive advantage, or be used against individuals or organisations.

Ownership and capability within the sector

Douma (2023) goes on to observe that uncertainty over who should lead interoperability efforts; whether software vendors, government, or industry bodies may also create inertia, as no party assumes clear responsibility. In the viticulture sector, Loder (2023) supports these findings, suggesting that hesitation around data sharing is often less about technical feasibility and more about unclear responsibility for funding and driving interoperable systems. In environments where data sharing is not culturally prioritised, this lack of initiative can stall progress and reinforce the status quo. Achieving sector-wide interoperability requires building capability at both farm and institutional levels, and a culture which is open to sharing information. Douma (2023) emphasises the need for coordinated investment in training, extension services, and collaborative initiatives to support adoption. Skinner (2023) highlights that low levels of digital literacy and inconsistent understanding of data governance across the wine value chain hinder the uptake of common identifiers and interoperable records. Additional studies point to broader concerns that reinforce cultural resistance.

3.3 Governance and Data Ownership

Evolution of Governance and trust

While greater data interoperability and subsequently wider data sharing are set to improve agricultural decision-making, it is important to that data governance in agriculture cannot be separated from ethical considerations; the two must evolve in tandem (Bronson & Knezevic, 2016). This is especially true with the rise of AI and even blockchain technologies, in narrow and well-governed use cases, which are poised to expand value-chain offerings by improving analytics, insights, monitoring and transparency (Marzougui et al., 2024; de Lange et al., 2025); but it raises the question over the fair and equitable distribution of these benefits. Bronson & Knezevic (2016) argue that the rise of big data raises fundamental questions about control, the distribution of benefits derived from that data, and the protection of farmer autonomy. Similarly, Carbonell (2016) warns that without explicit safeguards, big data practices risk reinforcing existing inequalities, adding that studies showed an overwhelming majority of farmers did not know what companies were doing with their data, despite believing they themselves had ownership of said data, highlighting the ambiguity of just what data ownership might represent. Taken together, these two articles highlight the importance of fair and equitable data ownership practices; where data is owned by one party, but another party benefits, lines may become blurred.

Dyckhoff (2020) goes on to echo these concerns, noting that when data is extracted and aggregated by external parties with limited transparency, mistrust often follows, which can also serve to undermine progress toward a more interoperable data future, going on to

suggest that trust and well-defined ownership are fundamental to the success. In practice, recent industry reports show how this ambiguity stalls progress towards interoperability; where vague, or even contradictory contracts exist, the result is fragmented tools, entrenchment of data silos in proprietary software, and day-to-day friction between software vendors, and software users, that serves to further stall innovation and may subsequently deter investment in shared systems (Carbonell ,2016; Loder, 2023, Skinner, 2023).

Open Data vs. Open Standards

Open data is defined by the Open Knowledge Foundation (n.d) as data that "anyone can freely access, use, modify, and share for any purpose," subject only to requirements that preserve provenance and openness. Dyckhoff (2020) goes on to suggest that open data should be FAIR. While FAIR and open data promotes transparency, it can also undermine trust if producers feel they are losing control or may be disadvantaged by third-party use of their data (Douma, 2023; Lefebvre et al., 2025). While the concept of open data may not appeal to all parties in all appications, Dyckhoff (2020) offers a useful framing (Figure 2), suggesting that openness should be viewed as a spectrum rather than a binary state. Data may be fully open, conditionally shared, or tightly controlled depending on context and stakeholder agreements.

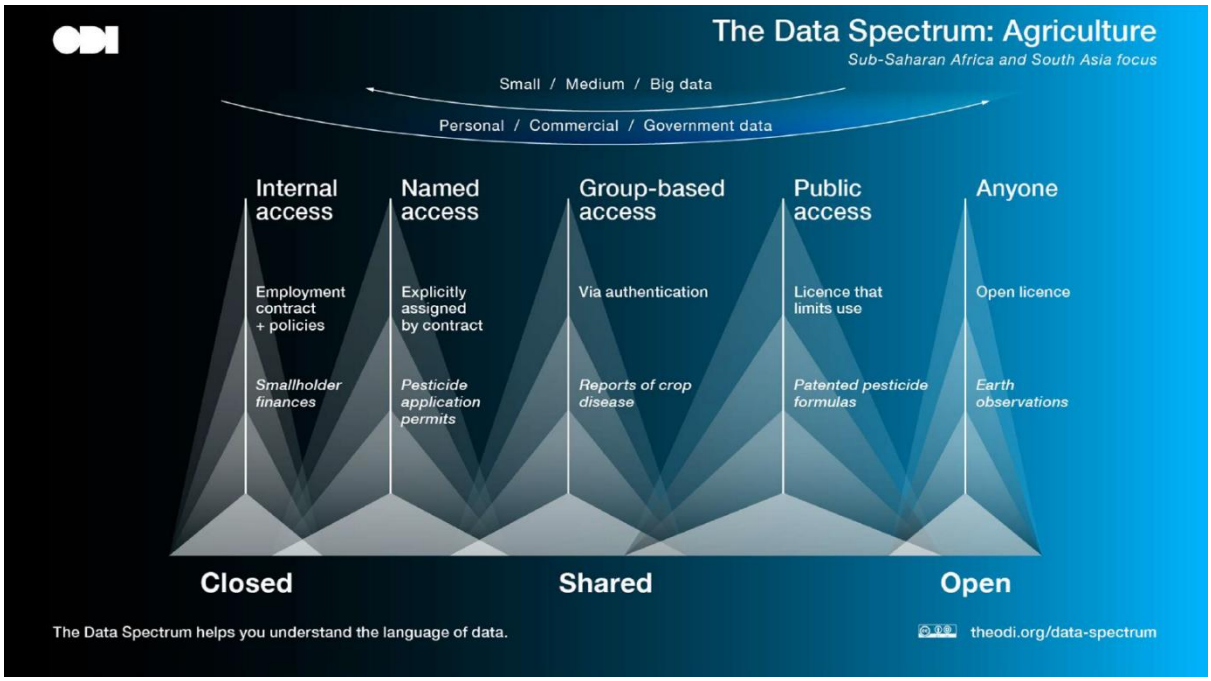

Figure 2: Showing framing of Data on a spectrum of openness from Closed to Open

3.4 Summary of Literature

The literature shows that data interoperability in agri-tech, particularly in New Zealand's wine industry, is a complex challenge influenced by more than just technical factors. Organisational structures, governance models, and economic realities play equally significant roles. From a technical perspective, fragmented systems and diverse datasets, especially those involving geospatial data critical to agriculture, lead to inconsistent naming, duplication, and seasonal data loss. These issues undermine traceability and reduce the analytical value of the data (Douma, 2023; Kharel et al., 2020; Loder, 2023). Although standards and integration frameworks are available, and would support greater interoperability, widespread adoption remains elusive. High implementation costs, legacy system constraints, and misalignment with commercial models continue to hinder progress. Additionally, everyday practices such as

unstructured data capture and reliance on siloed platforms underpinned by economics and resourcing constraints, compound these challenges (Loder, 2023; Douma, 2023).

Economic and resource limitations are a recurring theme in the literature. Tight margins, seasonal cash flow pressures, and rising input and compliance costs reduce the capacity to invest in interoperability, integration, and the skilled workforce needed to support these changes (Douma, 2023; Dyckhoff, 2020), serving to sustain data fragmentation. Organisational and cultural factors also contribute to inertia, including preferences for data privacy, uneven capability across the sector, and limited digital literacy, all of which slow collaboration even when technical solutions are available (Douma, 2023; Loder, 2023).

Governance and ownership concerns are central to the issue. As AI and blockchain technologies are set to expand value-chain opportunities, ethical questions around control, benefit sharing, and transparency become more pressing (Bronson & Knezevic, 2016; de Lange et al., 2025; Marzougui et al., 2024). The literature cautions against viewing "open data" as a binary concept; instead, openness should be treated as a spectrum, guided by FAIR principles and clear distinctions between rights to raw and derived data. Without predictable governance and trustworthy contracts, mistrust persists and adoption stalls; realising these opportunities depends on portable data, clear rights over raw vs derived outputs, and credible stewardship (Dyckhoff, 2020; Douma, 2023; Loder, 2023).

Despite these challenges, the literature identifies several practical enablers. Establishing neutral data trusts can help align incentives, centralise stewardship, and making FAIR compliance more achievable (Dyckhoff, 2020). Incremental, low-friction data sharing, anchored in co-designed use cases and supported by visible leadership and structured change management, can build momentum (Dyckhoff, 2020; Zhang et al., 2022). Sector-wide codes of practice, clear custodianship of key specifications, and transparent collaboration frameworks that define roles, incentives, and value flows can reduce uncertainty (Dyckhoff, 2020; Douma, 2023). While engaging trusted national bodies, to explore member-owned data pools or marketplaces, and applying emergent technologies where they are poised to solve real traceability and efficiency problems round out the near-term strategy (Lefebvre et al., 2025; Tagarakis et al., 2021; de Lange et al., 2025; Marzougui et al., 2024).

In conclusion, the literature suggests that while technical solutions are available, but they are not sufficient in their own-right to solve data interoperability challenges; their success depends on coordinated progress in governance, culture, and economics. Data interoperability presents an interdependent problem; one that requires aligned incentives, sustained capability building, and credible stewardship alongside continued technical innovation (Douma, 2023; Dyckhoff, 2020).

4.0 Methodology

4.1 Defining Stakeholders

This research component of this project gathered and analysed qualitative insights from key stakeholders within, or with connections to the NZ wine industry, or agri-tech sector. Broadly, these stakeholders fell into two groups, (1) Software Vendors, and (2) Software Users across growers, wineries, and industry bodies.

Software Vendors

- Software vendors
- Software investors

Software Users

- Wine companies
- Grape growers
- Winegrowing consultants
- Viticulturists
- Advocacy and Governance Groups
- Data interoperability researchers

4.2 Data Collection

Semi-structured interviews and conversations were held with a cross-section of 15 stakeholders from within the New Zealand wine industry, as well as the wider agri-tech sector. Participants included vineyard managers, software vendors, wine company representatives, and industry advocates. Conversations were guided by open questions around data interoperability, ownership, governance, barriers to adoption, and opportunities for innovation, which were tailored to the relevant stakeholder groups above. Notes and transcripts were captured from each discussion, allowing for review, and iterative comparison across stakeholders.

4.3 Thematic Analysis

Thematic Analysis as outlined by Braun & Clarke (2006) was used to identify and outline patterns in the interview data. ChatGPT and Microsoft Copilot (GPT-4 & GPT-5) were used to assist in summarising themes from the interview transcripts, helping to highlight recurring patterns and support the analysis. All transcripts were reviewed and validated by the Author prior to and data entering this report.

4.4 Ethical Considerations

An initial research proposal and list of research questions was submitted to Dr. Craig Trotter of Lincoln University to provide assurances that this research would be conducted ethically. Participant details have been kept strictly confidential and deliberately vague throughout the report in order to preserve privacy and confidentiality of all interviewees. The questions which were provided to Interviewees ahead of interviews taking place, can be found in the Appendix at the end of this report, along with a consent form which informed interviewees of the purpose of this research and outlined the above.

5.0 Results

5.1 Data Ownership & Commercial Models

Commercial incentives and collaboration

While the potential value of data sharing was widely acknowledged, participants on the vendor-side often noted that there is currently little commercial incentive for interoperability, with several noting that "there's not a lot of money in it" when compared to other product development priorities, also often noting that ongoing development this was more likely to

satisfy key internal-stakeholders, such as investors, who may expect to see a more immediate return on their investment, which progress towards interoperability may not satisfy. As a result, vendor collaboration on integration was limited, particularly among competitors who have developed similar products, or perhaps anticipate expanding into overlapping domains in the future. In this instance, it was noted that competitive pressures can be seen to discourage open cooperation, rather than serving as an enabler to innovation, with some vendors viewing interoperability as a potential threat to market differentiation rather than a shared opportunity for efficiency.

In practice, it was noted that integration may also be brought about by reciprocal value-add between partnering Agri tech solutions. While there is often no explicit commercial outcome beyond increased value proposition for the two parties, it was noted that this has been a valuable tool for implementing integration and can be particularly effective where vendors are not competing in the same area or marketplace. Though in reality, many interviewees suggested that improvements to data interoperability are most often achieved when driven by large customers, collectives, or industry bodies that can compel alignment through commercial, contractual or compliance requirements, with the latter being the most influential.

Unfortunately, it was suggested that forums to facilitate collective outcomes from within the industry are becoming more and more scarce, reducing the sector's ability to articulate a unified voice to software vendors, leaving vendors to seek out these opportunities themselves. Participants commented that this lack of alignment not only serves to fragment development efforts but can also frustrate vendors and users of software alike, where there is consistently conflicting or inconsistent demands from different stakeholders across the value chain, or seemingly obscure development roadmaps which do not align to customer requests.

Data and insights ownership

It was noted that one of the key issues underpinning the resistance to greater data interoperability was the absence of regulation that clearly differentiates rights over raw data from those over insights derived from that data; moreover, where vendors are required to exchange data or insights, which is generally of benefit the end user, this issue is sometimes compounded, whereby data ownership and insights is further complicated. From an industry perspective, it was noted that ambiguity over data ownership too often becomes a convenient exit ramp for vendors, stalling interoperability before its benefits can be tested. In some cases, a lack of interoperability might also be seen by opportunistic vendors as a means for perpetuating vendor lock-in, where vendors may want to limit opportunities for users to use their data on a competing platform. This can be especially frustrating for users who own the underlying data and want the freedom to share it across systems to streamline their data flows.

Continuing along the lines of commercialisation and data ownership, vendors also expressed a need for caution around open data models for data sharing, fearing it could undermine current commercial models and risk disincentivising further participation in the sector. Instead, there was suggestion that open data standards might lead to more equitable outcomes and could allow systems to interoperate without fully opening up data access. However, it is noted that a number of open data models have failed due to a lack of functional buy-in from key stakeholders, which makes the value proposition weak, and unappealing to vendors and end-users of technology alike.

5.2 Data Standards & Technical Challenges

Perspectives on technical feasibility

From a vendor's perspective, the technical challenges of interoperability are real but not insurmountable. Many vendors, particularly those who have started out in recent years, noted they have sought to future-proof their platforms by including API capability in their underlying infrastructure, and some already have the capability to deliver machine-readable formats, despite it not being an immediate requirement from their customer base. However, without clear routes to commercialisation, some suggest the investment isn't justified, preferring to focus their development efforts on their core business. For legacy systems, where data interoperability was not a requirement at all during development, there is often significant technical debt which has been accrued overtime, meaning that extensive refactoring would be required in order to adopt data standards, creating further barriers to integration.

Data heterogeneity in practice

The persistent challenges in data heterogeneity across organisations was highlighted. It was speculated that this has come about through a range of actions, but first and foremost may be the result of development occurring in silos, where data sharing was not required in order to deliver functional system requirements. Although widely recognised, these issues seldom appear to be tackled systematically, and where standards do exist, poor uptake by industry means there is no incentive for action or adoption by vendors.

There was suggestion that adoption of open data standards may be driven through governing bodies, though it was also suggested that no such governing body within the NZ wine industry currently has this remit. Other suggestions were that eventually, successful businesses may dominate the market in a similar way to Microsoft, and as such, find themselves well-positioned to implement standards; although another interviewee noted that in the wine industry, such businesses do exist, but the dynamic this has created, could mean they are not challenged to collaborate, rather operating in silos themselves, and the result is that no further standardisation occurs.

It was also noted that a contributing factor to low adoption of standards might be the wide variety of stakeholder within the industry, and the disparity between small and large enterprises; whereby smaller companies often lack the capability or resources to benefit from increased interoperability and quite happily continue to rely on PDFs and spreadsheets. In the interest of fairness, this dynamic can make it difficult for governing bodies and software vendors alike to satisfy the needs of all stakeholders when choosing where to invest their efforts.

5.3 Trust, Sustainability & Strategic Value

Open standards and the role of regulation

While open standards might serve to aid in solving some of these technical challenges, vendors expressed some scepticism about regulation dictating technical standards, warning that it might lead to things like "checkbox APIs" that provide the appearance of compliance without delivering real functionality. Generally, there was a preference for regulation to act as guardrails, focusing on privacy, security, and portability, while leaving technical design to the market. This does, however, raise further questions about how a widely adopted standard may be implemented. From a vendor's perspective, the technical challenges of interoperability are real but not insurmountable. Many vendors, particularly start-ups noted they have future-proofed by including API capability in their underlying infrastructure and some already have

the capability to deliver machine-readable formats. But for some, customer demand alone, without clear routes to commercialisation, often just doesn't justify the investment. This may be particularly true for legacy systems, where technical debt means extensive refactoring would be required in order to adopt data standards, creating further barriers to integration.

Fragmentation and non-standard reporting

The wine industry collects divergent datasets for regulation, compliance, and certification, reflecting the differing requirements of multiple stakeholders who often demand slightly different metrics or apply non-standard measures, which may be contingent on what their customers ask them for. Participants noted that this disparity can undermine both the accuracy and perceived validity of reporting, reducing its ultimate value. Several interviewees emphasised that the non-standard nature of reporting requirements, and a lack of transparency for final use of the data can sometimes feel like "data capture for data capture's sake," which was seen as a poor use of resources. There was suggestion that if open standards were to be developed, they should be comprised primarily of important metrics with a clear consensus-driven use case only.

Sustainability insights and biosecurity resilience

At the same time, there was strong agreement that functional interoperability in regulation and sustainability reporting would unlock efficiency while also reinforcing the industry's international competitiveness. There is also acute awareness that certification data, sustainability metrics, and traceability are directly tied to consumer trust, and market access, with one stakeholder remarking that "reputation and transparency drive value." In this framing, interoperability was not viewed as a technical convenience but as a strategic necessity underpinning both resilience and competitiveness. Data governance, therefore, must serve the sector's collective reputation, positioning certification, sustainability reporting, and biosecurity not merely as compliance exercises but as essential enablers of export access and international trust.

Participants also highlighted the potential of shared frameworks to enable richer sustainability insights, such as net-zero calculators and task- or machine-level carbon accounting, which extend beyond coarse financial measures. Similarly, integration across systems was linked to stronger biosecurity resilience, enabling faster and more coordinated responses to emerging risks. While vendors generally acknowledged the potential benefits of interoperability for certification and market access, they did not view them as immediate commercial drivers. Instead, they tended to see sustainability and certification requirements as external pressures. However, some vendors noted that enabling traceability and carbon accounting could emerge as commercial differentiators in the near term, should customer demand for these features increase.

5.4 Suggested Technology Pathways & Future Enablers

Interviewees suggested a number of potential solutions which might allow for greater industry interoperability to develop

- APIs as the new minimum standard: Some vendors are increasingly treating documented, backwards-compatible APIs as table stakes, enabling more efficient and effective vendor-to-vendor links.
- Iterate the data you ask for: Some Interviewees suggested an effective approach might be to start small and only capture data that clearly adds value, then expanding, echoing "start with what you have; plan the transition" rather than waiting for perfect

end-state standards. This also helps to steps away from perceptions of "data-capture for data-capture's sake" which was noted can be frustrating for stakeholders.

- AI as an on-ramp: Where practical uses included mapping fields, and vines, reducing duplication, and flagging bad data; it was noted that "value grows once data is clean and structured". Interviewees emphasised human oversight and governance guardrails would be critical in the implementation of AI tools, which mirrors sector guidance that trust/ownership must be addressed for AI to matter.
- Avoid locking into rigid standards too early: Concern about sunk costs and shifting tech pushed teams toward small, functional integrations now, consolidating proven patterns later.
- Addressing the legacy software issue: Where older systems and changing customer needs still constrain API rollout; many teams choose the path of least resistance (and expense) rather than engaging in large platform refactors, which can serve as an interim solution, but can also add to technical debt, causing further issues down the line. It was suggested that this might also be a consequence of low adoption of standards where benefits currently don't outweigh re-engineering costs.
- Timing matters: It was suggested that incremental improvements may be a factor of the seasonality of the agricultural sector, and that timing, in terms of the emergent technologies may also be pertinent to solving some of the issues which this report has highlighted.

5.5 Summary of findings

Across vendors, industry, and governance stakeholder interviews, there was general consensus and alignment that better data interoperability would unlock efficiency gains, support resilience, and advance sustainability outcomes for the NZ wine sector, which could in turn increase profitability, and aid in securing market-access into the future. Vendors recognise this upside but broadly speaking, emphasise that their behaviour is ultimately shaped by market incentives. Unclear data ownership arrangements, technical complexity (including legacy systems and schema inconsistencies, and uncertain returns on integration work serve to slow investment. Generally, vendors suggested they view progress as contingent on clearer governance settings and stronger, customer-led demand signals that make interoperability commercially viable. On the user side, industry and governance participants report daily friction, with frustrations resulting from fragmented systems, where duplicate data entry, limited ability to join datasets, and lost insight result; so, they frame interoperability as a practical enabler of productivity now and a strategic requirement for the future. They also tend to elevate traceability and transparency as the principal higher-level benefits, linking interoperable data to stronger partner trust, improved marketability, and protection against potential future barriers to market access. The results point to two preconditions for momentum towards data interoperability within the NZ wine sector: (1) codified governance (rights, roles, and rules for sharing) that reduces uncertainty, and enables progress, and (2) concentrated customer demand that aligns commercial incentives so vendors can justify the technical work required to implement interoperability at scale. I was suggested that where this has not been achievable in the past, it is suggested that emergent technologies may serve to enable increased interoperability where AI might help to align datasets, or as the end user, may provide a clearer value proposition for interoperable data. However, this is only true once core interoperability and governance are in place. In essence, the timing may be right, and prioritisation must be made to invest in data interoperability.

6.0 Discussion

6.1 Technical Barriers Vs. Resourcing Constraints

Despite viable technical approaches, data interoperability in the wine sector remains constrained by a combination of fragmented datasets, proprietary platforms with limited export or sharing options, and misaligned commercial incentives (Dyckhoff, 2020; Skinner, 2023) that leave vendors feeling they are carrying most of the engineering burden while users capture most of the benefit. Interviewees repeatedly described situations where the requisite interfaces or data pipelines were technically feasible but had to be deprioritised because they did not map cleanly to near-term growth targets. Under prevailing commercial models, it was suggested that interoperability competes with "quick-win" features that expand platform value or satisfy investor expectations, and this dynamic means otherwise feasible integrations stall or remain in the proof-of-concept phase for extended periods; perhaps indefinitely. While there was broad agreement that increased collaboration and prioritised investment could overcome these constraints, interviewees noted that such coordination is still the exception rather than the rule, particularly where costs are borne by individual vendors and benefits accrue diffusely across the sector.

Data heterogeneity forms the persistent backdrop to these challenges. The literature identifies multiple forms of heterogeneity; including structural, semantic, temporal, and spatial, that complicate integration and erode the analytical value of combined datasets (Douma, 2023). In practice, misaligned schemas, especially for geospatial elements that underpin vineyard operations, were cited as a frequent cause of re-work, with interviewees pointing to inconsistent row/block identifiers, overlapping boundary definitions across seasons, and divergent naming conventions that force manual reconciliation (Kharel et al., 2020; Skinner, 2023). In a viticultural context, the consequence is tangible: without consistent geospatial references, growers and wineries re-key the same information into multiple systems, heightening the risk of error and undermining cross-platform workflows that should, in principle, be straightforward (Skinner, 2023). These technical issues are compounded by poor data hygiene and closed platforms; interviewees described duplicated records, version drift between systems, and seasonal data loss where exports are partial or locked behind proprietary formats, collectively weakening traceability and limiting re-use (Dyckhoff, 2020; Loder, 2023; Skinner, 2023).

The absence of widely adopted standards sustains fragmentation. Although frameworks such as the Collabriculture Vineyard Data Model were developed, advancing FAIR data principles, and providing a shared vocabulary for vineyard data, uptake remained limited, with interviewees attributing this to governance and commercialisation hurdles rather than a lack of technical merit. More broadly, end-to-end interoperable traceability solutions across the value chain remain scarce (Tagarakis et al., 2021), and while established pathways such as ISOBUS and AgroXML offer routes to integration, the implementation and refactoring costs are frequently prohibitive for estates with complex histories and embedded workflows (Iftikhar & Pedersen, 2010; Dyckhoff, 2020). Several interviewees also noted a structural misalignment between open standards and prevailing software business models, with the result that investments in interoperability are again difficult to justify, where they do not clearly expand the addressable market or enhance defensible differentiation (Skinner, 2023).

Collaboration with legacy software intensifies the cost and complexity of interoperability ventures, at times making the exercise prohibitive, due to technical debt. Many systems were

built without interoperability in scope; accumulated this technical debt, through things such as bespoke data models, and as a result, enabling modern interfaces requires significant refactoring and extensive regression testing. Interviewees contrasted this with newer platforms where API capability ships as a baseline feature, allowing easier data exchange even when formal standards are not yet in place. The net effect is an uneven value proposition: incumbents face a heavy lift with limited near-term upside, while newer entrants, who often lack deep historical datasets, may stand to gain more from cross-system sharing, further complicating sector-wide progress and dampening the case for retrospective alignment.

In summary, technical solutions exist in principle, but without aligned incentives, clear accountability for funding, and practical resourcing, they remain unviable at scale. Interviewees repeatedly emphasised that users stand to benefit most from connected data, yet vendors absorb most of the engineering and maintenance burden; whether the platform improvements, or potential for reciprocity through engagement this drives with wine companies and vendors alike, adds value for the vendor is up for discussion; in the absence of mechanisms that rebalance this equation, such as aggregated customer demand, co-investment, or market-access-linked certification, the perception is generally that the commercial return often fails to justify the technical effort, and progress remains uneven despite feasible options.

6.2 Governance & ownership

Trust and ownership emerged as foundational constraints in the literature; without clear definitions and accepted norms, meaningful interoperability remains elusive (Dyckhoff, 2020). Interviewees generally agreed that customers own the raw data they input or generate within systems, yet some friction persists at the boundary between raw data and derived outputs or insights. In the absence of a widely accepted delineation of rights at this boundary, parties default to contracts that vary by vendor and use-case and have the potential to further embed ownership ambiguity. The EU Code of Conduct on Agricultural Data Sharing is cited as a constructive reference point (Dyckhoff, 2020), but its voluntary nature limits its influence; as Carbonell (2016) observes, contractual language can entrench uncertainty, with vague or conflicting clauses leaving room for interpretation that undermines the intent of sharing, and where not all parties agree to meet a contractual standard, it could be said that early adopters may be disadvantaged by increased regulation. Several interviewees characterised this ambiguity as both a practical barrier and, in some instances, a convenient exit ramp for parties reluctant to support wider interoperability.

Interviewees also noted that, in practice, value capture is negotiated commercially through integrations that enhance platform utility rather than through direct data monetisation. This positions ownership and re-use as matters of reciprocal value rather than purely legal principles, but it also raises the unresolved question as one interviewee put it, of "who wins with interoperable data," and therefore who should fund and drive change. Here, the role of governance bodies remains unsettled. Levy-funded organisations represent diverse stakeholders with uneven incentives for data standardisation; some who do not operate at scale are quite able to work effectively in closed systems using pdf documents. The same is true for software vendors, who must differentiate between the varied industry stakeholders. It is well documented in the literature, that the net result can be difficulty in prioritise, resource, and sustaining initiatives that do not present immediate value to all parties (Dyckhoff, 2020; Skinner, 2023). Across interviews there was strong support for a neutral industry convenor with a clear mandate to coordinate data interoperability within the industry. In the absence of such

leadership, the ecosystem relies on bespoke, ad-hoc integrations that are costly to build and maintain, and the sector risks slipping behind more coordinated peers. Unfortunately, it is unclear who this should be, with some suggesting that it might sit outside of the current governance frameworks altogether.

Standards and regulation also sit within this governance question. Frameworks such as the Collabriculture Vineyard Data Model provide shared semantics and align with FAIR data principles, yet interviewees pointed to limited adoption due to perceived governance and commercialisation challenges; end-to-end interoperable traceability remains scarce, and the implementation/refactoring costs inhibit uptake, especially for legacy systems with entrenched workflows (Loder, 2023; Douma, 2023; Tagarakis et al., 2021; Iftikhar & Pedersen, 2010; Dyckhoff, 2020). In interviews, vendors cautioned that prescriptive regulation risks "checkbox APIs," where interfaces satisfy compliance on paper but deliver little practical utility; the preferred stance was regulation as guardrails on privacy, security, and portability, leaving technical design room to evolve. Interviewees also warned that, in the absence of strong and direct governance, inconsistent standard adoption and one-off contracts can produce inequitable outcomes where parties hold unequal influence, raising transaction costs and discouraging participation; something which is also supported heavily by the literature (Carbonell, 2016; Noura et al., 2018; Dyckhoff, 2020; Skinner, 2023).

Taken together, the evidence indicates that governance and technology must evolve in tandem; clear rights and responsibilities at the raw-vs-derived data boundary, a credible convenor to hold profiles and conformance, and coherent standard-setting are all potential prerequisites for scaling data interoperability within the industry. Without these, ambiguity, uneven adoption, and cumulative transaction costs will continue to reduce sector-level value, regardless of technical feasibility.

6.3 Organisational culture & capability

Across interviews, most participants downplayed "cultural resistance" as the primary drag on interoperability. What is frequently labelled as culture was typically underpinned by uncertainty over who funds and drives the work. Additionally, willingness to share was inherently conditional; when incentives align and the purpose is clear, firms from both vendor and user sides generally reported they were prepared to participate. This aligns with findings that participation stalls under misaligned incentives and ambiguous value propositions and progresses when benefits and responsibilities are explicit (Lefebvre et al., 2025).

Concerns commonly emphasised in the literature such as fear of competitive exposure or loss of control when sharing data (Loder, 2023; Marzougui et al., 2024), surfaced less strongly in interviews, though it was suggested that concerns may arise where there could be perceived feelings of inadvertently undermining ones-self by over-sharing, or where there was a known shortcoming when compared a competitors dataset. Generally though, reluctance more often reflected unclear value propositions, uneven capability, or limited time and resourcing rather than principled refusal to collaborate. As Skinner (2023) notes, many stakeholders still struggle to see concrete returns from interoperability; in that context, what appears to be "cultural resistance" can be a rational pause when benefits are vague and the implementation lift falls on small, time-poor teams.

Interviewees consistently highlighted uneven digital literacy and variable data skills across vineyards and wineries, as well as seasonal cadences that push attention toward the next production cycle rather than iterative improvement of data and processes. These constraints

limit both uptake and the realisation of longer-term insights from shared datasets, as well as pointing to capability gaps within the sector. Notably, where capability building is concerned, the NZ wine sector is not starting from zero. Interviewees pointed to an existing institutional base, mentoring programmes, workforce initiatives, and industry networks, that could be oriented more explicitly toward digital capability and shared data practices. The limiting factor is therefore focus and relevance more than the absolute absence of support. Several participants observed that where responsibilities were clear, language was aligned, and the operational lift was feasible, collaboration followed; where those conditions were absent, hesitation tended to be misread as culture rather than what it often is: a surface expression of deeper issues of mandate, meaning, and means.

In aggregate, these observations suggest that organisational culture is best understood as nested within alignment to strategy, and capability constraints. When incentives, roles, and expected outcomes are clear, and the requirements are realistic, organisations are more likely to be willing to participate in pursuing interoperable data flows. When they are not, progress remains patchy even when technical solutions are available, reinforcing the broader conclusion that the barriers to interoperability are as much organisational, economic, and governance related as they are technical.

7.0 Research Limitations

The sample of interviewees was targeted rather than random, so findings reflect expert perspectives rather than a broad generalisation; the majority of agri-tech vendors interviewed, also specialised in supporting technology in the wine industry. Additionally, time limitations meant that only a very small subset of stakeholders could be interviewed when considering the industry as a whole. This means that the views shared in the results section may not necessarily be representative of the wine industry as a whole. Finally, conversations were conducted over a relatively short time horizon, and views may shift as the technology and vendor landscape is continuing to rapidly evolve.

8.0 Conclusion

This project draws on both literature and semi-structured stakeholder interviews, including software vendors, governance bodies, and producers, to capture a cross-section of industry perspectives on the current state of data interoperability, its barriers, and future possibilities. The goal is to identify practical solutions to the interoperability challenges affecting the New Zealand wine sector. While there is clear recognition of the value of data and interoperability, practical implementation remains limited. The initial hypothesis that the sector's vertical integration might ease adoption still holds promise; however, the reality is more nuanced. This report finds that the obstacles to interoperability are not primarily technical. The necessary tools exist, and many modern platforms already offer machine-readable interfaces. What constrains progress is the intersection of fragmented datasets, legacy technical debt, and, most critically, misaligned incentives and unclear accountability. Data interoperability in agri-tech, and specifically in the NZ wine sector, is a wicked problem shaped by the interdependency of these barriers (Kharel et al., 2020; Douma, 2023).

Data sharing often hinges on clarity around raw data and derived insights, and in the absence of widely accepted rules, stakeholders rely on bespoke contracts that can embed ambiguity (Carbonell, 2016). While governance and ownership emerge as decisive levers in solving this

challenge, the NZ wine industry does not have an obvious custodian of this. It is suggested that adoption of voluntary codes may help, but inconsistent uptake weakens their influence (Dyckhoff, 2020). Open standards also show promise; however, without aligned economic incentives, they struggle to move beyond templates (Dyckhoff, 2020). Additionally, where regulation was discussed in interviews, vendors cautioned against prescriptive measures such as "checkbox APIs" that meet compliance requirements without delivering real utility. Durable progress, they suggest, requires guardrails around privacy, security, and portability, while allowing flexibility in technical design. To date, market-led efforts to promote interoperability have largely stalled. Where organisational culture is seen as a barrier, it may be better understood as an alignment issue nested within capability constraints, rather than intrinsic resistance. Interviews revealed a conditional willingness to share data when the purpose and benefits are clearly articulated.

Taken together, the evidence points to a simple, if demanding, conclusion: technical solutions alone will not deliver sector-wide value unless incentives, governance, and capability evolve in tandem. Interoperability must be embedded into everyday tools and agreements, supported by clear rights and responsibilities, and championed by credible leadership capable of maintaining coherence across a diverse ecosystem. The strategic payoff includes lower compliance overheads, stronger sustainability and traceability claims, and improved biosecurity resilience. These benefits justify the effort. However, until funding, accountability, and a shared language are clarified, progress will remain uneven and the sector risks ceding advantage to more coordinated global peers.

Finally, these findings are indicative rather than exhaustive. They reflect a targeted sample of stakeholders over a short time horizon in a fast-evolving landscape. As technology, standards, and market expectations continue to shift, so too will the opportunity, and the cost, of remaining fragmented.

9.0 Recommendations

Intentional, pragmatic and iterative standardisation

The NZ wine industry, which in practice might constitute should aim to pragmatically and iteratively adopt standards, starting small and building on successes; in practice, this might see a coalition of wine companies, independent growers, and software vendors with potential for governing bodies to support where there is a need for mediation or clarity around current or future regulations, where specific interoperable data might support an improvement to process or reporting; NZ winegrowers might be a good candidate to fulfil this niche in the short-term, but as described above, may have trouble generating meaningful, fair and equitable change for all levy-paying stakeholders. Ultimately, the argument could be made for a specialist function to fulfil this niche from a broader governance agency.

There has been plenty of work done in the development of standards to date, meaning there may be opportunities to leverage this work, utilising existing specifications One example could be the widespread adoption of standards such as GeoJSON for all mapping solutions, to reduce the challenge of using maps across multiple systems. This set of standards should be published into a NZ-Wine "implementation profile" that sets out minimal required fields with worked examples, rather than inventing new bespoke standards, which may solve problems which may have already been solved. Additionally, because geospatial and temporal elements are foundational in viticulture, there should be provision for minimum viable

interoperability with a couple of high-value identifiers such as "sub-block x vintage" and "vineyard x vintage" which could link the geospatial and temporal elements to real world applications i.e., seasonal inputs such as labour and agrichemicals, as well as weather data and outputs such as profit, and quality insights, that multiple systems can reliably round-trip.

This approach will require oversight from both vendors and users of technology but should be industry driven to align on an operational standard. There may also be opportunities to understand which standards are currently embedded in industry and seek to adopt the ones which are most effective or easy to implement. Ultimately, what this should aim to do is to showcase the value of pragmatically implemented standards, as they support interoperability, and not fall into the trap of standardisation for standardisation's sake.

Review data ownership models

To foster trust and align incentives across the data ecosystem, vendors should investigate the feasibility of adopting split pricing models that clearly separate fees for data capture and hosting from those for analytics and insights, in conjunction with stakeholders from the industry. This approach could serve to increase transparency and ensures that data sharing does not compromise vendor business models. Contracts should make data portability the default, with explicit clauses covering the export of raw and derived data in standard formats or via APIs, as well as reversibility and clear sunset terms for data retention and deletion. It is also critical that they define rules around derived data from the outset, clarifying who can use, share, or resell model outputs, what attribution is required, and under what conditions models may be retrained. Transparency should be embedded by design, with standardised consent logs and data-use notices integrated at every touchpoint. Finally, stewardship of these practices should be assigned to an industry body, supported by a legal advisory panel, to maintain implementation profiles, publish template clauses, and resolve disputes.

Build sector digital capability and awareness of potential (people and practice)

Finally, the literature and stakeholder interviews consistently highlight capability gaps within the New Zealand wine industry. Without targeted investment in both people and emerging technologies, the sector risks falling behind international counterparts and losing competitiveness on the global stage, where price and quality are key drivers. Building sector-wide digital capability is a long-term endeavour and cannot be achieved overnight. To bridge these gaps and position the industry for future success, initiatives should focus on showcasing the transformative potential of interoperable data. This includes:

1. Inspiring individuals within the sector to upskill, providing forums to engage with digital tools and practices, supported by industry-led initiatives.
2. Attracting talent from outside the sector through incentives and investment in innovation.

Strong governance support will be essential to develop and sustain solutions to these challenges, and again this is likely best done by a specialist function which sits outside of the current levy structure. The key question for industry stakeholders is how to operationalise a framework that promotes and inspires digital transformation, particularly in a context where the value of interoperability may not be immediately recognised. Solving this challenge requires more than technical solutions; it demands a cultural shift toward data sharing across governance bodies, industry participants, and software vendors. These groups must collaborate to define what incentives might look like and determine who will lead and own the drive toward interoperability. Given that industry stands to benefit most from such an initiative, it is proposed that key actors within the sector align on a shared vision, seek

governance support, and then engage software vendors to co-design and implement practical solutions. In practice, this could include pilot programme run by industry bodies in collaboration with NZ wine growers, and local technology institutions.

10.0 References

Bellavista, P., Esposito, C., Foschini, L., Giannelli, C., Mazzocca, N., & Montanari, R. (2021). Interoperable blockchains for highly-integrated supply chains in collaborative manufacturing. Sensors, 21(15), 4955. https://doi.org/10.3390/s21154955

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bronson, K., & Knezevic, I. (2016). Big data in food and agriculture. *Big Data & Society, 3*(1), 1–5. https://doi.org/10.1177/2053951716648174

Carbonell, I. M. (2016). The ethics of big data in big agriculture. *Internet Policy Review, 5*(1), 1–13. https://doi.org/10.14763/2016.1.40

Collabriculture. (2021). Collabriculture vineyard logical data model [Computer software]. GitHub. https://github.com/CollabricultureOrg/vineyard-logical-schema

de Lange, W. J., van der Merwe, M., Takawira, K., & van Rooyen, C. J. (2025). Blockchain in agricultural value chains of developing economies: Progress, challenges, and future pathways. *Agrekon, 64*(2), 1–20. https://doi.org/10.1080/03031853.2025.2495245

Douma, L. (2023). *Data Sharing to Achieve Data Interoperability*. Nuffield New Zealand.

Dyckhoff, J. (2020). *Challenges in data interoperability in New Zealand agriculture* [MPI Data Interoperability Report v0.2]. Ministry for Primary Industries.

Henriyadi. (2021). The model of data interoperability in farm management information system [Conference paper]. Asian Institute of Technology.

Iftikhar, N., & Pedersen, T. B. (2010). Flexible exchange of farming device data. *Computers and Electronics in Agriculture, 75*(1), 52–63. https://doi.org/10.1016/j.compag.2010.09.010

Kharel, T. P., Ashworth, A. J., Owens, P. R., & Buser, M. (2020). Spatially and temporally disparate data in systems agriculture: Issues and prospective solutions. *Agronomy Journal, 112*(5), 4498–4510. https://doi.org/10.1002/agj2.20285

Lefebvre, H., Krasikov, P., Legner, C., & Flourac, G. (2025). Data management as a joint value proposition: A design theory for horizontal data sharing communities. *Electronic Markets, 35*, Article 21. https://doi.org/10.1007/s12525-025-00755-1

Loder, H. (2023). *Here come the robots, but what do we do with the data?* Nuffield New Zealand.

Marzougui, F., Elleuch, M., & Kherallah, M. (2024). Blockchain and IoT in smart agriculture: Analysis, opportunities, challenges, and future research directions. *Journal of Information Assurance and Security, 19*(3), 104–119. https://doi.org/10.2478/ias-2024-0008

New Zealand Winegrowers. (2024). *New Zealand Winegrowers annual report 2024*.

Naigeon, N., Picardat, S., & Auguste, P. (2023). Data for decision-making in viticulture in the face of climate change: Looking beyond production issues. *BIO Web of Conferences, 68*, 01040. https://doi.org/10.1051/bioconf/20236801040

Noura, M., Atiquzzaman, M., & Gaedke, M. (2018). Interoperability in Internet of Things: Taxonomies and open challenges. *Mobile Networks and Applications, 24*(3), 796–809. https://doi.org/10.1007/s11036-018-1089-9

Open Knowledge Foundation. (n.d.). *The open definition*. Retrieved October 22, 2025, from https://opendefinition.org/

Simeunović, M., Ratković, K., Kovač, N., Racković, T., & Fernandes, A. (2025). A knowledge-driven framework for a decision support platform in sustainable viticulture: Integrating climate data and supporting stakeholder collaboration. *Sustainability, 17*(4), 1387. https://doi.org/10.3390/su17041387

Skinner, A. (2023). *Common data specifications for spray diaries and vineyard blocks to enable data interoperability across the wine value chain (Project Harmony)* [Research report]. More Than Machines.

Tagarakis, A. C., Benos, L., Kateris, D., Tsotsolas, N., & Bochtis, D. (2021). Bridging the gaps in traceability systems for fresh produce supply chains: Overview and development of an integrated IoT-based system. *Applied Sciences, 11*, 7596.

Zeng, M. L. (2019). Interoperability. *Knowledge Organization, 46*(2), 122–146 https://doi.org/10.5771/0943-7444-2019-2-122

Zhang, J., Budhdeo, S., William, W., Cerrato, P., Shuaib, H., Sood, H., Ashrafian, H., Halamka, J., & Teo, J. T. (2022). Moving towards vertically integrated artificial intelligence development. *npj Digital Medicine, 5*, 143. https://doi.org/10.1038/s41746-022-00690-x

11.0 Appendices

Governing Bodies – Kellogg Questions

Data Collection and Use

1. What types of data do you collect from wine producers?
2. How is this data used to support compliance, sustainability, or industry development?

Interoperability and Policy

3. What challenges do you see in aligning regulatory data systems with industry platforms?
4. Are there any current efforts to standardise data formats or reporting requirements?

Stakeholder Engagement

5. How do you collaborate with wine companies and tech providers to improve data flows?
6. What incentives or support mechanisms exist to encourage better data practices?

Vision and Strategy

7. What is your long-term vision for digital transformation in the wine industry?
8. How do you see your role in enabling innovation through data?

Technology Companies – Kellogg Questions

Product Capabilities

1. What types of data do your systems typically handle for wine industry clients?
2. How do you approach integration with other platforms or APIs?

Interoperability Challenges

3. What are the most common technical or business barriers to achieving interoperability?
4. How do you manage data standardisation across different clients?

Collaboration and Innovation

5. Are you involved in any industry-wide initiatives to improve data interoperability?
6. What role do you see vendors playing in shaping data standards?

Client Needs

7. What feedback do you receive from wine companies regarding data integration?
8. What features or services are most requested to improve interoperability?

Wine Companies & Grape Producers – Kellogg Questions

Understanding Current Practices

1. What types of data do you currently collect (e.g., compliance, plant health, environmental, yield)?
2. What systems or platforms do you use to manage this data?
3. How do you currently share data internally and externally?

Challenges and Barriers

4. What are the biggest challenges you face when integrating data across systems?
5. Are there any specific examples where lack of interoperability has impacted decision-making or operations?

Collaboration and Standards

6. Have you engaged with other wine companies or industry bodies to improve data sharing?
7. What kind of data standards or protocols would help your business most?

Future Outlook

8. What improvements would you like to see in data systems over the next 3–5 years?
9. How do you see Agtech evolving in your operations?